No.

Independent Public Business Corporation

The Independent State of Papua New Guinea

DETAILED DESIGN (PHASE 2)
ON
PORT MORESBY SEWERAGE SYSTEM UPGRADING PROJECT
IN
THE INDEPENDENT STATE OF PAPUA NEW GUINEA

FINAL REPORT

PART II: Bidding Documents

Volume III – Technical Specifications

B: Standard Specification

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JAPAN INTERNATIONAL COOPERATION AGENCY

NJS CONSULTANTS CO., LTD.

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Independent Public Business Corporation
The Independent State of Papua New Guinea

PORT MORESBY SEWERAGE SYSTEM UPGRADING PROJECT

(JAPANESE ODA LOAN NO. PN-P9)

BIDDING DOCUMENTS FOR PROCUREMENT OF PORT MORESBY SEWERAGE SYSTEM UPGRADING WORKS

Volume 3
(Technical Specifications)

3B. Standard Specifications

[Insert Month and Year]

DIVISION 1.

GENERAL REQUIREMENT

Section 01010

Summary of Works

Part 1 - General

1.01 Description of the Works

The scope of work for the project (hereinafter referred to as the "Works") is described in the Particular Specifications.

1.02 Contract

A The Particular Specifications and the Standard Specifications shall be read in conjunction with the other Contract Documents.

B The Standard Specifications are to provide overall guidance in the execution of the Works and shall apply except any provisions contradicted by the Particular Specifications that shall take precedence.

C Notwithstanding anything contained herein, the Contractor shall be responsible for complying in all respects with any such Laws, Bylaws and Regulations and the regulation and requirements of Local Authority and Government Agency as may be in force at the time of execution of the Works.

D The Contractor shall provide, and do everything necessary, for the proper execution of the Works according to the intent and meaning of the Tender and Contract Documents for the Works.

E The Works shall be completed in strict accordance with the Contract Documents and with any further drawings, or instructions, issued, or approved, by the Engineer during the execution of the Works.

F The works to be performed under this Contract include, but are not necessarily limited to, the furnishing of all supervision, labour, materials, temporary works, false-work, plant, machinery, equipment, parts, tools, supplies, transportation, utilities, construction facilities, incidentals and logistic support necessary for the performance and maintenance of the works, accomplishing the same in a professional and workmanlike manner.

G All works shall be executed by skilled tradesman who shall be thoroughly acquainted with all aspects of their trades, including any special local customs and modes of operation.

H Workmanship will be accepted of only the highest standard.

J The Contractor shall be deemed to have based his Tender on the information in all respects of hydrological, physical, socio-economic and climatic conditions of the site(s) for the Works (hereinafter referred to as the "Site") and inspected the Site and its surroundings and satisfied himself of all conditions before submitting his tender for the Works (hereinafter referred to as the "Tender").

K The Engineer and any person authorized by him shall, at all times, have access to the Works and to the Site and to all workshops, stores and places associated with the Works.

1.03 Work Performed by Others

During the construction of the Works the Contractor shall ensure that none of his activities cause undue hindrance to others in the performance of their duties.

1.04 Contractor's Use of Site

A Access to the Site shall be maintained by the Contractor at all times and all necessary steps shall be taken to ensure the safety of persons on the Site.

B All construction operations and site establishment facilities shall be confined to within the Site boundaries and roads, railway, highway and river corridor as approved by the authorities and as shown on the Drawings (defined as "Tender/Contract Drawings"), unless otherwise approved by the Engineer and the relevant authorities. Following such approvals, all such areas shall also be designated and treated as included within the Site.

C The Contractor shall be responsible for safeguarding all structures and the like in the vicinity of the Site and shall ascertain from the public utility authorities and by detailed utility detection surveys positions of all existing underground services and shall maintain and protect or divert them as required.

1.05 Occupancy

A A soils investigation report is available as described in Section 02200 hereof. The report is indicative only of the conditions of various points within the Contract area. The Employer does not guarantee the accuracy of the data given in the report, nor does he guarantee it is typical of the ground conditions likely to be encountered. The Contractor shall inspect and examine the Site and its surroundings and shall satisfy himself before submitting his tender as to the nature of the ground and sub-soil, the quantities and nature of the works and materials, tools and equipment necessary for the completion of the Works. No claim will be considered for additional expenses that the Contractor may incur on account of any unforeseen obstacle of whatever nature, over and above such costs and expenses quoted and agreed by the Employer at the Tender stage. Any excavations needed to determine the exact location, and levels, of obstacles shall be done by the Contractor at his own cost. The Contractor shall obtain all further information required as to the risks, contingencies and other circumstances that may influence or affect the execution of the Works and include the costs thereof in his Tender.

B The information and details of existing services given on the Drawings are not guaranteed to be accurate, or correct, and are given for guidance in compiling the Tender. The Contractor shall make his own investigations and inquiries to all service authorities to ascertain what services exist at the Site, and get details of their exact positions, sizes, numbers etc. When the Contractor intends to carry out work in the vicinity of existing services, he shall notify the owner of each particular service present, of his intent to do so, at least one month in advance of his anticipated start date. The Contractor shall prepare a Notice of Intent signed by the Engineer, the service authority concerned and the Contractor's representative. The Contractor shall uncover and verify locations of all services in accordance with any special requirements of the services authority concerned. The Contractor shall not be allowed to work in any area where services are buried until the Contractor has uncovered and located them both vertically and horizontally. The Engineer shall have the right to stop the work in any part of the Works where the Contractor fails to take the necessary measures to uncover such services. The Employer shall not consider any

claims from the Contractor resulting from such instructions. The Contractor shall refer to, and comply with, the current regulations of all the relevant service authorities before commencing any work adjacent to services. These requirements will not relieve the Contractor of any responsibility for taking every precaution to avoid damage to any service. The Contractor will be held responsible for the cost or repair of all damage.

1.06 Items Furnished by the Employer

A The Employer or his authorized representative reserves the right to place and install equipment, furniture, furnishings, etc., in completed or partially completed areas of the Works upon the understanding that the exercising of such right will not substantially interfere with the regular progress and completion of the Works.

B. The Employer or his authorized representative reserves the right to occupy completed parts of the Works prior to substantial completion of the whole of the Works, provided that such occupancy does not substantially interfere with completion of the remaining parts of the Works.

END OF SECTION 01010

Section 01041

Project Co-ordination

Part 1 - General

1.01 Description

The Contractor shall provide the administrative and supervisory personnel necessary for project co-ordination, construction, completion, commissioning and maintenance.

1.02 Co-ordination

A The Contractor shall co-ordinate construction activities included under various sections of these Specifications, to ensure efficient and orderly delivery and installation of each part of the Works, and shall co-ordinate construction operations included under different sections of the Specifications that are dependent upon each other for proper installation, connection, and operation. Where installation of one part of the Works is dependent on installation of other components, either before or after its own installation, the Contractor shall schedule construction activities in the sequence required to obtain best results. Where availability of space is limited, the Contractor shall co-ordinate installation of different components to ensure maximum accessibility for required maintenance, service and repair and make adequate provisions to accommodate items scheduled for later installation. The Contractor shall, where necessary, prepare details for distribution to each party involved, outlining special procedures required for co-ordination including such items as required notices, reports and attendance at meetings. Similar details shall be prepared for the Employer and separate contractors where co-ordination of their work is required.

B The Contractor shall co-ordinate scheduling and timing of required administrative procedures with other construction activities to avoid conflicts and ensure orderly progress of the work. Such administrative activities shall include, but are not limited to, the following:
1 preparation of schedules,
2 installation and removal of temporary facilities,
3 deliveries and processing of submittals,
4 progress meetings,
5 project close-out activities.

C The Contractor shall prepare, and submit, co-ordination drawings where careful co-ordination is required for installation of products; where materials are fabricated off-site by separate entities and where limited access availability necessitates maximum utilisation of space for efficient installation of different components. These drawings shall indicate the interrelationship of components detailed on separate shop drawings, required installation sequences and shall comply with requirements contained in Section 01300 hereof. The Contractor shall take special care and precautions for specific co-ordination requirements for plant, equipment and other electromechanical installations, specified elsewhere or otherwise required.

D The arrangement of the specifications into divisions, sections, clauses, sub-clauses and paragraphs, shall not control the division of work among sub-contractors, nor establish the extent of work to be performed by any particular trade or sub-contractor. The Contractor shall be responsible for the proper co-ordination of all works including that required

between different trades and different sub-contractors, suppliers, utility agencies, governmental authorities, etc.

END OF SECTION 01041

Section 01043

Job Site Administration

Part 1 General

1.01 Description

This Section includes requirements for Contractor's supervisory staff and administration procedures.

1.02 Details of Contractor's Supervisory Staff and Subcontractors

The Contractor shall provide the names and details of the experience, qualifications, language capabilities and previous appointments for the supervisory staff, including those of the sub-contractors, who will be allocated to the Works. These details shall be for the same personnel and sub-contractors as detailed in the Contractor's Tender. If alternative personnel or sub-contractors are proposed, then the Contractor shall provide a detailed comparison of original and substitute personnel and sub-contractors. Approval of alternative personnel or sub-contractors will not be given readily, and will only be given consideration if the proposed alternative personnel or sub-contractors are of equal or superior qualifications and experience as those originally proposed and that the Contractor is able to furnish acceptable and verifiable reasons for the unavailability of those originally proposed. No substitution of the specialist sub-contractors, as detailed in the Contractor's Tender Documents shall be permitted.

It shall be clearly understood that the supervisory staff and sub-contractors, as detailed in the Tender, shall be made available for the execution of the Works under this Contract. The provision of the supervisory staff and sub-contractors, proposed by the Contractor in the Tender, does not relieve him, in any way, of his liability under the Contract to provide all the staff necessary for the satisfactory completion, commissioning and maintenance of works and within the dates stated in the Contract. Each person and sub-contractor listed in the Tender is subject to final approval by the Engineer. Approval of the Contractor's supervisory staff and sub-contractors does not waive the right of the Engineer to withdraw that approval at any time thereafter, as provided for in the Contract.

1.03 Use of Site

The Site shall not be used for any purpose other than the Works under this Contract.

1.04 Advertising

Advertisements shall not be displayed or permitted on, or along, the Site without consent of the Engineer.

1.05 Working Hours

The normal working hours of the Engineer and his Representative's supervisory staff are fixed by the Employer and shall be in accordance with local laws and Local Authority construction permit requirements. The Engineer shall approve the starting and finishing times of the Contractor's working day and week.

1.06 Accident Prevention

Refer to Section 01500 hereof.

1.07 Adjoining Plant and Property

The Contractor shall take all reasonable precautions to avoid interference with the operation of, and to prevent damage to, adjoining plant and property. To use adjoining property the Contractor shall obtain all permissions, as necessary, from the Local Authority and other relevant agencies, and the Contractor shall pay all charges, as required. All areas affected by the Works shall be cleared of excess material, trash and repairs made to the satisfaction of the property owner, Local Authority, relevant agencies and the Engineer.

1.08 Temporary Work

The Contractor shall provide, and maintain during the execution of the Works, all shoring, bracing and other supports, safety devices, lighting, barricades, safety signage, cautions or directional indicators, flagmen and other temporary items as may be necessary to preserve the stability of all plant and property that may be endangered, or affected, by the Works.

1.09 Roads and Footpaths and Other Services and Structures

The Contractor shall ensure that no damage, beyond normal wear and tear, is caused by delivery or construction traffic to roads, footpaths, drains, and pipes and other services and structures outside the boundaries of the Site. Approaches to the Site shall be adequately maintained. The Contractor will be required to repair damage directly attributable to his work.

1.10 Labour Record

Daily records shall be submitted to the Engineer in a format to be approved by the Engineer, showing the number and description of craftsmen, labourers and other persons employed on or in connection with the Works, including those employed by sub-contractors. This record shall be incorporated in the Daily Construction Report (see Section 01300 hereof).

1.11 Plant Record

A daily plant record shall be submitted to the Engineer in a format to be approved by the Engineer, showing the type, model and capacity, whether working, idle or under maintenance, of all mechanical and power operated plant employed on the Works. The Contractor will not be permitted to remove any plant unless written approval is obtained from the Engineer. This record shall be incorporated in the Daily Construction Report (see Section 01300 hereof).

1.12 Overtime Working

Whenever working outside normal approved working hours is proposed, the Contractor shall request approval from the Engineer giving not less than one working day notice, specifying times, types and locations of work and approximate number of labour, supervisors and plant involved. Concealed work executed outside normal hours for which approval has not been given may be required to be opened up for inspection and/or reinstated at the Contractor's expense.

1.13 Defective Works

When any part of the work is known or suspected to be defective, the Contractor shall submit proposals, as soon as possible, to the Engineer for his approval, on further testing, opening up, inspection, making good or removal and re-execution. Whenever inspection or testing shows that any part of the Works is not in accordance with the Contract, and measures are taken to establish the acceptability of the work (e.g., further testing, opening up, experimental making good), such measures will be at the expense of the Contractor, and not considered as grounds for extension of time.

1.14 Night Work

A Should the Contractor need to carry out any night work, written permission must be sought from the Engineer, at least two weeks beforehand. Even if sufficient notice is not possible due to the urgent nature of the work, permission from the Engineer is still required.

B In granting the permission to the Contractor, the Engineer may impose conditions to be complied with by the Contractor. The Contractor shall comply with such Engineer's conditions, which shall include the following:

1 The Contractor shall inform the residents in the immediate vicinity of the works of the impending night-work through letters or notices from the Employer. The letters or notices shall be cleared by the Employer.

2 The Contractor shall distribute or circulate of such letters/notices to the residents, and local community councils, management committees, etc., and also carry out other public relations tasks such as putting up signboards and posters, etc. and carry out door-to-door visits if necessary.

3 The Contractor's supervisor must be present full-time on site during the course of the night work and shall expeditiously handle all complaints/feedback with regard to the night work.

4 The Contractor's safety officer must be present during the night-work if the site for the work is in the vicinity of existing sewerage facilities or when his presence is deemed necessary by the Engineer or is required under existing regulations.

C The Contractor is to note that the above-mentioned conditions are not exhaustive and shall depend on the nature of the night-work. The Contractor is deemed to have included in his rates/prices for compliance with the above conditions and for all the other conditions that may be deemed necessary as a result of the night-work.

1.15 Continuous Working

A If, in the opinion of the Engineer, it is necessary, by reason of the safety of the works, or the restoration of interrupted services or for any other reason whatever, the Contractor shall, when so ordered, carry out the works or any portion thereof continuously by day and by night without extra charge.

B The Contractor, if he considers that it may become necessary to cause overtime to be worked on site in order to complete the Contract by the date for completion, shall request for written permission and allow for such a contingency in his Tender Price.

C It shall be clearly and definitely understood by the Contractor that no claims in respect of any of the above shall be allowed in the settlement of the Final Payment.

END OF SECTION 01043

Section 01050

Field Engineering

Part 1 General

1.01 Description

This Section includes the Contractor's responsibility for correctness of measurements.

1.02 Grades, Lines and Levels

A The Contractor shall verify all measurements and be responsible for their correctness. Any differences that may be found between actual measurements and the dimensions given in the Contract Documents shall be submitted to the Engineer, in writing, for consideration and directives before proceeding with the Works.

B Site bench marks shall be accurately and safely established, maintained and removed upon completion of the Works, all to the satisfaction of the Engineer. The Engineer will indicate the position, co-ordinates and elevation of bench marks near the works, as shown on the Drawings.

C The Contractor shall prepare a plan detailing the location of the bench marks and keep this up-to-date throughout the period of the Contract. Reproducible copies of the plan so prepared shall be supplied to the Engineer, as and when he may require.

D The Engineer reserves the right to order levels, considered necessary for the full and proper supervision and measurement of the works, to be taken at any time.

E Before the Works, or any part thereof, are commenced, the Contractor and the Engineer shall together make a complete survey, and take levels, of the Site, and agree on the dimensions and elevations upon which setting out of the Works shall be based.

F These levels shall be related to the bench marks and shall be plotted and drawn up by the Contractor. After agreement of the drawings, which shall be signed by the Engineer and the Contractor, these levels shall form the basis of setting out of the Works.

G Failing such surveys and agreements being prepared and/or signed by the Contractor, the surveys of the Engineer shall be final and binding upon both parties.

H The Contractor shall submit the original of the drawings, and three copies, to the Engineer.

1.03 Setting-Out

A The Contractor shall be responsible for the true and proper setting-out of the Works in relation to reference data given on the Drawings and shall accurately set out the positions, levels and dimensions of all parts of the Works. Any delay or loss resulting from errors in the setting-out of the Works shall be the responsibility of the Contractor.

B Setting-out shall be reviewed by the Engineer before commencing the Works, but any approval shall, in no way, relieve the Contractor of his responsibility for the correct execution of the Work.

C Setting-out of the Works shall use the methods and necessary instruments described in BS 5606 "Code of Practice for Accuracy in Building". The Contractor shall maintain, in good working order at all times, the instruments provided by him for the setting-out of the Works and shall make such instruments available to the Engineer as instructed for checking or taking measurements.

D The Contractor shall provide all assistance to the Engineer as required for taking measurements of the Works, including labour, equipment and transportation.

1.04 Non-Compliance

The Contractor shall rectify any work, if failed in meeting the specified levels of accuracy, but shall not without the Engineer's approval. Proposed rectification measures shall be submitted to the Engineer for approval. The Contractor shall note that rectification measures may include removal and replacement of sub-standard work at no cost to the Employer. All costs and losses associated with rectification of sub-standard work shall be borne by the Contractor.

1.05 Precondition Survey

The Contractor shall engage an independent Licensed Surveyor, approved by Engineer, to carry out a precondition survey of all structures in the vicinity of the Works. The precondition survey is to record photographic evidence including description of all existing cracks, defects, etc. prior to commencement of work. A precondition survey report with a completed set of photographs shall be submitted to the Engineer within one month from the date of site possession and prior to the commencement of the Works.

Every attempt shall be made to survey all premises likely to be affected by the construction work, and the Contractor shall remain responsible for any damages arising from the construction work irrespective of whether the survey was carried out on damaged premises.

END OF SECTION 01050

Section 01090

References and Standards

Part 1 General

1.01 Description

The Contractor shall comply with all codes, standards, specifications of regulatory agencies, specifications and standards referred to throughout the Contract Documents.

1.02 Definitions

A Where "as shown", "as indicated", "as detailed", or words of similar import are used, it shall be understood that reference to the Drawings and Specifications is made unless otherwise stated.

B Where "as approved", "as reviewed", "as accepted", or words of similar import are used, it shall be understood that the approval, direction, requirement, permission, authorization, review, or acceptance of the Engineer is intended, unless otherwise stated.

C As used in the Contract, "provide" shall be understood to mean "provide complete in place", that is, "furnish and install".

1.03 Reference Standards

A All references to codes, local and administrative orders, regulatory agency requirements, specifications and standards referred to in the Contract Documents shall, unless otherwise stated, mean the latest edition, amendment or revision of such reference standards in effect at the date of submission of the Tender.

B The Contractor shall obtain an original copy of the latest edition of all standards, codes, local and administrative orders, regulations, standards and technical literature referred to in the Contract Documents and the same shall be properly indexed and handed to the Engineer at the commencement of the Contract. Upon completion of the Works those copies of the said codes, standards, etc. shall be forwarded to the Employer.

C Whenever the Contract Documents require that a product complies with Japanese Standards, British Standard, ASTM Designation, ANSI Specification Federal Specification or other association standard, etc., the Contractor shall present an affidavit from the manufacturer certifying that the product complies therewith. Where requested, or specified, the Contractor shall submit supporting test data to substantiate the compliance.

D Materials conforming to any standards equivalent to Japanese (JIS), American (ANSI), British (BS), German (DIN) standards or other internationally recognized standards shall be acceptable, provided that the Contractor substantiates their equivalence and ensures their compatibility with other components of the system. Copies of the current version of the proposed standards, and a comparison with any specified standard, shall be submitted to the Engineer. The proposed details of such items to be qualified as being of the acceptable quality shall be submitted to the Engineer for his approval in accordance with Section 1300 hereof.

E Where a reference standard referred to herein is in the form of recommendation or suggestion, such recommendation or suggestion shall be deemed to be mandatory under this Contract unless conflicting with the Particular Specifications contained therein.

F There may be items for which there are no relative codes, specifications or standards, and materials and workmanship of such items shall be of suitable quality and conform to Japanese, Western European or USA industry norms.

1.04 Abbreviations and Standards

A The following abbreviations are used in the Specifications:

d	day
dia	diameter
ha	hectare
h	hour
hwl	high water level
kg	kilogram
km	kilometre
kN	kilo Newton
kW	kilowatt
l	litre
lwl	low water level
m	metre
m^2, sq m	square metre
m^3, cu m	cubic metre
MDD	maximum dry density
mg	milligram
mm	millimetre
Mg	megagram (1000 kg)
MPa	mega Pascal
nr	number
s	second

B Reference to a technical society, institution, association or governmental authority is made in the Specifications in accordance with the following abbreviations:

AA	Aluminium Association
AABC	Associated Air Balance Council
AAN	American Association of Nurserymen
AAMA	Architectural Aluminium Manufacturers Association
AASHTO	American Assoc. of State Highway and Transportation Officials
ACI	American Concrete Institute
ADC	Air Diffuser Council
AFI	Air Filter Institute
AGCA	Association General Contractors of America
AIA	American Institute of Architects
AIMA	Acoustical & Insulating Materials Association.
AIEE	American Institute of Electrical Engineering
AISC	American Institute of Steel Construction
AISI	American Iron & Steel Institute
AITC	American Institute of Timber Construction
ALS	American Lumber Standards
AMCA	Air Moving & Conditioning Association
ANSI	American National Standards Institute

AOAC	Association of Official Agricultural Chemists
APA	American Plywood Association
ARI	Air Conditioning & Refrigeration Institute
ASAHC	American Society of Architectural Hardware Engineers
ASHRAE	American Soc. of Heating, Refrigerating and Air-con. Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society for Testing & Materials
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers Association
AWPI	American Wood Preservers Institute
AWS	American Welding Society
AWWA	American Water Works Association
BHMA	Builders Hardware Manufacturers Ass.
BIA	Brick Institute of America
BRI	Building Research Institute
BS	British Standard
BSCP	British Standard Code of Practice
BSI	British Standards Institution
CDA	Copper Development Association
CEE	Int'l. Commission on Rules for Approval of Electrical Equipment
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standard, U.S. Department of Commerce
CSI	Construction Specifications Institute
CTI	Cooling Tower Institute
DIN	Deutsche Institute fur Normung, Germany
FGMA	Flat Glass Marketing Association
FPL	Forest Products Laboratory
FS	Federal Specification
FSIWA	Federation of Sewage & Industrial Waste Association
FTI	Facing Tile Institute
GA	Gypsum Association
GTA	Glass Tempering Association
HPMA	Hardwood Plywood Manufacturers Association
IEC	Int'l. Electrotechnical Commission
IEE	Institute of Electrical Engineers, London
IEEE	Institute of Electrical & Electronics Engineering
IES	Illuminating Engineering Society
ISO	International Organization for Standardization, Switzerland
JIS	Japanese Industrial Standards
MIA	Marble Institute of America
MLMA	Metal Lath Manufacturers Association
MSSVFI	Manufacturer's Standardization Society of the Valves and Fittings Industries
NAAMM	National Association of Architectural Metal Manufacturers
NAFM	National Association of Fan Manufacturers
NAPF	National Association of Plastic Manufacturers
NBGQA	National Building Granite Quarries Association
NBHA	National Builders Hardware Association
NBS	National Bureau of Standards
NCMA	National Concrete Masonry Association
NEC	National Electrical Code (NPFA No.70)
NEMA	National Electrical Manufacturers Association
NEMI	National Elevator Mfg. Industry, Inc.

NFC	National Fire Code
NFPA	National Fire Protection Association
NFPA	National Forest Products Association
NHLA	National Hardwood Lumber Association
NHPMA	National Hardwood & Pine Manufactures Association
NPA	National Particleboard Association
NRMCA	National Ready Mixed Concrete Association
NSC	National Safety Council
NSF	National Sanitation Foundation
NTMA	National Terrazzo & Mosaic Association
NWC	National Water Council, UK
NWMA	National Woodwork Manufacturers Association
OSHA	Occupational Safety & Health Administration
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PDI	Plumbing & Drainage Institute, USA
PEI	Porcelain Enamel Institute
PS	Product Standard, U.S. Dept. of Commerce
RIS	Redwood Inspection Service
RTI	Resilient Tile Institute
SCMA	Southern Cypress Manufacturers Association
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturers Association.
SJI	Steel Joint Institute
SMACNA	Sheet Metal & Air Conditioning Contractors National Association
SMFMA	Sprayed Mineral Fibre Manufacturers Association, Inc.
SPIB	Southern Pine Inspection Bureau
SPR	Simplified Practice Recommendation, U.S. Dept. of Commerce
SSPC	Steel Structure Painting council
SWFPA	Structural Wood Fibre Products Association
TCA	Tile Council of America
TEMA	Tubular Exchange Manufacturing Association
TIMA	Thermal Insulation Manufacturers Association
TPI	Truss Plate Institute
UL	Underwriters Laboratories, Inc.
UPC	Uniform Plumbing Code
USCGS	U.S. Coast & Geodetic Survey
WCLB	West Coast Lumber Inspection Bureau
WRI	Wire Reinforcement Institute
WPA	Western Wood Products Association

END OF SECTION 01090

Section 01200

Meetings

Part 1 General

1.01 Description

This Section includes:

1 Pre-Construction Conferences
2 Progress Meetings
3 Subcontractor's Site Meetings
4 Pre-Installation Conference
5 Pre-Start-up Conference
6 Pre-Training Conference
7 Post-Construction Conference
8 Minutes of Meetings

1.02 Pre-construction Conference

A A pre-construction conference shall be held at the Site, or other approved location, within fourteen (14) days after the Commencement Date of the Works and shall be attended by the Employer, the Engineer, the Engineer's Representative and Contractor.

B The agenda shall be provided by the Engineer's representative a minimum of three working days prior to the conference. Topics of discussion shall include, but not necessarily be limited to, the following:

1 Contractor's organization for the Works, including names, titles and language capabilities of all persons authorized by the Contractor to represent and execute documents for him, with a specimen of all authorized signatures, and also names, addresses, and telephone numbers of all those authorized by the Contractor to act for him in emergencies,
2 communication channels and procedures,
3 schedule of work progress/co-ordination meetings,
4 construction schedule including the sequence of critical work,
5 a financial estimate of the amount of work to be performed each month by the Contractor,
6 contractual administration documents including distribution of required copies,
7 submittal processing, including forms and procedures,
8 payment application forms and procedures, and the revised progress schedule reports to be accompanied with in the applications,
9 field order and variation order processing,
10 rules and regulations governing performance of works, including:
   a construction permit requirements, procedures, and posting,
   b procedures concerning the installation work on public or private property not owned by the Employer,
   c access and rights-of-way furnished by the Employer,
   d Contractor's provisions for barricades, traffic control, utilities, sanitary facilities and other temporary facilities and controls,
   e inspector(s) and his/their duties,
   f construction surveyor and initiation of surveying services,
   g testing laboratory or agency and testing procedures,

h public notice of starting work,
11 project sign board,
12 safety and first aid,
13 site security,
14 quality control,
15 construction equipment and methods proposed by the Contractor,
16 procedures for plant and labour returns by the Contractor,
17 miscellaneous project requirements such as housekeeping etc.,
18 monitoring and reporting procedures for work progress, project costs, materials, labour and equipment procurement, etc.,
19 Contractor mobilization and use of the project site,
20 other administrative and general matters as needed.

1.03 Progress Meetings

A Progress meetings shall be held twice each month to review work progress and performance as well as the Contractor's 90-day, look-ahead schedule. Progress and schedule reviews shall verify:
1 actual start and finish dates for activities completed during the update period,
2 remaining duration and percentage of completion for all activities not completed,
3 logic, activity duration, and cost data for variation order work that will be incorporated into the construction schedule,
4 Contractor's proposed measures to recover any lost time and place the Works back on schedule; such as increasing manpower, materials and equipment resources and working extended hours, or additional shifts,
5 sub-contractor activity,
6 other items not listed above; including, without limitation, any unresolved matters, deficiencies in the work or methods employed for the work, and problems, difficulties, or delays that have been, or maybe encountered.

B Meetings shall be attended by the Employer, the Engineer, the Engineer's Representative, the Contractor and his Site Agent. Subcontractors may attend when involved in the matters to be discussed, or resolved, but only when requested by the Employer or the Engineer. In addition to the attendees named herewith, the meeting shall be attended by the representatives of regulatory agencies having jurisdiction over the Project, if required, and such other persons the Employer may designate.

C The time and location of the progress meetings shall be as directed by the Engineer's Representative who shall chair the meetings.

D The Contractor shall submit the information itemized below to the Engineer at least three working days prior to each progress meeting:
1 a list of completed activities,
2 a list of current activities with an estimate of time required for completion,
3 a list of changes to planned starting dates and durations for all outstanding activities,
4 percentage of completion for each current activity,
5 a list of activities planned to start in the next period,
6 other information required by the Engineer's Representative.

E A request for additional meetings required by the Contractor shall be submitted to the Engineer's Representative, in writing, providing a proposed agenda for the meeting and the names of all personnel who are required to attend. The Engineer's Representative shall chair these meetings.

1.04 Sub-contractor's Site Meetings

The Contractor shall meet with subcontractors and suppliers prior to each progress meeting. The agenda should be identical to that presented above for the Contractor's progress meetings.

1.05 Pre-installation Conference

A The Contractor, as required in the relevant sections of the Specification, shall meet with subcontractors, equipment manufacturers and the Engineer to review equipment installation requirements.

B Attendance shall be by personnel performing the work, personnel who may be affected by the work, and by the equipment manufacturer.

C Site conditions, preparation requirements, logistics and installation procedures shall be reviewed.

1.06 Pre-start up Conference

A A pre-start up meeting shall be required prior to starting up any component, sub-system, or system and shall comply with requirements specified in Section 01650 hereof.

B The Contractor's mechanical coordinator, commissioning engineers and start-up foreman; Engineer and his representatives; plant operation staff; and equipment manufacturers (if necessary) shall attend.

C The agenda shall be provided by the Engineer's Representative a minimum of three working days prior to the conference. Topics of discussion will include, but not necessarily be limited to, the following:

1 start-up and validation prerequisites,
2 start-up plan and schedule,
3 temporary connections,
4 spare parts, chemicals, and operating fluids,
5 coordination with plant operating staff to minimize disruption to any existing plant operation,
6 other items deemed necessary by the Engineer's Representative.

1.07 Pre-training Conference

A A meeting shall be held prior to beginning training and shall comply with requirements specified in Section 01670 hereof. The Contractor's training instructor, Engineer and his representatives, and plant operation staff shall attend.

B The agenda shall be provided by the Engineer's Representative a minimum of three working days prior to the conference. Topics of discussion will include, but not necessarily be limited to, the following:

1 classroom and support requirements,
2 training schedule,
3 training plans,
4 prerequisites,
5 other items deemed necessary by the Engineer's Representative.

1.08 Post-construction Conference

A The conference shall be held prior to the final inspection of the Work. The Employer, Engineer, Engineer's Representatives, Contractor and his supervisory staff shall attend.

B The agenda shall be provided by the Engineer's Representatives a minimum of three working days prior to the conference. Topics of discussion will include, but not necessarily be limited to, the following:

1 discuss and resolve all unsettled matters,
2 guarantees and insurances,
3 schedules and procedures for the final inspection process,
4 correction of defects and deficiencies,
5 documents required to be submitted by the Contractor,
6 other items deemed necessary by the Engineer.

1.09 Minutes of Meetings

The Engineer's Representative will record minutes of each meeting and a copy of the minutes shall be furnished to the Contractor within five working days. The Contractor shall submit written objections, if any, to the contents of minutes within three days after presentation to him. In the absence of any objection, it shall be understood and agreed that the Contractor accepts the minutes as a true and complete record of the meeting.

END OF SECTION 01200

Section 01300

Submittals

Part 1 General

1.01 Description

This Section includes:

1 Definitions
2 Submittal Procedures
3 Product Data
4 Drawings
5 Samples
6 Operation and Maintenance Manuals
7 Certificates and Affidavits
8 Miscellaneous Submissions
9 Submissions required for approvals from local authority and utility company

1.02 Definitions

A. The Contract Drawings are diagrammatic and show the general layout of the complete construction work. The Contractor shall review the Drawings and Specifications and shall include work shown thereon required for the installations. The Contractor shall be responsible for preparing, and submitting to the Engineer for review, all general arrangement drawings showing the inter-relationships between civil construction and all mechanical, electrical and instrumentation equipment to be installed, if any. Should there be a need to deviate from the Contract Drawings and Specifications, the Contractor shall submit written details and reasons for all changes to the Engineer for his approval before making such changes. All extra costs to make the changes will be borne by the Contractor. In the event of varying interpretations of the Contract Documents, the Engineer's interpretation shall govern.

B. Product data and shop drawings include drawings, diagrams, illustrations, brochures, schedules, bills of materials, and other data prepared specifically for the Work. Information may be prepared by the Contractor, his sub-contractors, suppliers or distributors, equipment manufacturer, or fabricators. Information must illustrate or describe manufacture, fabrication, construction, and installation of the Work or a portion thereof.

C. The manufacturer's representative is a person actively working at the manufacturer's factory with minimum five years experience and who is familiar with problems of manufacturing, installing, and operating the product. Sales representatives or agents shall not be considered as the manufacturer's representative.

D. Working drawings are the Contractor's plans prepared for temporary structures and facilities. Any element of works that may affect safety of persons or property, shall be certified by a qualified engineer. Calculations demonstrating adequacy of the Contractor's design shall be submitted with any working drawings.

E. Samples are physical examples illustrating materials, equipment, or workmanship to establish standards by which quality of the relevant works will be judged.

F. Manuals are the manufacturer's written instructions for installation, start-up, operating, maintenance and repair, and include parts lists, pictures, sketches and diagrams specific to the equipment supplied to document the manufacturer's requirements and instructions.

G. The format of drawings shall conform to the following requirements:

1 Drawings shall be in A-sized format and no larger than A-1 size.
2 Scales shall be standard scales of 1:1, 1:2, 1:5 and multiples of ten thereof. Plans and pipeline profiles may be to scales of 1:1250 and 1:2500. No other scales shall be used.
3 All other documentation shall be A-4 size.

1.03 Submittal Procedures

A Only the Contractor shall make submissions to the Engineer. All data and correspondence prepared by sub-contractors and suppliers shall be submitted through the Contractor. All submittals shall be in English. The Contractor shall prepare submittals with sufficient information, and in such a manner that no more than two resubmittals are necessary to obtain the Engineer's approval. If more than two resubmittals are required, the Employer reserves the right to deduct the cost of the Engineer's time to review all additional resubmittals (after re-submittal no. 2) from the payment due to the Contractor.

B. The Contractor shall review and approve all drawings, product data, samples and manuals to be submitted to the Engineer prior to the submission of these submittals. Review and approval shall be for compliance with the requirements in accordance with the Specifications and other Contract Documents. Approval by the Contractor indicates that the Contractor has verified all materials, field measurements, field construction criteria and similar items. Approval also indicates that the Contractor has coordinated information contained in the submittal with work requirements of other trades and with the Contract Documents. The Contractors review and submission to the Engineer shall be in time so as not to delay the work.

C. The Contractor shall make all corrections and changes to submittals as required by the Engineer and resubmit until approved. The Contractor shall review submittals returned by the Engineer and shall determine if changes requested by the Engineer result in extra cost. If the Contractor views that such changes incur extra costs, the Contractor shall notify the Engineer in writing within five working days after receiving the returned submittal, indicating the estimate of extra costs needed for the changes. If the Contractor fails to notify the Engineer of the extra costs within the aforesaid time limit, or if the Contractor proceeds with such changes without any notice to the Engineer, it shall be deemed that the Contractor has agreed to carry out such changes with no claim on extra costs. .

D Submissions of manufacturer's data, including data specified as "for information only", shall be made prior to beginning any portion of the work using materials or equipment contained in the submittal.

E The Contractor shall submit drawings and product data in accordance with the schedule approved by the Engineer, and shall allow sufficient time for the Engineer's review, approval, and transmittal back to the Contractor.

F The Contractor shall detail items not completely described on the Contract Drawings in accordance with standard engineering practice, and shall adjust dimensions of concrete and building structures shown on the Contract Drawings to reflect actual dimensions of

equipment to be provided. The Contractor shall coordinate dimensions shown on the Drawings as well as actual equipment dimensions with measurements of existing, adjacent, incorporated, and completed work to ensure all components fit into the space available and shall verify all dimensions before beginning any work depending on such data.

G The Contractor shall identify each and every deviation from the Contract Documents to the Engineer, either on the drawing, or in the letter of transmittal. Reasons for the deviation shall be explained and the requested deviation compared with contract requirement and an explanation given as to why the deviation is equal to or better than contract requirement. The Contractor will not be relieved of responsibility for executing work in complete conformance with the Contract for submittals not identifying deviations, even though such submittals have been approved.

H The Contractor shall submit drawings and product data for related equipment items and integrated system components at the same time. Partial submissions may be returned to the Contractor without review.

I The Contractor shall coordinate drawings and product data, and such coordination shall include:
1 drawings and data previously submitted,
2 drawings and data being prepared
3 drawings and data previously approved.

The Contractor's approval and submission of drawings and data to the Engineer indicates that such coordination has been performed and completed.

J The Contractor shall direct the Engineer's attention, either in writing or on the re-submitted documents, to each and every revision other than those requested by the Engineer on previous submittals.

K Materials or equipment shall not be delivered, either to storage or to the Site, and shall not be incorporated into the work, until it has been approved or authorized in writing by the Engineer.

L The Contractor shall not perform any work until drawings or data have been submitted to, and approved by, the Engineer.

M All submittals from the Contractor shall include a label or stamp which indicates that the submittal has been reviewed and approved by the Contractor for conformance to the contract requirements. The labels or stamp shall generally conform to the following:

SUBMITTAL NO. _____
FOR CONTRACT NO. _____
PROJECT NO. _____
CONTRACTOR: _____
REVIEWED AND APPROVED (for Conformance with the Contract Documents)
BY: _____ DATE: _____

_____
(Signature)
REFERENCES:
DRAWING NOS. _____
SPECIFICATION NOS. _____

A ten-character submittal identification and numbering system shall be used as follows:

1 The first character shall be, either "D", "S", or "M" representing general arrangement, shop or working drawing (D), sample (S), and operation/ maintenance manual (M),
2 The next five digits shall be the applicable section number of the Specifications,
3 The next three digits shall be the numbers 001 through 999 to sequentially number each separate package submitted under each specific section number,
4 The last character shall be the letter "A" through "Z" indicating whether the submittal is the first submission (A) or a re-submission (B through Z). The letter "B" indicates the second submission, "C" the third submission, etc.,
5 An example of a submittal number is D-03300-008-B, which indicates:
D - Shop Drawing
03300 - Specification for Concrete
008 - The eighth separate submittal under this section.
B - The second submission of that particular information.

N Reviewed submittals will be returned to the Contractor with the Engineer's comments, if any. The Engineer's review is for general conformance with the contract requirements only, and all work is still subject to the detailed requirements of the Contract. The Engineer's review is to help the Contractor to discover errors and omissions. The Engineer's review does not relieve the Contractor of the obligation and responsibility to coordinate and plan the details of the Work and fulfil the intent and purpose of the Contract. The Engineer's review shall not relieve the Contractor of the responsibility for accuracy, proper fit, or proper functioning and performance of the work. The Engineer reserves the right to require written confirmation from the Contractor that the comments placed on submittals stamped "Approved As Noted" will actually be implemented. The Engineer will make every reasonable effort to process and return each submittal within 28 calendar days after its receipt in the Engineer's office, but with the following qualifications:

1 Large or multiple submittals may require additional time.
2 The Contractor may prioritize submittals and Engineer will review and return them in the order of the highest priority.,
3 If requested by the Contractor, individual drawings from large submittals with numerous drawings may be returned as they are reviewed rather than waiting for the entire review to be completed.
4 The need for re-submissions or delays in obtaining the Engineer's review or approval shall not entitle the Contractor to claim on the Extension of Time for Completion pursuant to the Conditions of Contract.

The categories used by the Engineer to evaluate submittals are defined below:

1	"Approved":	No discrepancies have been identified.
2	"Approved As Noted":	The submittal is acceptable subject to incorporation of the comments listed.
3	"Disapproved":	The submittal is unacceptable for the reasons cited.
4	"Noted":	The submittal is not required by the Contract Documents or the Engineer will include it in the project files only for information.

Incomplete submittals including those not correctly transmitted, incorrectly titled and identified, or not bearing the Contractor's review and approval stamp may be returned to the Contractor without review.

O Two reproducible copies, plus two photocopies or blue line prints, for each drawing are required, together with four copies of all product data and manuals. The Engineer will return one reproducible and one copy, or print, of each drawing and two copies of product data or manuals to the Contractor. The Engineer may require additional copies of all submittals by notifying the Contractor in writing and such additional copies will be at no extra cost charged to the Engineer/Employer.

1.04 Product Data

A The Contractor shall provide sufficient information to the Engineer to determine that the submitted products conform to the specification requirements. The data shall be explicit with regard to details of the actual products being furnished. The name of the product manufacturer shall be included on all catalogue data

B Submittals with more than one style, size, capacity, etc. of a product on a page shall clearly indicate which product type is being submitted for approval. Failure to do this shall be cause for disapproval.

1.05 Drawings

A The Contractor shall provide detailed shop drawings and written descriptions of all components and their assembly.

B Drawings shall indicate proposed installation as well as materials and equipment being furnished for the Works.

C The Contractor shall identify proposed deviations from the details or component arrangement as specified or shown on the Drawings and present reasons for the proposed deviations and shall explain why proposed deviation is “equal to” or “better than” that specified.

D Information shown on shop drawings shall be complete and sufficient for the Engineer to review for compliance with contract requirements and to illustrate construction or assembly of the components and materials. Information shall include, but not necessarily be limited to, the following:

1 manufacturer, model and type,
2 layout dimensions and component sizes including bases, foundations, anchors, and similar items,
3 design criteria,
4 materials of construction,
5 component and assembly weights,
6 utility requirements (power, water, etc.),
7 manufacturer’s rating or performance curves,
8 electrical wiring diagrams and control schematics,
9 design computations for bearing life and AGMA rating for each driven component as appropriate,
10 motor data,
11 recommended spare parts,
12 special tools,
13 deviations from contract requirements,
14 additional requirements contained in individual section of the Specifications.

E Copies of the Contract Drawings are not acceptable for submission as general arrangement (layout) drawings.

F Manufacturer's model numbers or catalogue numbers alone shall not be acceptable for describing equipment or components.

1.06 Samples

A The Contractor shall furnish samples as required by the individual section of the Specification. Unless otherwise specified, samples shall be submitted to the Engineer as specified and labelled and properly identified with:

1 date,
2 project / work area for which offered,
3 specification section and applicable paragraph numbers,
4 Contractor,
5 supplier / manufacturer,
6 product identification (trade name).

B Samples shall be accompanied by an approved transmittal form, specifications and other pertinent data required for Engineer to determine that the material conforms to the Specification.

C Three sets of samples shall be submitted unless otherwise specified. One set of approved samples, and all disapproved samples, will be returned to the Contractor and, if requested in writing by the Contractor, samples of value will be returned to the Contractor after completion of the Work. Approved samples returned to the Contractor may only be incorporated into the work upon written approval of the Engineer.

1.07 Installation and Operation and Maintenance Manuals

A The Contractor shall submit manuals for all equipment, valves and components furnished by the Contractor in accordance with the Specifications.

B The manuals shall be as specified in Section 01730 hereof and the Contractor shall submit two copies of drafts to the Engineer for his review. The Engineer will mark up one copy and return it to the Contractor for correction and will retain one copy for project files.

C The installation manuals shall be submitted at the same time as the draft operation and maintenance manuals.

D The Contractor shall submit twelve copies of approved installation manuals incorporating all of the Engineer's comments and corrections prior to beginning installation of equipment.

E The Contractor shall submit six copies of approved operation and maintenance manuals incorporating all of the Engineer's comments and corrections in accordance with the submission schedule approved by the Engineer prior to completion of the Works.

1.08 Certificates and Affidavits

A The Contractor shall provide the original and seven copies of manufacturer's certificates in accordance with the requirements specified in Section 01400 hereof. A certificate indicates test results, component manufacture, or that the installation complies with specified standards. An affidavit is a sworn statement by an officer of the company manufacturing

the product indicating that the information on the certificate is true and accurate. An affidavit shall accompany all certificates.

B A statement from the Contractor, sub-contractor, equipment supplier, or agent indicating that the product meets the requirements of the Contract Documents, shall not be considered to be a certificate, and such submittals shall not be approved. Corresponding equipment, products, or components shall not be accepted as well.

1.09 Miscellaneous Submissions

A Manufacturer's guarantees and warranties shall be submitted in three copies unless otherwise specified, and shall be submitted prior to final acceptance.

B Work plans shall be submitted in three copies, unless otherwise specified, at least 30 days prior to beginning work.

C The construction schedule shall show the proposed date on which the Contractor will deliver required submittals to the Engineer for his review.

D Accident reports shall be submitted in three copies unless otherwise specified, and shall conform to Section 01400 hereof.

E The Contractor shall prepare and submit the Progress Reports described hereunder in a form provided by the Engineer. Work activities and procurement reports should be referenced where relevant to the approved Contractor's Construction Schedule. The Contractor shall submit three copies unless otherwise specified. Reports shall comprise the followings:

1 Daily Reports
   a submit on a daily basis.
   b describe labour force and its allocation.
   c describe material and equipment utilized.
   d describe work progress during the day.
   e describe temperature and weather conditions.
   f describe any occurrence that may affect the progress of the Works.

2 Procurement Status Reports.
   a submit on a weekly basis.
   b include a list of materials and items to be imported into the country.
   c include a list of items delivered to the Site.
   d provide references to all correspondence and transmittals between the Contractor and the Engineer regarding approval of such materials and items.

3 Monthly Report
   a reflect monthly progress and status of the Work.
   b describe problem areas.
   c describe current or anticipated causes of delay along with their estimated impact on progress and the corrective measures taken or proposed.
   d include construction photographs.

F Inspection and test reports shall be submitted in three copies unless otherwise specified.

G Survey data shall be submitted in three copies unless otherwise specified. Survey data is

required to develop a quantitative record of actual work constructed, as part of damage and settlement surveys, surveys of adjacent construction and similar efforts. In this regard a pre-construction survey shall be conducted by the Contractor to clearly indicate the existing condition of the Site and any other areas that may be affected by the construction works. A pre-construction survey report, including detailed photographs and date stamped, shall be submitted to the Engineer in three copies.

H Close-out submittals shall be as specified in Section 01700 hereof.

I Record (as-built) documents shall be submitted in three sets unless otherwise specified.

J Organization Chart

1 The Contractor shall submit an organization chart for the Engineer's approval prior to beginning construction activity on the Site, but not later than fourteen (14) days from the Commencement Date under the Contract. It shall show the executive, administrative, and construction supervision organization, and shall include the followings:
   a indicate all personnel from Project Manager through foreman level.
   b describe personnel duties.
   c amplify details provided in the "Schedule of Data" submitted with the Tender.
   d provide qualifications and experience of all personnel shown on the organization chart.
   e indicate English language capability.

2 The Contractor shall update the organization chart whenever key personnel are reassigned.

3 The Engineer may interview any of the Contractor's proposed staff prior to approval.

4 The Engineer may direct the Contractor to remove personnel from the Site whom the Engineer judges, in his sole opinion, to be:
   a inappropriate conduct,
   b incompetent and negligent in the performance of their duties,
   c for foremen and higher, unsatisfactory English language capability, or
   d otherwise considered undesirable.

M The Contractor shall submit a letter of authority to the Engineer within ten (10) calendar days after receipt of notice to proceed, and prior to beginning any construction activities. It shall identify the project manager and detail the extent of his authority and responsibility. All work shall be under the direct supervision of the Contractor's on-site representative who shall be the project manager and shall be present at the job site whenever any work is underway and shall have full authority to represent the Contractor. Communication given to or received from the project manager shall be as binding as that given to or received from the Contractor.

N The Contractor shall submit the site layout for the Contractor's facilities within fourteen (14) days after the Commencement Date, for approval by the Engineer. The site plan should include, but not necessarily be limited to, the following:

1 Temporary facilities including offices and sanitation facilities;
2 Storage areas;
3 Crane positioning;

4 Fences, gates and security lighting;
5 Access for other Contractors, vendors, plant staff, visitors, etc.
6 Vehicle washing areas (before entry to public roads)
7 Safety signage, barriers, cordoning of operational and construction areas.

O The Contractor shall provide one original and three photocopies of transmittals and letters including attachments and enclosures. The following shall be clearly indicated on each document.

1 Contract Number.
2 Title of Project.
3 Contractor's Name.
4 Date.
5 Correspondence Reference Number.

1.10 Submissions required for Approvals from Local Authority and Utility Company

A The Contractor shall make all necessary arrangements at his own cost to obtain approvals for carrying out the Work from Local Authorities, Utility Companies and/or any other authorities as required. Such arrangements shall include endorsement by local professional engineers (PE) required on all submittals.

END OF SECTION 01300

Section 01310

Progress Schedules

Part 1 General

1.01 Description

This Section includes:

1 Interim Schedule.
2 Construction Schedule.
3 Updates and Revisions.
4 Payment Applications.
5 Requested Time Adjustment Schedule.
6 Schedule of Off-Site Activities.
7 Coordination.

1.02 General Scheduling Requirements

A The required completion date for the Works must be met as indicated in the Contract and failure to meet this completion date shall result in liquidated damages being levied.

B The Contractor shall schedule all work activities using critical path scheduling techniques and shall update the schedule as specified herein and other parts of the Contract. The schedule and all reports shall be computer generated. Scheduling software, which shall be Microsoft Project, Primavera or similar, shall be approved by the Engineer. The Contractor shall use a network analysis system in either an activity on arrow or activity on node format and shall:

1 show how the Works will be planned, executed and coordinated,
2 show the base schedule with milestones, including these milestones and the specified contract completion date as scheduled activities,
3 show the order in the Works to be performed,
4 show planned dates of the installation of equipment, subsystem and system, start-up, and testing,
5 show all interface activities requiring mutual support between/among the Contractor, subcontractors, suppliers, and/or the Employer, and
6 use the schedule in planning, scheduling, directing, coordinating, and executing the Works.

C Scheduling software shall provide data reports or data sorts in each of the following formats:

1 activity listing by activity,
2 activity listing by early and late start dates,
3 activity listing by early and late finish dates,
4 critical path activities,
5 activity listing by responsibility code, subcontractor, or division,
6 activity listing by total float,
7 computer produced time scaled logic diagram,
8 computer produced bar chart.

D The Contractor's application for payment shall not be processed until the Contractor has

submitted an acceptable Construction Schedule meeting the requirements of these Specifications.

E The Contractor shall adjust network logic, activity sequences, activity durations, and similar items as necessary to maintain adequate progress to ensure that the Works are completed within the specified time frame. Adjustments shall account for events which include, but are not limited, to the following:

1 schedule slippages
2 delays
3 sequence changes necessitated by project conditions
4. labour inefficiency

1.03 Interim Schedule

A The Contractor shall submit an Interim Construction Schedule within ten calendar days of receipt of Letter of Acceptance. It shall depict work to be performed and work which is being performed during the first 90 days of the project. After approval, this shall be the Contractor's work plan for the initial 90-day period. The schedule shall be presented as a bar chart consisting of horizontal lines or bars plotted along a daily time scale. The horizontal bars shall indicate start and finish dates for each activity shown. The schedule shall be reviewed and approved by the Engineer prior to issuing the Notice to Commence.

B The Interim Construction Schedule will be superseded upon approval of the Construction Schedule described below. All activities contained in the Interim Schedule shall also be included in the Construction Schedule.

1.04 Construction Schedule

A The Contractor shall submit the Construction Schedule to the Engineer within the period stated in Sub-Clause 8.3 of the Conditions of Contract. The schedule shall be used as basis for progress reporting, schedule controlling and schedule forecasting and shall be provided in sufficient detail to enable the Employer to evaluate the Contractor's planned schedule and monitor progress on a day to day basis throughout the project. The schedule shall clearly indicate all restraints and contract milestones and consist of three parts:

1 computer drawn, time scaled network diagram,
2 computer generated, mathematical analysis or printout,
3 computer generated, off site schedule.

B The approved Construction Schedule shall be the Baseline Schedule against which all progress is measured. It shall also be used by both the Contractor and the Engineer as the basis for evaluating changes, claims, and applications for payment.

C If the Engineer rejects the Contractor's Construction Schedule, including any subsequent update or revision, the Contractor shall, within 14 days of receiving the rejection, revise the schedule to comply with the Contract Documents and resubmit it to the Engineer. Changes shall be made as directed by the Engineer even if the Engineer and Contractor cannot agree as to the revisions required.

D Activity durations shall be measured in calendar days. Activities shall be selected such that the duration is generally less than 21 calendar days. Activities with a duration exceeding 21 days shall be divided using logical measuring points of quantities, time or accomplishment.

This limitation is not intended to impede or restrict Contractor's flexibility to properly plan and schedule the Work.

E The schedule shall represent an accurate, efficient, reasonable and feasible plan and method for accomplishing the Work within the number of days specified. The Engineer will review the schedule but will not be responsible for whether the schedule will result in timely Works completion. The schedule shall be the Contractor's sole responsibility, including but not limited to, preparation, content, revisions, and updating in accordance with the Contract requirements.

F The Contractor shall understand and agree that the Employer does not guarantee work activities. If work by the Employer, or a separate contractor, is scheduled to be complete by a specific date, or within a specific duration, the Employer or separate contractor must agree to those dates in writing; otherwise the dates are not considered valid. The Employer's or Engineer's overall review and approval of the schedule does not constitute an agreement to specific dates or durations for activities of the Employer or any separate contractor.

G The Construction Schedule shall indicate the following:

1 on-site and off-site activities as defined elsewhere hereof, such as deliveries, Employer's operational adjustments, start-up, testing, mobilization, and demobilization, shop drawing submittals, etc.
2 Interfaces with the work of outside contractors including, but not limited to, the various utilities, and the Employer's operating personnel.
3 Activity descriptions including the activity number.
4 The planned and remaining duration for each activity.
5 Early start and late start dates for each activity.
6 Early finish and late finish dates for each activity.
7 Available float for each path of activities containing float.
8 Actual start and actual finish dates for each activity.
9 Identification of all critical path activities.
10 Works critical path which shall be clearly shown and easily recognizable and shall clearly show the relationship between all non-critical activities and activities on the critical path.
11 The planned and earned monetary value of each activity and the total planned value shall equal the total contract value.
12 The planned and earned craft and staff manpower utilization for each activity including a plot of manpower versus time for each schedule of value item and the total project.
13 Identification as to whether the Contractor or subcontractor is responsible for performing a particular activity.
14 The percent complete for each activity in progress or completed.
15 Planned progress curve consisting of a plot of percent complete versus time for each schedule of value item and the total project.

H The Contractor shall submit a narrative report with the Construction Schedule indicating anticipated use of the following resources and work shifts:

1 Labour resources.
2 Equipment resources.
3 Work shifts (e.g. single, double, or triple shifts)
4 Work weeks (5, 6, or 7 day work week)

1.05 Updates and Revisions

A The Contractor shall update the Construction Schedule every month to reflect the actual "as built" data. Two copies of the preceding month's Construction Schedule shall be submitted at least seven (7) calendar days prior to submitting each monthly payment application and shall be marked with the proposed updates and revisions. The Engineer will review the marked-up schedule and return one annotated copy to the Contractor for use in preparing the monthly update. The schedule up date will be used to review the Contractor's payment application. The Contractor shall submit updated schedule, reflecting Engineer's comments, with the monthly payment application. The Contractor shall indicate the following in the mathematical analysis which accompanies the updated schedule:

1 activities in progress or to be performed in the future,
2 percent complete for each activity,
3 the critical path for the project based on the latest update data,
4 the earned value for each activity.

B Progress Reports

1 The Contractor shall submit a report with each payment application which summarizes Works progress. The format of the report shall be acceptable to the Engineer. The required information shall include, but not necessarily be limited to, the following:

a work progress whether at the factory or in the field,
b state existing status, rate of progress, estimated time of completion, and cause of any delay (if any),
c description of Work accomplished since submission of previous progress schedule,
d compare actual work status against the Contractor's previous Construction Schedule,
e status of equipment and material deliveries,
f changes or additions to Contractor's supervisory personnel since the preceding progress report,
g causes or any delays,
h changes in logic, construction sequence and activity duration including an explanation of why the changes are necessary,
i proposed actions by the Contractor to restore the schedule including what is being done or what is planned to be done in each problem area.
j identify anticipated problems or changes and present plan to deal with them so as to minimize or prevent delays.
k construction photographs.

2 Updates and revisions to required schedules and reports shall not modify or limit, in any way, the Contractor's obligations under this Contract; including but not limited to the Contract Time, Contract Completion Dates, Contract Milestone Dates, etc.

1.06 Payment Applications

A The Engineer shall be under no obligation to process the Contractor's payment application until the Contractor meets the requirements of this Section.

B The Contractor shall furnish three copies of the updated Construction Schedule, Monthly

Summary Report and the following network analysis reports with each payment application:

1 activity listing with activity code, description, original and remaining duration, percent complete, early and late start and finish dates and float for each activity.
2 critical path report with activities listed by most critical and early finish dates,
3 activity listing with planned and earned values,

C One set of computer diskettes containing the updated construction schedule used to compute the total earnings reported in the Payment Application shall be furnished.

1.07 Requested Time Adjustment Schedule

A If the Contractor believes he is entitled to an extension of the Time for Completion, he shall submit a "Requested Time Adjustment Schedule" (RTAS) to the Engineer as a proposed variation order. This shall include:

1 a separate schedule and analysis indicating proposed adjustments to the specified Time for Completion. The proposed adjustments may be due to actual or anticipated changes or delays,
2 a time scaled, computer generated, and computer drawn network analysis schedule,
3 a formal time extension request and detailed narrative justifying the requested time extension shall accompany the schedule.
4 schedule forecasts that predict the actual project completion date and which forecast milestone achievement dates with the request for time adjustment.

B The RTAS shall clearly and accurately reflect the following:

1 Contractor's actual Work intention and proposed time adjustments as of the latest update,.
2 adjustments to the logic, sequence or duration of any activities in the schedule,
3 time extensions previously granted,
4 actual and expected progress.

C The Engineer shall not be obligated to consider any time extension request unless all specified contract requirements are met. The Engineer shall not be responsible or liable to the Contractor for any constructive acceleration if a requested time extension is denied due to the Contractor's failure to comply with the specified submission and justification requirements. The Contractor's failure to perform in accordance with the approved Construction Schedule shall not be excused and shall not be chargeable to the Employer as a result of the Contractor having submitted time extension requests.

D "Float" or "slack time" is defined as the amount of time between the early start date and the late start date or between the early finish date and the late finish date of any activity in the Construction Schedule. "Float" or "slack time" is not time for the exclusive use or benefit of either the Employer or the Contractor. Time extensions for Work required by the Contract Documents will be granted only to the extent that time adjustments for affected activities exceed the total float available along the affected path of activities, and available float will be determined at the time a change is authorized, or at the start of the condition or delay for which an adjustment is warranted under the Contract Documents.

E If a milestone or completion date is modified by a variation order issued by the Engineer, the Contractor shall modify his Construction Schedule accordingly. All activities impacted

by the variation order shall be adjusted to reflect the revised requirements.

F The Contractor shall make the following available to the Engineer within seven calendar days of receiving a written request from the Engineer.

1 all documents, data, etc. which support or provide the basis for schedules, reports, and project forecasts,
2 Detailed calculations,
3 Subcontractor documents and data.

1.08 Schedule of Off-site Activities

A The Contractor shall include all procurement and delivery related activities in the Construction Schedule. These activities may be submitted as a separate "Off-site Activities" Schedule upon written approval by the Engineer. Off-site activities shall be properly correlated and interrelated to the Construction Schedule. All restraints and dependent activities which may affect the Construction Schedule shall be shown.

B The "Off-site Activities Schedule" shall include, but not necessarily be limited to:

1 activities for submitting, ordering, manufacturing, fabricating, and delivering long lead items to the project site,
2 significant construction related activities performed by the Contractor away from the project site, including material and equipment purchase and delivery,
3 Contractor's drawings and submittals for long lead items,
4 required off site inspection activities by the Employer or the Engineer.

C The Contractor shall be solely responsible for expediting deliveries to ensure the latest approved Construction Schedule is maintained.

D The Engineer shall be notified, in writing, whenever it is anticipated that delivery will be later than shown on the latest approved Construction Schedule.

1.09 Co-ordination

A Work at times other than the approved normal work hours requires approval by the Engineer at least 48 hours in advance of the work.

B A pre-approved plan (in writing) shall be required for all construction activities requiring actions by the Employer's authorized operating personnel. Such activities requiring the Employer's authorized personnel shall generally be related to rerouting of sewer services, short-term interruptions or removing any existing treatment facilities or pipelines from service. The Contractor shall submit written request to the Engineer for using the Employer's personnel at least seven (7) calendar days prior to the requirement and activities shall not be scheduled outside of normal working hours. Costs associated with operating personnel provided to the Contractor, but not used for the stated purpose, shall be borne by the Contractor at the billing rate (including fringe benefits) in effect at that time.

C The Contractor shall submit any required traffic control, detour and staging plans at least five (5) working days prior to blocking any streets, walks or, parking areas and such plans must be approved prior to implementation.

1.10 Engineer Interface with Scheduling System

To enable the Engineer to interface with the scheduling system, the Contractor shall provide to the Engineer an original, licensed copy of the software used by the Contractor for scheduling purposes registered in the name of the Employer. This software shall be handed over to the Employer at the end of the Works and will become the property of the Employer thereafter.

END OF SECTION 01310

Section 01350

Special Procedures For Environmental Management

Part 1 General

1.01 General

A The Contractor shall execute the work in full compliance with the relevant environmental statutory and legislative regulations and requirements of the country where the Project is implemented.

B The Contractor shall ensure that throughout the overall execution of the work, necessary guidelines, procedures and methods are defined and implemented for the control of environmental pollution and its associated hazard impacts to the well-being of workers and the surrounding communities in the vicinity of the Project.

C The Contractor shall have adequate personnel available to implement the environmental quality management aims and objectives that are required for the Project. The Contractor shall monitor the environmental quality management aspects of the Project arising through its work activities and its appointed sub-contractors to ensure that specified standards are adhered to.

D In this regard, the Contractor shall formulate a dedicated Environmental Management Plan (EMP) for the Works that details the plans and procedures for effective management of environment impacts associated with the implementation of the Project.

E The Contractor shall prepare the EMP for submission to the Employer. The Plan shall include and update details of the Environmental Programme as outlined in the Contractor's Technical Proposal. The Contractor's EMP shall be submitted to the Employer for endorsement within one (1) week from the Date of Commencement for the Works.

1.02 Compliance with Environmental Legislation and Regulations

A Contractor shall comply with all the requirements of the governing environmental legislation in the Project country, including new Acts, Regulations, Orders and Rules that may be made during the duration of the Works.

B In addition to the requirements for the Works imposed by the relevant Environment Regulatory Authority (hereinafter called "ERA") in connection with their approval on the Works, environmental laws, statutes, guidelines and other norms which control, inter-alia, water and gaseous pollutant emission rates, ambient air quality standards, ambient water quality standards for various types of water bodies, regulation for solid waste disposal, noise and vibration emissions, and maintenance of accepted ambient levels of noise in the surrounding environment, shall form the basis of the Contractor's environmental management and supervision of the Work.

C The Contractor shall be required to establish and maintain a procedure to record all legislative regulations and other policy requirements and codes applicable to the environmental quality management aspect of the Works activities and the materials used in the execution of these activities during the course of the Works. The Contractor shall meet or exceed the requirements of the relevant codes and standards that are in effect during the execution of the Works.

D The Contractor shall warrant that it is familiar with the contents and implications of such applicable environmental laws and regulations, as well as the environmental compliance requirements and standards of the Employer.

E The Contractor shall ensure the implementation of all mitigation and abatement measures outlined in the relevant environmental guidelines issued by ERA and/or the Employer The programme shall remain in place from the commencement of mobilisation through to the completion of the Works.

F The Contractor shall monitor the Works in progress to ensure compliance with the regulations, guidelines and conditions laid down by the environmental authority or agency in the Project country.

G The Contractor shall be required to conform to the Employer's environmental management policy, ERA's guidelines and regulations, and the general requirements of the Environmental Management Systems (EMS) principles stipulated in the ISO 14000 series.

1.03 Compliance With The Project's EIA Report

A The Contractor shall ensure that its work activities for the Works are in compliance with the Project EIA report undertaken by the Employer or operator of sewerage systems, its recommendations on mitigation and abatement measures, and the Conditions of Environmental Approval for the Project issued by ERA.

B The Contractor shall familiarise itself with the Conditions of Environmental Approval for the Project and its relevant supporting documents. The Contractor shall document and maintain a regular status report of this compliance that shall be updated on a monthly basis, and shall constitute an integral component of the Contractor's progress reporting to the Employer.

C As the approval of the EIA report is not construed as a basis to obtain final approval for implementation of the Project, the Contractor shall co-ordinate and support the Employer in obtaining the necessary approvals for the Project from the relevant environmental authority and/or its agency. Notwithstanding the above, the Contractor shall review and appraise the environmental related abatement measures that are identified in the Project's EIA report, as well as the Conditions of Environmental Approval to ensure that these measures are achievable and shall be incorporated during the execution of the Works.

D Any environmental related abatement measures and/or Conditions of Environmental Approval that will not be achieved nor incorporated into the Works, based on the "Best Economically Achievable Technology" shall be highlighted to the Employer.

F Subsequently, if the need for appeal is required by the Employer, the Contractor shall assist the Employer in appealing to ERA on this matter and suggest alternatives to ensure that the alternative mitigation measures are professionally implemented and meet local and international environmental standards.

1.04 Manpower

A The Contractor shall maintain a dedicated Environmental Section within its Works Organization, whose personnel shall have a sufficient knowledge and understanding of the local conditions as well as current environmental legislation and requirements. The dedicated Environmental Section shall consist of an Environmental Officer and appropriate support staff whose responsibility shall be to monitor environmental compliance at the Site.

B The Contractor's Environmental Officer shall be registered as an Environmental Consultant with ERA or any other authority as required, and shall be familiar with all the guidelines and requirements necessary to ensure environmental compliance for the Project. This person shall have the relevant experience, qualification, capability and authority to ensure that environmentally sound working practices are implemented and maintained. The

Environmental Officer shall be clearly identifiable to other workers and shall be stationed on site throughout the duration of the construction activities.

C The Contractor's Environmental Officer shall ensure that the EMP requirements for the execution of the Works are adhered to on a daily basis; vis-à-vis, overseeing the compliance and performance of the Works. Any reportable items and corrective actions taken shall be promptly reported to the Contractor and the Engineer. The Environmental Officer shall maintain a record of the environmental compliance status and reportable items, which shall be.

D The Contractor shall be required to co-ordinate and supervise the activities of its appointed sub-contractors, consultants and laboratories which shall undertake the relevant environmental baseline sampling, inspections and monitoring programmes that are required for the successful implementation of the environmental quality management for the Works.

Part 2 Product

2.01 Environmental Management Plan

A The Contractor shall formulate an Environmental Management Plan (EMP) for the entire duration of the Works. The EMP shall contain method statements for the implementation of mitigation measures as outlined in the relevant environmental management guidelines by the Employer and/or ERA, the EIA report and the Conditions of Environmental Approval for the Project issued by ERA. The Contractor shall prepare the EMP for submission to the Employer for concurrence prior to submission to and approval by the relevant environment regulatory authority or its agent prior to the commencement of the Works. The Plan shall include and update details of the environmental management programme as outlined in The Contractor's Technical Proposal.

B The Contractor's EMP shall be submitted to the Employer for endorsement within one (1) week from the Date of Commencement for the Works. Upon endorsement by the Employer, the Contractor shall submit the EMP to ERA for approval. The Contractor shall be responsible for the receipt of approval from ERA and compliance to the EMP and conditions of approval thereof. The principal objectives of the EMP shall be to ensure that the Contractor:

- has adequate instructions documented, and keeps records in compliance with the requirements of all the environmental guidelines and regulations;
- establishes regular monitoring, supervision and the necessary reporting mechanisms;
- conducts in-house induction and training so that the environmental requirements shall be adequately comprehend by its staff and sub-contractors' personnel;
- identifies potential sources of pollution within and in the vicinity of the Site, and takes steps to prevent their recurrence;
- conducts audits at regular intervals to evaluate the performance and compliance to the environmental requirements; plans and implements pollution prevention programmes and measures (including emergency pollution control measures and procedures); establishes a committee to meet regularly to review all existing environmental measures; and establishes environmental control instructions for all work activities at the Site.

C The Contractor's EMP shall include, though not be limited to, the following key information and execution procedures:

- Introduction: The objectives of the EMP, the scope of the EMP, a statement of key environmental issues for the Works, environmental management requirements as

empowered through the conditions of environmental approval for the Project issued by ERA.

- Project Description: A description of the construction/operations activities including a schedule of the Works.
- Environmental Monitoring and Auditing Requirements: Under the headings of each potential environmental issue: water quality, air quality, noise, and solid waste management; a description of specific conditions imposed by ERA, and legal requirements; monitoring requirements as recommended in this EIA and by ERA; and
- Mitigation measures that are proposed in accordance with the ERA's conditions and EIA recommendations, and proposals for environmental auditing.
- Administration Procedures: A statement of the environmental management staffing structure within the Contractor/operator organisation, reporting procedures, complaint response procedures, and actions to be undertaken if adverse monitoring results are reported.
- site clearing and preparation, including the borrow sites used for the Works.
- interfacing with government agencies and/or their appointed agencies/ contractors as well as nearby land developers/owners.
- drainage and erosion control, taking into consideration adverse ground and climatic conditions.
- work or activity specific environmental protection plan and methodology (i.e., method statements).
- protection of project-related environmental parameters and associated receptors. protection of properties within and in the vicinity of the Site.
- re-vegetation and agronomic erosion controls, and oceanic ecology preservation in the surrounding ocean if any.
- restoration of the Site and affected areas (including borrow sites and surrounding ocean, if any).

D The EMP shall adequately identify the function and activities that affect significantly or have the potential to affect significantly, the surrounding environment and receptors. The EMP shall identify such function and activities to ensure that they are carried out by the Contractor under controlled conditions. The Contractor shall establish and maintain adequate procedures for verification of compliance with specified requirements (i.e., programmes and work instructions) and establish and maintain records of the results. In addition, the Contractor shall also establish and maintain procedures for initiating investigations and corrective action in the event of a non-compliance.

Part 3 Execution

3.01 Environmental Monitoring

A The Contractor shall implement an environmental monitoring programme for the Project; which is intended to ensure that the environmental impacts that will inevitably arise during the construction of the Works are properly monitored, managed, and any potential adverse environmental impacts are mitigated or minimized as far as possible. The philosophy is to strike a balance between the development of the Works and environmental preservation.

B The environmental monitoring programme shall identify standards and procedures for environmental baseline parameter sampling and monitoring; and then assign the party(ies) responsible for implementing and monitoring the relevant parameters and receptors. The environmental monitoring programme shall be in full compliance with the legislated environmental standards and guidelines. The parameters and the locations of the monitoring

points shall be selected based on the anticipated impacts induced by the Works on the environment within and in the vicinity of the Site. Wherever possible, the parameters and sampling stations shall be similar to those indicated in the Project's EIA report.

C Nevertheless, the frequency and location of sampling points proposed by the Contractor shall be agreed by the Employer and shall be approved by ERA prior to the commencement of the Works. The Contractor's environmental sampling and analysis for the monitoring programme shall be conducted by a laboratory accredited by ERA and/or any other relevant authority.

3.02 Baseline Data

A Sample baseline data has been collected and is presented in the EIA. This provides a general description of the baseline environmental conditions, but must be supplemented by additional baseline surveys prior to the commencement of construction activities. In general, it will be adequate to repeat the sampling approach stipulated, to obtain a statistically reliable data set, and to allow for any shift in conditions between now and immediately prior to the commencement of construction activities.

B Noise, air and water quality during the construction and operations phases should be monitored against these baseline conditions, with the results used to indicate any change in the environment which may be attributable to the Project.

3.02 Environmental Audit

A The Contractor shall establish and maintain a system of records in order to demonstrate compliance with the environmental management requirements, and to record the extent to which the objectives and targets have been met. Pertinent records, results or audits and reviews, and training records shall form an element of these records.

B The Contractor shall, in line with established procedures and a published schedule, enforce audits on the performance of the Works throughout the duration of the Works. To ensure audit effectiveness, the Contractor shall ensure that the audit personnel have the support and authority to obtain the necessary information. The methodologies for conducting these audits shall involve the use of questionnaires, checklists, interviews, measurements and direct observations, depending upon the nature of the function being audited.

C The specific areas to be audited shall include the Contractor's organisational structure itself, to ensure that there is a relevant organisation allocating responsibility, working procedures, capacity and equipment, documentation and the necessary performance results.

D The Contractor shall periodically review its EMP to ensure its continuing suitability and effectiveness with regards to environmental quality management. The review shall also address the possible need for changes to the policy and objectives, in light of the changing work activities and the commitment to continual improvement.

E The Contractor shall allow the Employer or its appointed third party access at any time to plant, equipment, personnel and records when requested, to enable the Employer or its appointed third party to inspect or audit any aspect of the Contractor's work activities relevant to health, safety and environmental compliance of the Works.

F Similarly, the Contractor shall expect, at any time, site visits and inspections of the Works by statutory authorities. The Contractor shall permit free access at all times to the Employer and applicable statutory authorities for the completion of environmental inspections and/or audits of the Contractor's performance. The Contractor shall develop procedures to address these site visits and shall notify the Employer of the intent and content of any meetings, discussions and correspondence with the statutory authorities.

3.03 Works Close-Out

A The Contractor shall, on completion of all construction activities of the Works, hand over all relevant documents to the Employer. The relevant documents shall include, though not limited to, minutes of meetings, correspondences, reports and other records pertaining to discussions, meetings, site visits and compliance audits on environmental management aspects by relevant Government authorities.

B The Contractor's EMP shall also be updated as part of the close-out procedures and shall also include records of all legislative regulation and other policy requirements and codes applicable to the environmental and hazard control aspects of the work activities and the materials used in the execution of these activities during the course of the Works.

C On an on-going basis, the Contractor shall keep the Employer informed of all communications and correspondence with the ERA and other relevant Governmental authorities.

END OF SECTION 01350

Section 01380

Construction Photographs

Part 1 General

1.01 Description

A This Section includes construction photography.

1.02 Submittals

A The Contractor shall submit qualifications of a professional photographer and a representative 200 x 250 mm sample of the photographer's work to the Engineer for approval. The sample shall be of outdoor construction in colour.

B Monthly progress photographs shall be delivered with the monthly Progress Report.

1.03 Photography Requirements

A Prior to the commencement of construction, initial photographs shall be taken of construction sites as may be applicable as follows:

1 Sufficient numbers of photographs shall be taken of the site, access roads, buildings and structures adjacent to site, to record the existing conditions prior to construction within the Site.

2 Photographs at every bend, junction, culvert, bridge, drains, every building and structure adjacent to the construction routes at intervals of no more than 0.5 km apart along the said linear construction routes to record the existing conditions prior to construction.

B Monthly progress photographs shall be taken throughout the construction period on the cut-off date for each application for payment. The Contractor shall use a high quality digital camera, with a minimum resolution of 3.3 Mega Pixel and shall furnish four colour presentation prints (200 mm x 250 mm) and JPEG format files of each of the maximum of twenty of the photographs selected by the Engineer.

C Presentation prints shall be smooth surface, matt finish, processed by an approved professional, and mounted on heavy weight A4 sized sheets. One print shall be mounted in each sheet and shall be professionally labelled, in black type-face on the front, with the following:

1 name of project,
2 contract no.,
3 date,
4 orientation and description of view,
5 name and address of photographer,
6 photographer's numbered identification of exposure.

D Copyright of all photographs shall be vested in the Employer and all digital files shall be submitted to the Employer at the end of construction. Photographs shall not be used for any other purposes whatsoever without the Employer's approval.

END OF SECTION 01380

Section 01400

Quality Control

Part 1 General

1.01 Description

This Section includes:

1 Submittals.
2 General Quality Control Requirements.
3 Quality Control Plan.
4 Inspection Procedures.
5 Inspection and Test Plan.
6 Document and Submittal Control.
7 Identification and Control of Items and Materials.
8 Inspections and Tests.
9 Measuring and Test Equipment.
10 Non-Conformance Monitoring.
11 Personnel Qualifications.
12 Quality Control Audits.
13 Equipment/Material Handling and Storage.
14 Quality Control Records.
15 Workmanship.
16 Protection of Property

1.02 Submittals

A The Contractor shall submit a Quality Control Plan (QCP) to the Engineer no later than fourteen (14) calendar days from the Date of Commencement for the Works. No work covered by the Contractor's QCP shall begin until the plan has been approved. The plan shall describe all of the Contractor's quality control procedures that will be used throughout the execution of the Works and the minimum requirements shall be as specified herein.

B The QCP shall include the Contractor's quality control organization. It shall include the name, qualifications, and experience of the quality control manager and key support staff. Once approved, the Contractor's quality control manager shall have full authority to represent and act for the Contractor on all quality related matters. The Contractor shall notify the Engineer in writing prior to re-assigning any of the designated quality control personnel and shall obtain the Engineer's approval for replacement prior to re-assigning or re-locating approved quality control personnel.

C The Contractor shall submit a list of proposed suppliers and sub-contractors and which shall include the following:

a items to be supplied by each supplier and sub-contractor,
b model or catalogue numbers,
c specifications,
d inspection and test requirements,
e performance data,
f anticipated inspection and test dates,
g other pertinent information as appropriate.

D Inspection and test results, certificates of compliance, and certified material test reports shall be submitted to the Engineer as specified in Section 01300 hereof.

E Quality control procedures and instructions shall be submitted to the Engineer no later than fourteen (14) calendar days prior to using such procedures or instructions. Work governed by quality control procedures shall not begin until such procedures have been approved by the Engineer.

F A records index shall be prepared of all work records which will be developed and maintained during progress of the Works. This shall be submitted to the Engineer no later than fourteen (14) calendar days from the Date of Commencement for the Works.

G Inspection and test results shall be submitted to the Engineer at least fourteen (14) calendar days prior to incorporating such results into the Work Report, indicating compliance to or failure in the requirements.

1.03 General Quality Control Requirements

A The Contractor shall develop, implement and maintain a quality control programme consistent with the requirements of this Section ensuring that equipment and materials conform to applicable requirements of each section of the Specifications. Quality shall be maintained in all areas of the Works including, but not limited to:
1 design of temporary structures
2 inspection
3 testing
4 packaging, shipping, handling and storage of equipment and materials
5 site construction activities.

B Procedures shall be established to prevent deficiencies from occurring. Discrepancies shall be identified when they do occur and corrective action shall be taken. The Contractor shall instruct workmen, sub-contractors, material suppliers, and other personnel involved in the Works on the correct procedures to follow.

C The Contractor shall assign specific responsibility for implementing the quality control programme.

D Compliance with the specified requirements shall be systematically verified using quality control audits and the results shall be recorded.

E The Contractor shall assist the Engineer in auditing quality control activities. The Engineer's audits may be either pre-planned, or random, as warranted by general quality trends.

F All works under this Contract shall be inspected and tested and records of such inspections and tests shall be maintained.

G The Contractor shall arrange for factory inspections and tests when required by the Contract Documents.

H The Contractor shall provide equipment, instruments, qualified personnel, and facilities necessary to inspect the work and perform the tests as required by the Contract Documents.

I The Contractor shall repeat tests and inspections after correcting non-conforming work until all works comply with the contract requirements. All re-testing and re-inspections shall be performed at no additional cost to the Employer.

J The Engineer may elect to perform additional inspections and tests at the place of the manufacture, the shipping point, or at the destination, to verify compliance with applicable specifications. inspections and tests performed by the Engineer shall not relieve the Contractor of his responsibility to meet the Specifications. Inspections and tests by the Engineer shall not be considered a guarantee that materials delivered at a later time will be acceptable.

K The Employer may, at his cost, employ the services of a specialist firm to assist the Engineer, as he may require, in any matter connected with materials, including the inspection of materials and workmanship and the witnessing of tests at any stage during the execution and maintenance of the Works (including manufacture, where supply and installation are done by the same contractor). Such independent tests may be carried out at any stage during the execution and maintenance of the Works, but they shall not relieve the Contractor of any of his own obligations under the Contract. To the extent ordered by the Engineer, the Contractor shall provide labour, plant and materials (but not special testing equipment) for direct assistance to the specialist firm in their inspection and independent testing, and for any further work of investigation and repair which the Engineer considers necessary as a result of such inspection or testing. Cost of providing labour, plant and materials as aforesaid shall be borne by the Contractor where, in the Engineer's opinion, the inspection test or further investigation shows that materials and workmanship provided by the Contractor do not comply with the specified requirements, but otherwise shall be borne by the Employer.

L Non-conforming materials, whether in place or not, will be rejected by the Engineer. The Contractor shall be notified in writing to correct or remove the defective material from the Works. If the Contractor fails to respond, the Engineer may order correction, removal, and/or replacement of defective materials by others. The Contractor shall bear all costs for such work.

M Materials accepted on the basis of a Certificate of Compliance may be sampled and inspected/tested by the Engineer at any time. The fact that the materials were accepted on the basis of a certificate shall not relieve the Contractor of his responsibility to use materials which comply with the Specifications.

N The Contractor shall impose all of the specified QCP requirements (including inspection and test procedures) upon suppliers and Sub-Contractors.

O In the event that the Contractor fails to adequately perform any or all of the provisions of this Section, the Employer, at its sole discretion, reserves the right to have the Engineer perform any or all of the provisions of this Section and back-charge the Contractor for the actual cost of such work. This remedy for the Contractor's failure to perform shall be in addition to any other right or remedy available under this Contract.

P The measuring and test equipment provided by the Contractor shall be available for the use of the Engineer as required. The Contractor shall provide all necessary assistance and attendance to the Engineer for this use.

1.04 Quality Control Plan

A The Quality Control Plan (QCP) shall provide detailed description of procedures, instructions, and reports used to ensure compliance with the Contract Documents. No construction shall begin and no requests for payment shall be processed until the Contractor's QCP is approved.

B The Contractor's QCP shall include the following as a minimum:
1 organization chart identifying all personnel responsible for quality control and identifying the manager of the QC programme showing that the position is independent of the job supervisory staff with clear lines of authority. The QC manager shall report directly to the Contractor's corporate management. The chart shall show areas of responsibility and authority of each individual in the quality control system describing the area of responsibility and authority of each individual in the quality control system. The QC manager or designated substitute shall be present at the Site at any time of the work being in progress.
2 procedures for reviewing shop drawings, samples, certificates, and other submittals necessary for contract compliance including the name of all personnel authorized to sign the submittals for the Contractor certifying that they comply with the contract requirements.
3 procedures used to ensure compliance with the Contract Documents, as well as problem identification, reporting and resolution, including a copy of forms and reports used to document quality control operations and a submittal status log listing required submittals and action required by the Contractor and the Engineer.
4 a description of the services provided by outside organizations such as testing laboratories and consulting engineers.
5 a test and inspection schedule keyed to the construction schedule and following the order of the relevant sections of the Specification Sections indicating the following:
a inspections and tests required,
b names of responsible personnel for each segment of the Works,.
c schedule for each inspection and test.
6 document and submittal control procedures.
7 procedures to identify and control use of items and materials.

1.05 Inspection Procedures

A As a minimum, work shall be inspected before beginning each work segment and after completing a representative portion of the work.

B The Contractor shall perform follow-up inspections as necessary to ensure compliance with the Contract Documents.

C Preparatory inspections shall include:
1 review of the contract requirements,
2 review of approved shop drawings and submittal data,
3 check availability of required control testing,
4 ensure equipment conform to the Specifications and approved submittal data,
5 ensure the necessary preparatory work has been completed and is of acceptable quality.

D The Contractor shall perform an initial inspection as soon as a representative segment of the particular item of work has been completed. This inspection shall include scheduled tests and results shall cite the contract requirements, the test or analytical procedures used,

and the actual test results and state whether item tested or analysed "conforms" or "fails to conform" to the Specifications. Test reports shall be signed by the laboratory representative who is authorized to sign certified test reports. The quality of workmanship shall be examined, checks made for omissions or dimensional errors and the initial work approved or rejected.

E The Contractor shall provide follow-up inspections and tests at his own cost as necessary including continued testing and examinations to ensure compliance with the contract requirements.

1.06 Inspection and Test Plan

A The Contractor shall develop an Inspection and Test Plan for each section of the Specifications, identifying the following:
1 all required inspections and tests required by that section of the Specifications,
2 required testing frequency,
3 criteria for acceptance or rejection,
4 records required to document compliance,
5 procedures or instruction to be used for control of each activity.

B The Contractor shall provide sufficient detail to allow the Engineer and other agencies having jurisdictional authority over the work to identify operations to be inspected by that organization. Such operations shall not be bypassed by the Contractor, unless a written waiver is given by the witnessing organization.

1.07 Document and Submittal Control

A The Contractor shall establish written procedures for processing all documents and submittals associated with the Works. Procedures shall address receipt, filing, safe-guarding, processing and transmitting. The Contractor shall establish procedures to ensure that documents are prepared and transmitted or distributed in a timely manner. Procedures shall also ensure that documents contain the required technical information.

B The Contractor shall provide quality control procedures, methods, and current documents at the locations where they are to be used.

C Separate files shall be maintained for quality related documents and such files shall be made available to the Engineer upon request. The Contractor shall retain all quality related records for not less than three (3) years and shall protect all records from damage, deterioration, and loss.

D The Contractor shall not change or alter approved submittals, procedures, shop drawings or any other pertinent documentation without the Engineer's written authorization.

1.08 Identification and Control of Items and Materials

A The Contractor shall establish control procedures to ensure that items or materials accepted through shipping or receiving inspection are properly used and installed.

B The Contractor shall identify all items and materials so that they are traceable throughout all inspections, test activities, and records. For stored items, the identification method shall be consistent with the expected duration and type of storage.

C The Contractor shall record equipment and material identifications and ensure that they are traceable to the location where they are incorporated into the Works.

D The Contractor shall develop and maintain a receiving/inspection log containing at least the information itemized below:
1 purchase order number,
2 item number,
3 supplier's name,
4 quantity,
5 item description,
6 reference to applicable contract requirements,
7 date received,
8 heat number, serial number or other Identification, as applicable,
9 verification of receipt of all required supporting documentation,
10 QC acceptance sign-off and date,
11 non-conformance number, if applicable.

1.09 Inspection and Tests

A The Contractor shall use an approved material testing laboratory for testing required by these specifications at his cost. An on-site laboratory staffed by qualified personnel may also be used if allowed by the Engineer. The name and qualifications of independent testing laboratories shall be submitted to Engineer for approval no less than thirty calendar days prior to the date the laboratories are to be used. Once approved, dismissal and replacement of the approved independent testing laboratory shall require written authorization by the Engineer.

B All inspections and tests shall be conducted in accordance with written test procedures that have been reviewed and approved by the Engineer. The Contractor shall have adequate QC personnel on site during all shift of test operations. Test procedures submitted for approval shall include the following, as a minimum:
1 prerequisites for the given test,
2 required tools, equipment, and instrumentation,
3 necessary environmental conditions,
4 acceptance criteria,
5 data to be recorded,
6 test results reporting forms,
7 identification of items tested.

C Inspection and testing work shall be performed by personnel designated by the Contractor. Such personnel shall not be the same as those that performed the work.

D Approved procedures and instructions shall be "on hand" and used by inspection and test personnel at the time of inspection or test. All revisions shall be approved prior to being used to inspect or test the work. No deviations from approved work procedures and instruction shall be allowed without written authorization from the Engineer.

E The Contractor shall provide the Engineer with not less than 48 hours written notice of the occurrence of an assigned test point. Any test point inspected by outside agencies shall require a minimum 14 days prior written notification. The Engineer reserves the right to select a different test point at any time.

F The Contractor shall submit inspection/test results to the Engineer prior to incorporating the item(s) into the work. Inspection/test failures shall be reported to the Engineer immediately upon receipt of the inspection/test results, and certificates of compliance shall be submitted 15 days prior to incorporating a product into the Works.

G Inspections and tests conducted by persons or agencies other than the Contractor, shall not in any way relieve the Contractor of his responsibility and obligation to meet all Specifications and referenced standards.

H Inspection and test records shall, as a minimum, identify the following:
1 name of items inspected/tested,
2 quantity of items,
3 inspection/test procedure reference,
4 date,
5 name of inspector/tester,
6 observations/comments,
7 specified requirements,
8 acceptability,
9 deviations/non-conformances,
10 corrective action,
11 evaluation of results,
12 signature of authorized evaluator.

I The Contractor shall clearly document and identify the inspections and test status of materials and equipment throughout construction. Identification may be by means of stamps, tags, or other control devices attached to, or accompanying, the material or equipment.

1.10 Measuring and Test Equipment

A The Contractor shall provide measuring and test equipment necessary to ensure construction conforms to the requirements of this Specification.

B The Contractor shall maintain the accuracy of all measuring and test equipment and shall provide a unique identification number or mark permanently affixed to each item of measuring and test equipment. Each item of measuring and test equipment shall be calibrated at intervals recommended by the manufacturer. The Contractor shall develop a log of all measuring and test equipment and record:
1 equipment description,
2 identification number,
3 date of the last calibration,
4 date that the next calibration is due.

1.11 Non-conformance Monitoring

A The Contractor shall develop a system to identify, document, control and process non-conforming material and equipment. A non-conformance exists when, either material and equipment, documentation, or construction, do not comply with the requirements of the Contract Documents. The monitoring system shall apply to material and equipment as well as installation and construction which fail to conform to the Contract Documents.

B The Contractor shall provide the engineer with the following information for each non-conformance:

1 identification of non-conformance,
2 description of non-conformance,
3 evaluation of non-conformance to establish the cause,
4 recommended corrective action,
5 date on which non-conformance was identified,
6 date on which corrective action was completed,
7 description of final corrective action.

C The Contractor shall develop and maintain a non-conformance log to track all non-conformances. The log shall contain the following information as a minimum:
1 sequential reference number,
2 date issued,
3 originator,
4 description of item deemed to be in non-conformance,
5 description of non-conformance,
6 recommended and final disposition,
7 date closed,
8 Initial sign by the Contractor's QC Managers,
9 remarks, as applicable.

D The Contractor's QC personnel shall have the authority to stop that portion of the work which does not comply with the contract requirements.

E The dispositions for non-conforming items and materials shall be subject to approval by the Engineer.

F The Contractor shall clearly identify each non-conforming item with a distinguishing mark and shall establish procedures for installing, monitoring, and removing these marks after approval of the Engineer. The Contractor shall identify personnel authorized to remove these marks.

G The Contractor shall take prompt action to identify the causes of each non-conformance and the corrective action necessary to prevent recurrence. The results of failure and discrepancy report summaries, supplier evaluations, and any other pertinent applicable data shall be used for determining corrective action. Information developed during construction, tests, and inspections, that support the implementation of required improvements and corrections, shall be used to support the adequacy of corrective action taken.

1.12 Personnel Qualifications

A The Contractor shall identify activities requiring qualified production, inspection, and test personnel and establish their minimum competence level. The Contractor shall maintain records of personnel qualifications as quality records.

B Personnel inspecting and testing special operations (e.g., welding, brazing, etc.) shall have the experience, training, and certification commensurate with the scope, complexity, or nature of the activity. Such personnel shall be approved by the Engineer.

C The Contractor shall submit the following for all such production, inspection and test personnel:
1 qualifications description,
2 orientation,
3 skill evaluation,

4 certification credentials.

1.13 Quality Control Audits

The Contractor shall perform regularly scheduled internal audits to verify that his quality control procedures ensure total compliance with the Specifications and referenced standards. Quality control audits shall be scheduled not less than monthly. The Contractor shall maintain records of these audits as quality records and make them available to the Engineer upon request. The Engineer shall be provided with access to the audit records upon request. The Contractor shall allow the Engineer to observe the Contractor's internal audit upon request.

1.14 Equipment/material Handling and Storage

The Contractor shall be responsible for all handling, storing and preserving equipment and material from the time of receipt to the time of acceptance by the Employer. The Contractor's storage and handling procedures shall be designed to prevent damage, deterioration, distortion of shape or dimension, loss, degradation, loss of identification, or substitution. The handling procedures shall address the use, inspection and maintenance of special devices such as crates, boxes, containers, dividers, slings, cranes, material handling and transportation equipment and other facilities. The Contractor shall identify equipment and material requiring special handling or testing.

1.15 Quality Control Records

A The Contractor shall develop a complete records index based on the requirements for document and data submittals in each Section of these Specifications. The Contractor shall indicate all quality control records, documentation, submittals and data required by the Contract and shall supplement these records as necessary to monitor quality throughout the execution of the Works. The records identified in the index shall provide objective evidence that quality control programme activities conform to the contract requirements including evidence that required verifications have been performed. The Contractor shall authenticate all records. Only complete and properly authenticated documents shall be maintained as records of material and equipment quality.

B Quality records shall be indexed, filed and maintained in a manner that provides for timely retrieval; traceability, easy identification and the latest status (acceptability) of equipment and material and shall be protected from deterioration and damage. As a minimum, records shall include:

1 name of equipment/material inspected/ tested;
2 specification reference by section and paragraph (where applicable);
3 quantity of items;
4 location and installation;
5 inspection/test procedure reference;
6 date;
7 signature of inspector;
8 observations/comments.

1.16 Workmanship

A The Contractor shall comply with industry standards except the case where more restrictive tolerances or specified requirements indicate more rigid standards or more precise workmanship.

B Work shall be performed by persons qualified to produce workmanship of the specified quality.

C Products shall be secured in place with positive anchorage devices designed and sized to withstand stresses, vibration, and racking.

D The Contractor shall comply with manufacturer's published installation instructions in full detail, including each step in sequence. Should instructions conflict with the Contract Documents, clarification shall be requested from the Engineer before proceeding.

1.17 Protection of Property

A. The Contractor shall not load or permit a structure to be loaded in a manner that will endanger the structure and shall not subject Work or adjacent property to stresses or pressures that will endanger it.

B The Contractor shall take positive action to protect existing surfaces and facilities from damage resulting from construction operations unless modifications to the surfaces or facilities are required as part of the Contract. All features and facilities shall be protected from damage caused by mobile and stationary equipment, including vehicles delivering materials to the Site. Finished surfaces, including jambs and soffits of openings used as passageways through which materials are handled, shall be protected against possible damage resulting from the conduct of the work by trades. The Contractor shall provide and maintain adequate protection for adjacent structures. When required by law or for the safety of the Works, shore, brace, underpin, or otherwise protect those portions of adjacent structures that may be affected by the Works.

C Known utilities and related facilities are shown on the Drawings but location of these facilities are not guaranteed, nor is there any guarantee that other utilities are not present. Unless otherwise specifically provided, the Contractor shall protect utilities and related facilities from damage and cause no interruption of service. The Contractor shall establish and maintain direct contact with the owner or operator of each utility that may be affected by the Work and shall proceed with Work that may affect a utility only with the cooperation and approval of the owner or operator of the utility. The Contractor shall immediately inform the Engineer of any agreement with the utility operator concerning the Work under this Contract. The Contractor shall verify the location of all utilities in the vicinity of the works by actual field measurements before commencing construction, and shall submit a plan for performing the works to the Engineer for approval including evidence of approval by the utility owner or operator.

D All finished surfaces shall be clean and un-marred upon acceptance of the structure. The Contractor shall not permit traffic or material storage on roof surfaces. Where some activity must take place on the roof in order to perform the work, the Contractor shall provide and maintain adequate protection. Adequate protection shall be maintained against the weather at all times so as to preserve the work, materials, equipment, apparatus, and fixtures free from injury or damage. The Contractor shall not use items of equipment that are intended to from a part of the completed work as construction equipment without specific approval from the Engineer in each instance.

E The Contractor and the Engineer shall conduct a pre-construction inspection of existing facilities and structures in the vicinity of the works, and the Contractor shall document the inspection by photographs, sketches, and narratives assembled into an inspection report. The inspection report shall be signed and dated by the Engineer, indicating agreement that the report represents an accurate description of the existing conditions. The Contractor shall

establish reference points on or about any structure that may be affected by excavation performed as part of this Contract. Reference points shall be sufficient to detect any horizontal or vertical movement which may occur. Points shall be accurately referenced to a stable benchmark remote from the Works. The Contractor shall accurately survey reference points at least weekly during excavation in the vicinity. Prior to beginning excavation, a detailed description of the proposed movement detection system shall be submitted to the Engineer for approval. Submit A copy of each survey of the movement detection system shall be submitted to the Engineer within 24 hours after the survey is completed.

F The Contractor shall repair damage as soon as possible after discovery for those surfaces and facilities which are to remain in place. Repairs shall be as strong as the undamaged item. Repaired surfaces shall be identical in colour and texture to the adjacent existing materials. Where materials cannot be matched, refinish the surrounding area to give a uniform appearance acceptable to the owner and the Engineer. The Contractor shall replace damaged shrubs, vegetation, and trees outside the clearing limits that are damaged by construction operations; replace trees larger than 75 mm in a diameter measured at a height of 1 m above ground with trees 75 mm in size; and replace all other vegetation with the same species and size as that damaged, unless otherwise approved or instructed by the Engineer.

END OF SECTION 01400

Section 01450

Health and Safety

Part 1 General

1.01 Safety and Security

A In addition to any requirements as stipulated in the General Conditions of Contract, the Contractor shall at all times maintain a safe system of working and shall comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by the Works.

B In particular the Contractor shall ensure that only persons who are properly trained for their duties are employed, and that the correct tools and procedures are used.

C Not later than four (4) weeks before work commences on the Site, the Contractor shall submit to the Engineer his comprehensive proposals relating to the safety, health and welfare of all his personnel on the Site.

D In addition to any requirements as stipulated in the General Conditions of Contract, the Contractor shall be responsible for the implementation of safety related site procedures which shall include, but not be limited to, the following:

1. Safety
2. Working in hazardous areas
3. Permit to work
4. Fire and smoking regulations
5. First aid
6. Warning signs
7. Trenching scaffolding and other construction structures
8. Safety barriers
9. Protective clothing and equipment
10. Safety training
11. Safety meetings and inspections
12. Health and welfare

E The proposals shall be appropriate for all grades of labour and personnel who will work on or visit the Site on behalf of the Employer, Engineer or Contractor.

F The Engineer shall have the power to stop any activity or work in any area where there is a breach of the published site safety rules such that health or life is put at risk.

G The Contractor shall, in addition, comply with the Safety Policy of the Employer, copies of which are available on request from the Engineer.

1.02 First Aid and Life-saving Apparatus

The Contractor shall provide on the Site such life-saving apparatus as may be appropriate and an adequate and easily accessible first aid outfits. In addition, an adequate number of persons permanently on the Site shall be instructed in their use, and the persons so designated shall be made known to all employees by the posting of their names and designations in a prominent position on the Site.

1.03 Electrical Safety

A The Contractor shall be responsible for the electrical safety of all Plant supplied and installed. Whilst any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on the Site. If necessary, this shall include fencing off areas which are considered to pose a risk, and erecting warning notices.

B The Contractor shall be responsible for ensuring that the electrical installation is carried out by suitably trained competent personnel and that the work is carried out in a safe manner.

C The Contractor shall be responsible for the operation on site of a permit-to-work system during the period of electrical equipment installation and testing. This system shall regulate the installation, the energising and the use of electrical equipment/system installed and the method of work adopted.

D Power hand tools for use on site shall operate at no greater than 230 V.

1.04 Warning and Safety Signs

Statutory safety signs in accordance with ISO 3864 shall be adequately provided throughout the Site, both indoors and outdoors. These safety signs shall cover mandatory, prohibition, warning, emergency, fire-fighting and general notices. All signs shall be positioned around the Site at highly visible points. Provision of signs, and the positions of signs shall be subject to the Engineer's approval. Special attention shall be given to areas designated hazardous.

1.05 Hazardous Material Identification

A There may be hazardous materials supplied as part of the Works. The Contractor shall be alert to potentially hazardous materials even though the materials may be located outside the construction area or in an area not normally accessible to the Contractor or his employees. Neither the requirements of this clause nor an act or failure to act by the Employer or the Engineer shall relieve the Contractor of responsibility and liability for the safety of the Engineer, Employer, Contractor, or subcontractor personnel and property.

B Hazardous materials may include, but are not necessarily limited to, petroleum and associated by-products, paints, thinners and other such construction materials together with those chemicals used in the operation of the facilities to be constructed.

C The Contractor shall ensure that all containers of substances belonging to the Contractor and his subcontractors that are on-site or in storage are properly labelled as to the contents and the potential hazard (if any). The Contractor shall submit a Material Safety Data Sheet (USA Department of Labour Form OSHA-20), or the local equivalent, for all hazardous material brought to the Site at least five (5) days before delivery.

1.06 Guidelines to Safety In Sewers And Sanitary Structures

A The Contractor shall be aware of the guidance and provisions contained in 'Safe Working in Sewers and at Sewage Works' published by the United Kingdom National Joint Health and Safety Committee for the Water Service.

B The Contractor must inform his work force of the:

1 hazards of inflammatory or otherwise noxious volatile liquids being discharged into sewers. Some of these may produce vapours which can cause irritation to the eyes, nose or skin. Should the presence of such liquids be suspected, suitable precautionary measures shall be taken.

2 danger of bacterial infection while working in a sewage contaminated environment and shall impress upon them the importance of personal hygiene.

C If working in sewers where accumulations of sludge or silt occur, the Contractor's attention is drawn to the fact that, when disturbed, sludge may release toxic gases.

D The Contractor shall be responsible for ensuring adequate precautions are taken by his workforce to safeguard against any accidents to whosoever while working in or adjacent to sewers, sewage works, manholes, pumping stations, etc.

E All members of the workforce shall be vaccinated against tetanus, typhoid and para-typhoid, and the Contractor must have up to date medical records of each person. The Contractor shall provide a medical certificate of fitness for each of his personnel. Should any one working in a manhole, sewer or chamber, complain of nausea or dizziness then all personnel should be removed from that location and work should resume only when it is safe to do so, or with the use of breathing apparatus under site supervision of safety officer.

F All members of the workforce shall be fit and everyone who will be expected to work in sewers shall not suffer from:
1 any heart defect,
2 any history of fits or blackouts,
3 deafness or loss of balance,
4 claustrophobia,
5 recurrent back ailments,
3 shortage of breath on light exertion.

G The Contractor shall safeguard his workforce against dangers of toxic, asphyxiatory, inflammable or explosive gaseous conditions in manholes, sewers and ancillary structures and physical injury, caused by falling objects, or by falling themselves.

H Each group of workers engaged on sewers, manholes, pumping or lifting stations and ancillary structures shall be provided with and be familiar with the operation of reputable gas testing equipment suitable to check hydrogen sulphide combustible gases and lack of oxygen.

I Precautions to be taken include, but not by way of limitation, the provision for each person working in sewage works of:
1 safety helmet,
2 safety boots with no ferrous studded soles,
3 safety belt (strong readily washable with no ferrous attachments for lifeline),
4 gloves,
5 overalls.

J In addition to the above items, each group shall have with them at each entry point to a confined space of the following:
1 a lifting harness,
2 4 No. 15 metre life lines with spring shackle one end, eye at other,
3 ladder,
4 lifting frame complete with ropes and shackles for hand operation,
5 powerful hand lamp, with flameproof switch,
6 ventilation blowers together with portable generator and flexible trunking,
7 positive pressure respiratory face masks with associated portable compressor and air hoses,
8 gas detectors (suitable for H_2S),
9 radio activity detectors,
10 an atmosphere monitoring device capable of monitoring oxygen levels and levels of

toxic and flammable gas,
11 washing facilities with disinfectants and toiletries,
12 communication facilities.

K Before entering any manhole, sewer and ancillary structure, the atmosphere shall be tested as mentioned.

L The Contractor shall also test for radioactivity. Any increase found abnormal shall be reported immediately to the concerned authorities, and all works in the vicinity must be stopped.

M The Contractor shall provide, erect and maintain, adequate scaffolding, ladders, etc., required for work and to facilitate the Engineer's Representative to inspect and test. These shall be removed as directed upon completion of all works.

N The Contractor shall be solely responsible for liability in respect of any claim or legal action arising as a result of an accident and shall not be absolved of any liability under the Contract in respect of his having complied with the above requirement.

O The Contractor shall appoint a safety officer who shall be responsible for ensuring that the Contractor's employees follow the safety procedures. The safety officer shall ensure that at least one person in each gang shall be instructed rescue procedures, resuscitation techniques, basic first aid and the use of gas detection apparatus.

P A mobile mess room with washing and changing facilities shall be provided by the Contractor for each working area.

Q The Contractor shall keep installed in the mobile changing rooms, or mobile office, within easy access of each working group emergency equipment which shall include, but not by way of limitation:
1 barrier cream,
2 disinfectant,
3 first aid kit with eye bath,
4 stretcher,
5 15m long lifelines with spring shackle one end, eye at other, lifting harnesses,
6 breathing apparatus with air bottle - 2 sets.

R Address and telephone number of the nearest hospital with emergency facilities shall be posted in each mess room.

S The Contractor shall provide safety barriers to be erected around all unattended open manholes and cover them with suitable temporary steel sheets. Whenever the Contractor’s workforce leaves the site of the works all manhole covers shall be replaced.

End of Section 01450

Section 01460

Erosion and Silt Control Measures

Part 1 General

The Contractor shall be responsible for preventing silt from being washed into drains and streams. The Contractor shall comply with the following requirements strictly:

1.01 Treatment of Silt-laden Water

The Contractor shall ensure that silt-laden water is not discharged directly or by pumping into drains or streams. The silt-laden water shall be channelled to silt traps, sedimentation tanks or other measures for removal of silt before discharging into drains or canals.

1.02 Provision of Silt Traps and Perimeter Cut-off Drains

Silt traps, perimeter cut-off drains and other facilities shall be provided to ensure that earth, silt, mud, etc. are not discharged into drains or canals. Details of these facilities are to be duly designed and endorsed by a Professional Engineer. These facilities are to be constructed before the commencement of relevant work.

Silt traps, perimeter cut-off drains and other facilities shall be de-silted and maintained at least once a week or more often if necessary to effectively prevent the discharge of silt from the worksite.

1.03 Protection of Exposed Earth Surfaces

The Contractor shall carry out close turfing promptly to prevent soil erosion at worksite. All exposed earth surfaces not affected by construction activities shall be planted with turfing on an immediate basis. Where necessary to effectively prevent soil erosion, he shall also carry out progressive turfing on site. In cases where turfing is not practical or not effective in protecting exposed earth surfaces which are left bare and undisturbed for more than one month, such surfaces shall be protected from soil erosion by spraying with bitumen based emulsion or other effective methods to be approved by the Engineer. Notwithstanding the approval of the Engineer, the Contractor is to ensure that the methods are effective in prevention of soil erosion.

1.04 Excavated Material

All surplus excavated materials shall be carted away to the Contractor's own disposal ground immediately. The surplus excavated material shall not be stockpiled on site.

Earth materials stockpiled on site for construction work should be within properly contained areas and covered to prevent the earth from washing into drains or canals. The locations for stockpiling the earth shall be subject to approval by the Engineer. Notwithstanding the approval of the Engineer, the Contractor is to ensure that earth is not washed into drains or canals.

The Contractor shall only carry out trench excavation work, provided the rate of construction keeps pace with the rate of excavation.

End of Section 01460

Section 01500

Construction Facilities and Temporary Controls

Part 1 General

1.01 Description

This Section includes

1 Field Offices
2 Roads
3 Electricity and Site Lighting
4 Ventilation
5 Telephone Service
6 Potable Water
7 Sanitary Facilities
8 Barriers
9 Enclosures
10 Protection of Installed Work
11 Site Security
12 Water Control
13 Cleaning During Construction

1.02 Submittals

Working drawings showing proposed locations, access and sizes of offices, workshops, storage areas, fencing, temporary stationary equipment, and similar facilities together with connections to utilities shall be submitted to the Engineer for approval in accordance with Section 01300 hereof.

1.03 General Utility Requirements

The Contractor shall provide and maintain temporary and interim utility services necessary for performance of the Works. Installation and maintenance of utilities shall comply with applicable codes, safety and utility company requirements. Connections to the Employer's utilities shall only be with the approval of the Employer and the Engineer. Meters shall be provided for all connections to the Employer's utilities, and the Contractor shall pay all costs for these utilities.

1.04 Site Offices

A. The Contractor shall provide separate, temporary, furnished and equipped site offices on the construction site for the Engineer and site supervision staff. They shall be provided at the start of construction and remain until the end of commissioning for the whole of the Works. The offices shall be located in the construction site acceptable to the Engineer in proximity to those of the Contractor, and/or shall be as specified in the Particular Specifications.

   All offices shall be weather-tight, with lighting, electrical outlets, air conditioning and ventilation equipment, sanitary facilities and furniture. All costs to install and maintain the Engineer's site offices including, but not limited to, air conditioning, lighting, utilities, pest control and cleaning, shall be paid by the Contractor and shall be included in the Contract Price.

B The Contractor shall have completed the installation and furnishing of the Engineer's main site office within thirty (30) calendar days after the Date of Commencement for the Works.

C All office equipment and furnishings shall be for the exclusive use of the Engineer. At completion, all office equipment and furnishings of the site office shall revert to the Contractor.

G The main site office shall be insulated, and painted internally and externally. Floor to ceiling height in the main site office shall be at least 2.7 m. Each external wall of each room shall have at least one screened window. All windows shall have blinds. The office shall have at least two external lockable doors.

H The Contractor shall provide janitorial services to maintain a good working environment and security service at each office. Water and electricity supply including receptacles on all walls shall be provided. The offices shall be well lighted, equipped with air-conditioners with temperature control capable of maintaining a constant temperature of about 23 to 25ºC. The Contractor shall provide all wiring, receptacles and fixtures in accordance with relevant codes and regulations. Offices, in general, shall comply with local building ordinances and be provided with all necessary fire extinguishers and an approved first-aid kit.

1.05 Storage Sheds for Tools, Materials and Equipment

The Contractor shall provide weather tight storage sheds with ventilation or air-conditioning, as necessary, for products requiring controlled climatic conditions. Adequate space and lighting shall be provided for organized storage, access and inspection.

1.06 Roads

The Contractor shall use established roads or routes approved by the Engineer and shall review traffic restrictions with authorities having jurisdiction and obtain the required approvals. Roads shall be maintained free of dirt, trash, construction debris, etc. and provided with traffic controls as required and as specified in Section 01570 hereof.

1.07 Electricity and Site Lighting

The Contractor shall provide all electrical services required for offices and construction operations including branch wiring and distribution boxes as necessary, terminations for each voltage supply complete with circuit breakers, disconnect switches and other electrical devices as required to protect the permanent power supply system. The Contractor shall pay for all power used for construction operations.

1.08 Ventilation

Ventilation shall be provided to maintain specified conditions for construction operations and to protect materials and finishes from damage due to temperature or humidity. The Contractor shall verify that ventilation equipment is properly installed, ready for continuous operation, and that filters are in place, prior to operating permanent facilities for temporary purposes.

1.09 Telephone Service and IT Network System

Telephone services and IT network system shall be provided to the Engineer's site office as specified in the Particular Specification.

1.10 Potable Water

Potable water services shall be provided as necessary for construction operations, and the Contractor shall pay for all costs. The Contractor shall also provide, maintain and supply bottled water, including dispensers for cooling and heating the delivered water, for the Engineer's site offices.

1.11 Sanitary Facilities

Sanitary facilities shall be provided and maintained for the Engineer's site office as well as for construction personnel. Any existing facilities shall not be used by construction personnel.

1.12 Barriers

Barriers shall be provided to prevent public entry to construction areas; protect existing facilities and adjacent properties from damage; to prevent damage to trees and plants; to protect traffic from open trenches; to protect pedestrian and vehicular traffic; to protect stored materials and to prevent puddling or running water.

1.13 Enclosures

Temporary, weather-tight closures shall be provided for openings in exterior surfaces to ensure acceptable working conditions, to protect installed materials and equipment, and to prevent unauthorized entry.

1.14 Protection of Installed Work

Temporary protection shall be provided for installed products and traffic shall be controlled in the immediate area to minimize damage. Walls, projections, jambs, sills, and soffits of all openings shall be covered and finished, and floors and stairs shall be protected from traffic, movement of heavy objects, and storage damage. Traffic and material storage shall be prohibited on waterproofed and roofed surfaces, and on lawn and landscaped areas.

1.15 Site Security

A security programme shall be established, and necessary facilities and personnel shall be provided to protect the Works.

1.16 Water Control

The Site and excavations shall be maintained free of water by use of grading and/or provision, operation and maintenance of necessary pumping and dewatering equipment.

1.17 Cleaning During Construction

The Contractor shall control the accumulation of waste materials and rubbish and periodically dispose of legally at an off-site location. All interior surfaces shall be cleaned prior to starting finish work. All areas shall be maintained free of dust and other contaminants during finishing operations.

1.18 Removal of Temporary Items

Temporary materials, equipment, etc. shall be removed prior to substantial completion of the Works, and damage caused by installation or use of temporary facilities shall be repaired. Underground installations shall be removed to a depth of 600 mm, and the areas shall be graded to match adjacent areas.

1.19 Rodent and Pest Control

The Contractor shall keep the work area, including all storage areas, free from rodents, noxious pests, and other vermin at all times. The Employer or the Engineer shall notify the Contractor of any non-compliance and the corrective action required. The Contractor shall take immediate corrective action upon receiving such notice, and if the Contractor fails to eliminate both the rodents and/or pests and the causes thereof, the Employer may have the rodents and/or pests exterminated and charge the cost to the Contractor.

1.20 Vehicle Cleaning Facilities

The Contractor shall provide a wash water trough and vehicle cleaning facilities. The vehicle cleaning facilities shall be provided as close as possible to the site entrance so that construction plant/equipment and vehicles may be cleaned prior to entering public roads.

1.21 Dust Control

The Contractor shall prevent dust from developing at the site as a result of dry ground conditions by the use of watering tanker trucks fitted with spray attachments or by other approved methods as often as required or as directed by the Engineer.

END OF SECTION 01500

Section 01570

Traffic Control

Part 1 General

1.01 Description

This Section includes traffic control requirements and dust control.

1.02 Submittals

The Contractor shall comply with requirements for the submittals pertaining to traffic control and management as specified in Section 01300 hereof.

1.03 General Traffic Control Requirements

A In order to perform work on public or private Rights-of-Way, the Contractor shall submit to the Engineer for his approval a traffic management plan complying with the requirements of relevant authorities, which shall include the requirements described hereinafter but not limited to these.

B The Contractor shall not make use of public or private rights of way for depositing or storing plant or materials, other than such plant, materials, tools or implements as shall from time to time be required for immediate use on the several sections of the Works. Plant, Materials and Temporary Works shall be placed in such a way as to cause minimum interference with the use of any right of way by the public, and the Contractor shall maintain those parts of the right of way not temporarily occupied by the Works in a clear, passable and safe state at all times.

C In addition to any other requirements stated in the Contract, temporary traffic arrangements on public roads shall be in accordance with conditions and restrictions imposed by the relevant authorities. Temporary lighting, signing, guarding and traffic control arrangements shall be in accordance with conditions and restrictions imposed by the authorities and shall conform to the relevant standards and regulations.

D The Contractor shall make all arrangements with and obtain the necessary approvals from the relevant authorities for temporary traffic arrangements and control on public roads.

E The Contractor shall maintain and protect vehicular and pedestrian traffic through all construction areas. Work shall include, but not necessarily be limited to, temporary detours, furnishing, erecting and maintaining temporary traffic control devices including barriers, barricades, cones, drums, warning signs, traffic signals, radio communications, lights and flagmen.

F No work shall be performed during the hours of darkness unless otherwise authorized in writing by the Engineer and approved by the local authority.

G The Contractor shall ensure that adequate access is maintained at all times to properties and facilities affected by construction activities. All access ways shall be replaced with the same width, standard and surface type as the existing access facilities. The access locations to be maintained may not be shown on the Drawings. All existing access ways; whether public or

private, paved or unpaved, shall be maintained at all times during the contract period unless specifically authorized otherwise by the Engineer in writing.

H If detours are proposed by the Contractor, a written plan and drawings shall be submitted to the Engineer, Local Authority and traffic police for their approval. Detour work shall include but not necessarily be limited to:

1 field surveys,
2 construction and maintenance of paved and unpaved detour carriageways including earthwork,
3 providing and installing metal beam guardrails, barriers, drainage, lighting, traffic signals, signs, barricades, and other traffic control devices,
4 temporary protections of existing utility services as required by the concerned Service Authority or company,
5 restoration of the Detour sites to their original condition (or such other condition as directed or approved by the Engineer) when the Detours are no longer required.

1.04 Particulars of Temporary Traffic Arrangements and Control

A The following particulars of the proposed temporary traffic arrangements and control on public roads shall be submitted to the Engineer's Representative for approval at least 28 days before the traffic arrangements and control are implemented:

1 Details of traffic diversions and pedestrian routes;
2 Details of lighting, signing, guarding and traffic control arrangements and equipment;
3 Any conditions or restrictions imposed by the relevant authorities, including copies of applications, correspondence and approvals.
4 Provisions for flagmen at various locations
5 Assignment of an Engineer who shall be in charge of traffic diversions and safety associated with Contractor's work.

1.05 Quality Assurance

A The Contractor shall provide a competent Traffic Safety Supervisor, who shall be available at all times to oversee the safety and maintenance of vehicular and pedestrian traffic operations. The supervisor shall have received traffic safety training or shall have had previous experience regulating traffic flow through construction work areas. The Traffic Safety Supervisor's duties and responsibilities shall include, but not necessarily be limited to, the following:

1 maintain traffic flow through and around the construction site as required by the Contract Documents,
2 coordinate traffic control procedures with all relevant authorities, including the traffic police,
3 inspect the condition and location of traffic control devices to ensure that they are in proper working order, clean, visible and conform to these specifications,
4 establish traffic control requirements and develop the appropriate control procedures,
5 provide and maintain such devices as being necessary for safe and efficient traffic movement, and ensure that these devices are in place at the required time and removed

when no longer required,

6 coordinate traffic control operations, including maintenance, with the Engineer,

7 review the Contractor's construction plan and material delivery, storage and handling procedures with respect to traffic safety and operation,

8 conduct an initial traffic safety meeting with the Contractor and any subcontractors prior to beginning construction to review traffic control procedures, safety, etc.,

9 conduct periodic meetings, at least monthly thereafter, to review traffic control problems, implement solutions, and provide the Engineer with minutes summarizing all discussions.

B Flagmen, when provided or required, shall be physically and mentally qualified, trained on their duties, and courteous. Each flagman on duty shall wear appropriate reflective and distinctive apparel as approved by the Engineer and shall be equipped with a STOP/GO sign and radio communications, as appropriate.

1.05 Dust Control

The Contractor shall prevent nuisance conditions from developing as a result of dust, and dust shall be controlled by watering using tanker trucks with spray attachments or by other approved methods, as often as needed and as directed by the Engineer.

Part 2 Products

2.01 Temporary Traffic Arrangements and Control

A Temporary traffic diversions and pedestrian routes shall be provided for works in roads or footways that obstruct existing vehicular or pedestrian access. The relevant work shall not commence until the approved temporary traffic arrangements and control have been implemented.

B Temporary traffic arrangements and control for work in public roads and footways shall comply with the requirements of the relevant authorities. Copies of documents containing such requirements shall be kept on the work site at all times.

C Temporary traffic signs, including posts, backing plates and faces, shall comply with the requirements of the relevant authorities.

D The thickness of backing plates for temporary traffic signs may not be less than 1.5 mm; the posts for the signs may be constructed of timber or other material, provided that these are in conformance to the requirements of the local authorities.

E The arrangement of information contained on sign faces for temporary traffic directional signs shall be designed by the Contractor. The details of the background, borders and legends, including letters, numerals, characters and symbols, shall comply with the requirements of the relevant authorities.

F Temporary traffic arrangements and control shall be inspected and maintained regularly, both by day and night. Lights and signs shall be kept clean and easy to read. Any equipment damaged, dirty, incorrectly positioned or not in working order shall be repaired or replaced immediately.

2.02 Materials and Equipment

All traffic control devices shall be approved by the Engineer before being used on the work site. All sign panels, barricades, drums, vertical panels and flagmen's paddles shall be placed in reflectorized conditions. Painting shall not be considered as an approved substitute for reflectorization. Barricades shall be made of metal, wood or plastic and shall collapse when tipped over. Cones shall be manufactured of a material capable of withstanding impact without damage to the cones or vehicles. All cones shall be red or orange and shall have a white reflectorized band and shall be capable of remaining upright during normal traffic flow and wind conditions in the area where they are used. Vertical panels shall be constructed of metal or plastic. Warning lights shall be Type A (low intensity flashing), or Type C (steady burn) and shall meet the minimum requirement of the Institute of Transportation Engineers "Standard for Flashing and Steady-Burn Barricade Warning Lights".

Part 3 Execution

3.01 Application of Traffic Control Devices

A The Contractor shall provide and maintain traffic control devices, both inside and outside the work site boundary, as needed to direct traffic and ensure vehicular and pedestrian safety. Prior to beginning construction, the necessary signs, barricades, and other traffic control devices shall be erected. All warning signs except those required for public safety during non-working hours or when construction in that area is completed, shall be removed or covered with either metal or plywood sheets so that the entire sign cannot be seen by on-coming traffic. Traffic control devices shall be used for only as long as they are needed.

B Reflective materials on signs, drums, barricades, and other devices shall be kept clean, free from dirt, mud and road grime. Scratches, rips, and tears in the sheeting shall be promptly repaired by the Contractor to the Engineer's satisfaction. Reflective sheeting materials shall maintain a reflectivity of not less than 50 percent of their design intensity values.

C Warning lights shall be securely fixed to barricades or drums used singly or in combination with other devices, unless otherwise specified.

3.02 Use of Roads and Foot-ways

A Public roads and footways on the work site in which work is not being carried out shall be maintained in a clean and passable condition.

B Measures shall be taken to prevent excavated material, silt or debris from entering gullies in roads and footways; entry of water to the gullies shall not be obstructed.

C Surfaced roads on the work site and leading to the work site shall not be used by tracked vehicles unless protection against damage is provided.

D Contractor’s equipment and other vehicles leaving the work site shall be loaded in such a manner that excavated material, mud or debris will not be deposited on roads. All such loads shall be covered or protected to prevent dust being emitted. The wheels of all vehicles shall be washed in proper washing pits with adequate drainage when necessary before leaving the work site to avoid the deposition of mud and debris on roads.

3.03 Reinstatement of Public Roads and Footways

A Temporary diversions, pedestrian access and lighting, signing, guarding and traffic control equipment shall be removed immediately when they are no longer required. Roads,

footways and other items affected by temporary traffic arrangements and control shall be reinstated to the same condition as existed before the work started or as permitted by the Engineer immediately after the relevant work is complete or at other times permitted by the Engineer. If the reinstatement is not performed promptly, the Engineer reserves the right to have the work performed by others and deduct cost thereof from sums due to the Contractor.

3.04 Emergency Services Access

A The Contractor shall be fully responsible for ensuring that access to adjoining properties is continuously available 24 hours/day for each and every emergency service. Such provisions shall be approved by the relevant emergency services.

B In portions of the work site bounded by fencing that obstruct fire or rescue access to occupied building entrances or arcades, the required emergency access shall be provided with colour-coded knockout panels at 10 m intervals to enable entry to be made through the fencing in an emergency.

END OF SECTION 01570

Section 01580

Project Identification Signs

Part General

1.01 Description

This Section includes Project Identification Signs and sign maintenance and removal.

1.02 Quality Assurance

The Project Identification Signs and structures shall be designed to withstand a wind speed in the Project area. Paint selection and application shall be adequate to withstand weathering, rain and high humidity, fading and chipping for the contract period. Signs shall be painted by a professional sign painter.

1.03 Submittals

Shop drawings of the Project Identification Signs and samples of the proposed sign painters work shall be submitted to the Engineer for approval in accordance with Section 01300 hereof.

1.04 Project Identification Sign

The size and locations shall be as shown on the Drawings. The signs shall include names and logos of the Employer, Funding Agency, Engineer, and Contractor; project title and contract reference.

Part 2 Products

2.01 Sign materials

The signs shall be a plywood or fibreglass mounted on a steel frame or concrete posts with concrete foundations. Paint shall conform to Section 09900 hereof and be exterior grade primer with two finish coats.

Part 3 Execution

3.01 Erection, Maintenance and Removal

A The Contractor shall erect the Project Identification Signs not later than 30 days after the Date of Commencement for the Works.

B The Contractor shall keep all signs clean, repair them if damaged and repaint them as necessary to maintain a neat and visually pleasing appearance throughout the construction period. Signs shall be replaced if missing for any reason.

C The Contractor shall remove the signs and structures, and repair ground disturbed during removal to its original condition, within one (1) month after the completion of the Works.

END OF SECTION 01580

Section 1600

Materials and Equipment

Part 1 General

1.01 Description

This Section includes:

1 Products;
2 Transportation, delivery, receiving and handling;
3 Storage and protection;
4 Products list;
5 Substitutions;
6 Product acceptance.

1.02 Products

A The term "product" in this Section means any equipment or material including proprietary goods, equipment and manufactured items that are incorporated into the Works. It does not include machinery and equipment used for the preparation, fabrication, conveying and erection of the Works.

B Products of a similar nature shall be standardized, interchangeable and supplied by the same manufacturer as proposed in the Technical Proposal, unless any substitute is agreed by the Employer and Engineer.

C Products shall be new and shall comply with the Specifications and referenced standards as minimum requirements.

1.03 Transportation and Handling

A Products shall be transported and handled so as to avoid product damage. They shall be delivered dry and in undamaged condition in the manufacturer's unopened containers or packaging. Detailed transportation and handling requirements specified in individual section of the Specifications shall be complied with.

B Shipments shall be inspected upon delivery to ensure that the products comply with the requirements of the Contract Documents and are undamaged, and also that the delivered quantities are correct.

C All products procured outside of the Project country shall be imported in the name of THE EMPLOYER, and originals of all test certificates including the guarantees and warranties to THE EMPLOYER named as the beneficiary shall be submitted to the Engineer at the time of delivery of all such products to the Site.

1.04 Storage and Protection

A Products shall be stored in accordance with manufacturer's instructions, with seals and labels intact and legible. Sensitive products shall be stored in weather-tight enclosures with temperature and humidity ranges maintained as required by manufacturer's instructions.

B Exterior storage of fabricated products shall be placed with sloped supports above ground with products subject to deterioration and those which must be kept dry entirely, covered with impervious sheeting and provided with ventilation to prevent condensation.

C Loose granular materials shall be stored on solid surfaces in a well-drained area, and mixing with foreign matter shall be prevented.

D Products shall be stored so as to allow ready access for inspection. Products shall be periodically inspected to ensure that they are undamaged and that they are maintained under required conditions.

E At all times the Engineer shall have access to, and may inspect any or all stored products and will notify the Contractor of unacceptable storage methods, protection or packaging.

1.05 Products List

A The Contractor shall submit to the Engineer four (4) copies of a list of all products to be supplied by him for installation, not later than 60 calendar days after the Date of Commencement for the Works, which list shall include the name of manufacturer and supplier, the trade name, and the model number of each product if applicable. The product list shall be arranged according to the relevant section of the Specifications in the order of section number including the specification title and the paragraph designation.

B The Contractor shall ensure that the listed products comply with the requirements of the Contract Documents.

C The Engineer will notify the Contractor in writing of any product deemed to be unacceptable. Notification shall be made not later than 30 calendar days after the submission of the products list. The Engineer's objection or failure to object to a listed item shall not constitute a waiver of the requirements of the Contract Documents.

1.06 Substitutions

A The Contractor must submit requests for substitution of the products if any, within 60 calendar days after the Date of Commencement for the Works; otherwise any Contractor's request for substitution of the products will not be considered. The Contractor shall document each request with his justification on the reason for substitution and complete data substantiating that the proposed substitution complies with the Contract Documents.

B A request for substitution constitutes a representation that the Contractor has investigated the proposed product and has determined that (a) a substitution is proposed due to inevitable reasons; (b) the proposed substitution meets or exceeds, in all respects, the specified product; (c) the same warranty as the originally proposed product will be provided for the substitution; (d) well-organized coordination will be provided to meet the installation requirements of the substitution and to make all changes necessary for the Works to be complete in all respects. The costs of such changes shall be at the Contractor's sole expense and the Contractor waives claims for additional costs resulting from the substitution which may subsequently become apparent.

C Substitutions will not be considered when such substitution is indicated or implied on shop drawing or product data submittals without separate written request complying with the above requirements or when acceptance will require substantial revisions to the Contract

Documents.

D The Engineer will determine the acceptability of the proposed substitution and will notify the Contractor of acceptance or rejection in writing within a reasonable time.

E Only one request for substitution will be considered for each product. When substitution is not accepted, the Contractor shall provide the specified product.

1.07 Product Acceptance

A All products shall be tested as required by the Specification and shall be by an approved independent laboratory or a recognized testing organization, when required either by the Specifications or the Engineer. Such tests by the manufacturer or the supplier will not generally be acceptable. The Contractor shall be responsible for all costs associated with product testing including labour, transportation and the cost of the test itself and certifications required by the specifications.

B Testing samples shall be taken at the place of origin, place of fabrication or from the site as required by the Engineer. Samples that are of value after testing shall remain the property of the Contractor. Samples used for testing may only be incorporated into the Work with the written approval of the Engineer.

C The Contractor shall provide all necessary facilities required for on-site testing of products and shall ensure that products are made available for testing sufficiently in advance of intended use so as to allow time for testing. Delays resulting from the time taken to test a product shall not be acceptable as cause for a claim.

D Prior to final inspection, all components, systems and subsystems, shall be tested to demonstrate compliance with the specified performance requirements. Such testing shall be as specified in Section 01670.

END OF SECTION 01600

Section 01650

Starting of Systems/Commissioning

Part 1 General

1.01 Description

This Section includes requirements for system and facility start-up. Exceptions to these requirements are stated in individual sections of the Specifications, which only modify the individual article and topic stated herein. Other articles and topics in this section remain in force unless specifically deleted by the individual sections of the Specifications.

1.02 Definitions

A "Component" means an individual item, piece of equipment, or equipment group as specified in a single section of the Specifications.

B "Start-up Plan" means a single and complete plan incorporating all requirements of this Section.

C "Subsystem" means a grouping or assembly of components, all of which operate together to accomplish the specified performance.

D "System" means an assembly of subsystems and components.

E "Validate" means to support, substantiate, and authenticate specified operation on a sound and authoritative basis.

1.03 Quality Assurance

A pre-start-up conference shall be scheduled not less than fourteen (14) calendar days prior to beginning start-up. The Employer, Engineer, Contractor and other responsible parties (e.g., equipment manufacturers) shall attend. The Contractor shall submit an agenda for the pre-start-up conference not later than five (5) working days prior to the conference, which shall include:

1 start-up and equipment demonstration/testing schedule,
2 examination of facilities, systems, subsystems and components,
3 problem identification and resolution.

1.04 Submittals

A All submittals shall be as specified in Section 01300 hereof, and the Contractor shall submit a Start-up Plan to the Engineer for his approval not less than 90 calendar days prior to start-up. The Start-up Plan shall provide a schedule for testing and start-up of each component and system with step by step procedures for starting each element of each system. The Contractor is responsible for means, methods, techniques, sequences, procedures, coordination, completeness, accuracy, and validity of the plan. The Contractor may submit individual sections of the start-up plan progressively as they are developed, and upon approval, incorporate these individual sections into the overall facility start-up plan. However rejection of individual sections of the start-up plan by the Engineer shall not be considered as a cause for delay in work. The plan shall identify each person and organization participating in the start-up and identify their duties and responsibilities, and

shall prepare an adequate start-up schedule taking into account of such contingencies that problems may develop during start-up or a component may fail to perform as specified.

B The Contractor shall submit the necessary shop drawings showing connections to facilitate start-up and testing, together with written descriptions of how any temporary connection will be used. Separate drawings and descriptions shall be provided for each item or subsystem identified in the start-up plan.

C Start-up validation procedures shall be submitted, giving a complete and step-by-step description of each test, simulation, and start-up. The start-up schedule shall be submitted by system or subsystem, as appropriate. Process systems are depicted on the Contract Drawings on process and instrumentation. The Contractor shall identify individuals and organizations involved in the start-up as well as their duties and responsibilities; test equipment required, including accuracy and calibration information; and shall list data requirements and identify proposed methods of demonstrating compliance with specified performance requirements,

D A validation report shall be submitted within seven (7) working days after completing start-up and validation testing, which shall include test procedures, specified performance requirements, performance data, and data evaluation.

1.05 Start-up Requirements

A The followings are prerequisites to start-up.
1 Building enclosures are complete and weather-tight, and all painting has been completed.
2 All system components have been checked by the manufacturer (where required in the Specifications) and are certified as "ready to operate",
3 Electrical and instrumentation components are connected to the permanent power supply.
4 Outdoor or partially protected equipment and system components are accessible.
5 The predicted weather is acceptable.

B The Contractor shall design and provide all:
1 process and utility connections to meet the specified design requirements of the component, subsystem, and system to which they are connected,
2 temporary supports and restraints, ensuring that no structural loads are placed on the permanent facility beyond its design capacity,
3 dielectric unions on temporary connections wherever dissimilar metals connect, and
4 safety devices on temporary connections wherever they would be required if the connections were permanent.

C The Contractor shall :
1 conduct field test on each system and all of its components,
2 demonstrate compliance with the performance specified in the individual sections of Specifications; including operation in all available modes (e.g., manual and automatic), and
3 collect operating data for all system components as specified.

D The Contractor shall:
1 maintain all components through completion of start-up and testing,
2 follow manufacturer's recommendations,
3 record all maintenance or repairs performed, and

4 submit records to the Employer with validation report.

Part 2 Products

2.01 Temporary Connections

The Contractor shall provide all materials necessary for temporary connections. Materials shall be adequate for the application, and the Engineer shall be the sole judge of suitability.

2.02 Chemicals and Operating Fluids

The Contractor shall provide all necessary chemicals, power, fuels and operating fluids required for duration of start-up and performance testing. Products and items required for testing and start-up shall be provided in addition to those provided under the Specifications.

2.03 Spare Parts

The Contractor shall provide all maintenance and replacement parts required during start-up and testing. Maintenance and replacement parts used by the Contractor during the start-up and testing shall be provided in addition to those required by the Specifications.

Part 3 Execution

3.01 Component and System Validation

A Each component and each system shall be validated using one or more of the methods described below:
1 field testing to show compliance with the Specifications,
2 simulate actual operation using a method certified as acceptable and valid by both the component manufacturer and the Engineer,
3 certification by an independent testing laboratory that the component meets the specified industry standard.

Where test procedures are specified, substitute procedures will not be accepted without prior written approval from the Engineer.

B Validate components prior to system start-up and testing. Component validation shall include, but not necessarily limited to, the followings:
1 operate each component over its full design range,
2 demonstrate manual and automatic operation of all components,
3 demonstrate all emergency shut down and safety devices,
4 demonstrate normal start-up and shut-down procedures,
5 demonstrate “out of parameter” corrections,
6 document actions taken and procedures developed on aspects which are not covered in the Operation and Maintenance manual. Provide this information as an Appendix to the manuals.

C Validate each system to demonstrate that components operate together to produce the specified system performance. Validation shall require the same items as required for the individual components.

3.02 Validation Prerequisites

The following items must be satisfactorily completed before validation may commence:

1 Start-up submittals have been accepted.
2 Manufacturers have certified component installations wherever required.
3 Specified manufacturer's field services have been completed.
4 Auxiliary and support systems are running properly.
5 No safety defects exist.
6 Arrangements for waste disposal (both solid and liquid) have been made.
7 All manual and automatic controls are operational.
8 All equipment has been lubricated and serviced, and it is ready for continuous operation.

3.03 Validation Preparation

The Contractor shall implement safeguards and procedures to protect equipment and facilities from damage during start-up and performance testing and shall construct approved temporary connections and test all temporary connections using the same procedures that would be required if the connection were permanent.

3.04 Performance Testing

A Where appropriate (e.g., will not cause damage), tests shall be conducted using either raw sewage, or as approved appropriate by the Engineer.

B Components and subsystems shall be tested before testing the complete system.

C Each test shall be conducted in accordance with the approved testing procedures, and shall be scheduled and coordinated with the Engineer. The Engineer shall be notified at least 48 hours prior to re-scheduling a test. The Engineer shall observe all tests in their entirety.

D The Contractor shall repair or modify components, subsystems, and systems which do not meet specified performance criteria. The cost of repairs or modifications shall be at the Contractor's expense, and testing shall be repeated until acceptable performance is achieved. A maximum of two re-tests will be allowed (three tests in total) unless the Engineer agrees in writing that additional tests are justified. All equipment, which does not meet the specified performance, shall be removed and replaced with equipment which can meet the criteria, and all such work, including the cost of the replacement, shall be at the Contractor's expense. Alternatively the Employer may elect to withhold funds from amounts due to the Contractor and/or claim against the Contractor's Performance Security, in lieu of replacing the faulty equipment, in accordance with the provisions of the General Conditions of Contract and the terms and conditions of the Performance Security.

E The Contractor shall collect operating data as specified and, at the conclusion of start-up and testing, shall drain all water and other fluid, as directed by the Engineer; replace or clean all filters; replace operating fluids, and shall perform equipment services recommended by the manufacturer.

3.05 Field Quality Control

Test equipment used for performance validation shall be calibrated immediately prior to testing. Calibration shall be reconfirmed immediately after testing. Re-testing will be required whenever test equipment is out of calibration at the conclusion of validation testing. The Engineer shall be present during calibration validation.

END OF SECTION 01650

Section 01661

Operational, Field and Performance Testing

Part 1 General

1.01 Description

This Section includes operational, field and performance testing.

1.02 Operational, Field and Performance Testing

A After all construction is complete and before acceptance, the Contractor shall perform operational, field and performance tests as called for in the Specifications. The Contractor shall demonstrate to the Engineer the operation of the facilities for proper sequence of operation and satisfactory performance of the system and individual components. Any improper operation of the system or any improper, neglected or faulty construction shall be repaired or corrected to the satisfaction of the Engineer. The Contractor shall make such changes, adjustments or replacement of equipment as may be required to make the same comply with the Specifications, or replace any defective parts or material.

B At the time of testing, failure of the system to perform at the specified level will be the responsibility of the Contractor. In the event of failure of equipment to meet the specified performance, the Employer reserves the right to not accept such equipment or system, withhold funds due to the Contractor and/or make claims on the performance security.

C The Contractor shall prepare and submit a consolidated schedule of operational, field and performance tests not later than three (3) months before the scheduled start of the first test. The schedule shall be updated at monthly intervals. The Contractor shall prepare and submit weekly a schedule of tests to be carried out during the following week and shall inform the Engineer not later than twenty-four (24) hours in advance of changes in the scheduling of a test.

D For all specified performance tests, the Contractor shall prepare and submit:
1 draft test procedures not later than two (2) months in advance of the scheduled date,
2 final test procedure not later than two (2) months in advance of the scheduled date, and
3 test report within fourteen (14) days after the successful completion of the test.

END OF SECTION 01661

Section 01670

Training

Part 1 General

1.01 Description

This Section establishes the requirements for operation and maintenance training. Exceptions to these requirements are in individual sections of the Specifications, which only modify the individual article and topic stated herein. Other articles and topics in this section remain in force unless specifically deleted by the individual sections of the Specifications. Training required by this Section is in addition to, and not a replacement for, manufacturer's equipment training required by the individual sections of the Specifications. The Employer reserves the right to hold video tape or otherwise records the instruction in training presentations.

1.02 Training Requirements

A The Contractor shall develop individual training courses for each system identified on the Contract Documents. Three separate training sessions shall be provided for mechanical operations, mechanical maintenance, and electrical and instrumentation operation and maintenance All manuals and presentations shall be presented, or conducted, in the English language.

B The Contractor shall develop and submit the curriculum to the Engineer for approval based on the following:
1 The curriculum shall be established for high school graduate level and shall include tests with at least 15 questions on each outline topic
2 A task and skills analysis shall be performed, identifying the requirements for proper operation, maintenance, and repair of the system and all of its components.
3 A training analysis shall be performed, identifying tasks requiring training; logical order of presentation; objectives of each training segment; and methods for measuring achievement of objectives for each segment.

C An instructor's manual shall be prepared, including notes to the instructor, for each training session. The manual shall address:
1 session objectives,
2 session outline,
3 session application,
4 instructor qualification and knowledge requirements,
5 list of tools and supplies required for instruction,
6 safety and standby equipment,
7 student and course evaluation forms,
8 audio/visual resources or reproductions,
9 session tests and a grading guide,
10 references to the source of answers shall be provided in the course material, and
11 additional notes such as references, review questions, demonstration techniques, class exercises, coordination with other sessions, and achievement measurements.

D Instruction shall be in accordance with the following:
1 Timing of sessions shall be to suit the Employer's normal working hours.
2 A 10 minute break shall be provided after each hour of instruction.

3 The size of the class shall not exceed 15 people.

E Minimum curriculum requirements shall be the following aspects:

1 Theory of operation and control shall include both classroom and "hands on" training,
2 How to use the Operation and Maintenance Manual including the location of information,
3 System layout,
4 Wiring, instrumentation and controls,
5 Control sequence and logic,
6 Normal and emergency operating procedures,
7 Basic and advanced operation and maintenance,
8 Equipment/instrument adjustment and calibration,
9 Site walk through to locate and identify equipment,
10 Preventive maintenance,
11 Major maintenance,
12 Safety,
13 Trouble shooting,
14 How to use special tools,
15 Operation and maintenance supplies,
16 Spare parts.

1.03 Submittals

All submittals shall be as specified in Section 01300 hereof, and the following shall be written in English and submitted to the Employer for approval:

1 Curriculum development document.
2 One copy of an instructor's manual shall be provided for review. After acceptance (and before training) one copy and one camera-ready original shall be provided.
3 Complete schedule of training activities including: schedule of submittals; schedule of classes; and coordinate with start-up activities specified in Section 01650 hereof.
4 Training plan including course outline; time allocation for each training segment and instructor qualifications.
5 Presentation materials - two reproducible copies.
6 Manuals and class hand-outs – one reproducible copy for review and one copy for each student at least five working days prior to class.

1.04 Quality Assurance

A The minimum experience for the instructor shall be three years actually operating and maintaining equipment and he/she shall have academic or factory training with a combination of training and experience. The Employer reserves the right to reject instructors lacking experience and education required to conduct the training. The instructor's qualifications shall be submitted for approval.

B A pre-training conference shall be scheduled not less than seven (7) calendar days prior to training. The Employer, Engineer, Contractor, a training instructor(s), and other responsible parties shall attend. The Contractor shall submit an agenda five (5) working days prior to the conference. The agenda shall include: training schedule; examination of training facilities; and problem identification and resolution.

1.05 Training Area

The training area shall be provided by the Contractor and the minimum requirements to be provided are:

1 air conditioned,
2 seating for 15 trainees,
3 tables suitable for students to write and lay out class materials,
4 all equipment required for audio/visual presentations.

1.06 Sequencing and Scheduling

A The Contractor shall conduct classroom training prior to system start-up and conduct hands-on training prior to system demonstration tests.

B The Contractor shall notify the Engineer at least three (3) working days in advance of scheduled training of any delays. Failure to provide required notice shall make the Contractor responsible for costs incurred by the Employer for Employer's personnel. The Employer may delay scheduled training by up to five (5) working days for personnel time conflicts, but shall notify the Contractor of delay at least three (3) working days in advance of scheduled training.

Part 2 Products

2.01 Materials

The Contractor shall provide; all materials and supplies (including consumables) necessary for training and demonstrations; special tools required for training and demonstrations; and all safety equipment required by instructors.

Part 3 Execution

3.01 Preparation

All required submittals must be approved prior to their use by the Contractor in delivering training courses. The Contractor shall assemble instruction materials and set up demonstration material prior to classes.

3.02 Training

A The Contractor shall provide not less than the days of training specified in the Particular Specifications.

B The Contractor shall prepare a student evaluation for each attending student and present in a summary report. Originals of the student course evaluations shall be submitted to the Employer in the summary report.

C The Contractor shall evaluate students' understanding of course material and shall conduct written tests at the end of each training segment. Tests shall be graded and evaluated to ensure fulfilment of course objectives. The original graded tests shall be submitted to the Employer.

D Training methods, teaching techniques, and trainer qualifications will be evaluated by the Employer or his designated representative. Unacceptable training will be repeated at the Contractor's cost.

END OF SECTION 01670

Section 01700

Contract Close-out

Part 1 General

1.01 Description

This Section includes:

1 Substantial Completion.
2 Final Inspection.
3 Close-out Procedures.
4 Approvals from Public Authorities.
5 Final Cleaning.
6 Equipment Operating Data.
7 Operating and Maintenance Instructions.
8 Warranties and Bonds.
9 Spare Parts and Maintenance Materials.

1.02 Definitions

Contract close-out requirements include general requirements in preparation for final acceptance such as final payment; normal termination of the Contract and similar actions evidencing completion of the Work. Specific requirements for individual units/sections of the Works are specified in the individual sections of the Specifications. Time of close-out is directly related to substantial completion and may be a single time period for the entire work. It may also be a series of time periods for individual parts of the Works that have been certified as "Substantially Complete" at different dates. These procedures shall accord to the provisions of the General Conditions of Contract.

1.03 Prerequisites for Substantial Completion

For substantial completion of the Works, the Contractor shall comply with the following:

1 submit final manufacturer certifications, guarantees, warranties, and similar documents,
2 submit clearance certificates and approvals from government authorities as necessary to connect the Works to the permanent power supply,
3 submit occupancy permits, operating certificates, final inspection and test certificates and similar releases enabling full and unrestricted use of the Works,
4 submit record drawings, final operation and maintenance manuals, final project photographs, damage or settlement surveys, property surveys, and similar physical items,
5 make final changeover of locks and deliver keys to the Engineer,
6 complete start-up, testing of systems, and training of the Employer's operations and maintenance personnel to the extent that is required to conduct prior to the taking-over of the Works by the Employer. Submit equipment operating data as well as all test reports and test data required by the Contract,
7 dismantle and remove temporary facilities and services from the Site. This includes utilities, construction equipment and tools, buildings and facilities, mock-ups, and similar elements,
8 complete final cleaning,

9 repair and restore exposed finishes which have been marred or damaged,
10 submit all spare parts, tools and maintenance equipment,
11 submit an itemized list of all deviations and non-conformances to the contract requirements including the detailed plan to correct each deviation and non-conformance,
12 notify the Engineer that the facilities or Works are ready for the substantial completion inspection. Include the itemized list of deviations and non-conformances in the notification letter.

1.04 Prerequisites for Final Inspection

A The Contractor shall:
1 submit the Engineer's and Contractor's list of deficiencies from the substantial completion inspection stating how each item has been corrected or otherwise resolved for acceptance;
2 submit final meter readings for all utilities, a measured record of stored fuel and chemicals, and similar data as of the time of final completion;
3 complete listing of all consumable stores and spare parts used by the Contractor to service the electro-mechanical works throughout the maintenance period;
4 complete submittal of record documents;
5 notify the Engineer that the facilities or Works are ready for the final inspection including the itemized list of deviations and non-conformances in the notification letter.

1.05 Contract Close-out Procedures

A The Contractor shall comply with specified and contractual procedures necessary for issuance of the "Certificate of Substantial Completion" and eventually "Taking-over Certificate" in accordance with the provisions of the General Conditions of Contract.
B When the Contractor considers that the Works have reached completion, the Contractor shall submit the following:
1 statement that the Contract Documents have been reviewed, works have been inspected and are complete and meet the requirements of the Contract Documents.
2 all submittals required by governing authorities.
3 any supplemental data and documents to substantiate the completion as required by the Engineer.

1.06 Approvals from Public Authorities

The Contractor shall obtain all clearance certificates and approvals required as a prerequisite to connecting the Works to the permanent power supply and shall coordinate with the Engineer to obtain all necessary documents from the Local Authority and other relevant authorities regarding final clearances.

1.07 Final Cleaning

A Prior to final inspection the Contractor shall clean all interior and exterior surfaces exposed to view but shall avoid disturbing natural weathering of exterior surfaces and shall:
1 remove temporary labels, stains, and foreign substances,
2 polish transparent and glossy surfaces,
3 clean or replace all air and oil filters for mechanical equipment,
4 clean roofs, gutters, downspouts, and drainage systems,
5 remove debris and surface dust from limited access spaces,
6 clean concrete floors in unoccupied spaces broom clean,

7 clean light fixtures and lamps and install light bulbs so they operate at maximum efficiency,
8 clean the plant site,
9 sweep paved areas and rake all other surfaces,
10 remove litter and foreign substances,
11 remove stains, chemical spills, and other foreign deposits.

B The Contractor shall comply with safety standards and governing regulations for cleaning operations and shall:
1 not burn waste materials at the site;
2 not bury debris or excess material on the site;
3 not discharge volatile or other harmful or dangerous materials into the drainage or sewerage systems;
4 remove and properly dispose of all waste materials from the site.

1.08 Project Record Documents

A Documents shall be stored separately from those used for construction, in a secure, fire resistive location and protected from deterioration and loss. Documents shall be kept current throughout the construction period, and works shall not be concealed until "As-Built" information has been recorded.

B For record drawings (as-built) the Contractor shall:
1 maintain a blue line or black line set of prints of all Contract Drawings and Shop Drawings;
2 keep drawings clean and undamaged;
3 mark up drawings to show actual installation if that differs from what is shown on the Contract Drawings. Changes shall be marked up using a red erasable pencil showing "as built" conditions fully and accurately;
4 mark up drawings to show new information of importance which was not shown on either the Contract Drawings or the Shop Drawings. Particular attention shall be given to concealed work that will be difficult to measure or record at a later date;
5 note related change order numbers, as applicable, next to the relevant item on the record drawing;
6 submit documents with transmittal letter containing date, project title, Contractor's name and address, itemized list of documents, and the Contractor's signature.

1.09 Equipment Operating Data

A The Contractor shall provide operating data for all equipment specified in the Specifications and shall:
1 comply with Section 01300 hereof and submit four sets prior to final inspection;
2 index and present data in a three-ring side binder with durable plastic cover;
3 present data on A4 size paper;
4 separate data by process system. Process systems are defined by the process and instrumentation diagrams included with the Contract Drawings.

B The operating data identified below shall be provided for each motor operated equipment item in the stated divisions of the Specifications. The data shall be obtained with the equipment operating under design conditions and while handling the process fluid or material specified. No readings shall be taken until the equipment has operated as specified for at least one (1) hour.
1 description of material handled;

2 materials or fluid delivery rate;
3 system operating temperature and pressure;
4 motor operating speed;
5 motor current draw under normal operation and under starting conditions;
6 bearing operating temperatures;
7 vibration levels for equipment items with specified vibration limits;
8 noise levels for equipment items with specified noise limits.

1.10 Operating and Maintenance Instructions

The Contractor shall provide Operation and Maintenance Training as specified in Section 01670 hereof and approved Operation and Maintenance Manuals as specified in Section 01730 hereof prior to the final inspection.

1.11 Warranties

The Contractor shall provide, in duplicate, notarized copies of all specified guarantees and warranties, including those required of manufacturers, suppliers and sub-contractors. Documents shall be assembled in a binder with a durable plastic cover and with a table of contents. The start of the Defects Notification (Defect Liability) period shall be as defined in the Contract.

1.12 Spare Parts and Maintenance Materials

A The Contractor shall provide products, spare parts, and maintenance materials as specified in the relevant sections of the Specifications, together with itemized lists of all items furnished, describing each item and citing the relevant section and paragraph of the Specifications. Each item shall be packaged for long term storage and shall be marked or tagged for easy identification.

B Items shall be delivered to the Site. The Contractor shall provide an inventory of items to the Engineer, and obtain a receipt prior to final payment. Complete listings of all consumable stores and spare parts used by the Contractor during the maintenance period shall be provided.

END OF SECTION 01700

Section 01730

Operation and Maintenance Manuals

Part 1 General

1.01 Description

This Section includes format and content of Operation and Maintenance (O&M) Manuals and the submission schedule thereof.

1.02 Submittals

Final O&M Manuals are required to be submitted prior to Substantial Completion.

1.03 Format

A Manuals shall be prepared as instruction manuals and presented in commercial quality, three ring binders with hard plastic coated covers and maximum ring size shall be 75 mm. Manual contents shall be organized into numbered section titles and each section shall be separated by a tabbed fly sheet.

B The Contract number and title of the "OPERATION AND MAINTENANCE MANUAL" shall be printed on the cover of each binder, listing the contents of each binder on the cover.

C All manuals shall be prepared in English.

1.04 MANUAL CONTENTS

A Operation and Maintenance manuals shall include, but not limited to:

1 A detail description of the Sewage Treatment Plant, Pumping Stations and other associated facilities as installed and commissioned.

2 A full description of the individual systems installed, written to ensure that the Employer's s staff understand the scope of facilities provided.

3 Interface details between the equipment systems within the Works and related systems installed by others.

4 Diagrammatic drawings of each system indicating principal items of plant, machinery, equipment, pipes, valves etc.

5 A photo-reduction of all record drawings to A2 to A3 size together with an index.

6 Legend for all colour-coded services.

7 Schedules (system by system) of plant, machinery, equipment, pipes, valves, etc., stating their locations, duties and performance figures. Each item shall have a unique number cross-referenced to the record and diagrammatic drawings and schedules.

8 The name, address and telephone number of the manufacturer of every item of plant, equipment and materials together with catalogue list numbers.

9 Manufacturer's technical literature for all items of plant, equipment and materials assembled specifically for the Works, including detailed drawings, electrical circuit details and operating and maintenance instructions.

10 A set of all certified test certificates and reports (including but not limited to electrical circuit tests, corrosion tests, type tests, works tests, start and commissioning tests) for the installation and plant, equipment, pipes, valves, etc., used in the installation.

11 A set of all manufacturers' guarantees or warranties.

12 Starting-up, operating and shutting-down instructions for all equipment and systems installed.

13 Control sequences for all systems installed.

14 Schedules of all fixed and variable equipment settings during commissioning.

15 Procedures for seasonable changeover.

16 Recommendations as to the preventive maintenance frequency and procedures to be adopted to ensure the most efficient operation of the systems.

17 Lubrication schedules for all lubricated items.

18 A list of normal consumable items.

19 A list of recommended spares to be kept in stock by the Employer, being those items subject to wear or deterioration and which may involve the Employer in extended deliveries when replacement are required at some future date.

20 Procedure for fault finding.

21 Emergency procedures, including telephone numbers for emergency services.

22 Other useful data and information regarding the operation and maintenance of the equipment and system as required by the Employer's operating personnel.

B The Contractor shall prepare the manuals in A4 size plastic covered, loose leaf, four (4) ring binders with hard covers, each indexed, divided and appropriately titled. The Contractor shall properly fold drawings larger than A4 to accommodate them in the binders. The Contractor shall prepare five (5) preliminary sets of manuals with preliminary record drawings and preliminary performance data available and submit them at the commencement of pre-commissioning to enable the Employer's operating personnel to familiarise themselves with the documentation and to acquaint themselves with the installed equipment and facilities.

C The submitted documents will be used during the pre-commissioning and post commissioning periods, and relevant comments will be forwarded to the Contractor for incorporation into the final manuals for the approval of the Engineer. These will become the format for the final manuals.

1.05 EMERGENCY RESPONSE PLAN

A O&M Manuals should have a section for the Emergency Response Plan (ERP) for the constructed Sewage Treatment Plant (STP) and associated facilities. ERP should describe actions and procedures to deal with all anticipated hazards, both natural and man-made that could adversely affect the operation of the STP, associated facilities and/or the environment.

There are four phases of emergency activities:

- Emergency preparedness planning
- Mitigation
- Response.
- Recovery

B ERP should identify the hazards and dangers arising from the operation of the sewerage works. Examples of hazards are chemical release, power supply shortage, pipe ruptures, fire, strike, etc. The corresponding dangers are electrocution, plant shutdown, health risks and death, damage to the environment, etc.

C ERP for each potential situation caused by the occurrence of hazards should be developed and described. A typical ERP outlines the following:

1 Emergency flow chart

- Contact lists: name, position, location, telephone numbers (including home numbers)
- Chain of commands for the line of authority in an emergency
- Organisation chart of duties identifying each group and its emergency response activities
- Emergency equipment list of all heavy equipment and vehicles by their locations
- Damage assessment forms
- Maintenance or clean-up contractor list
- Public information procedures for communication about emergency and response activities
- Emergency operations centre

D During O&M training to be conducted by the Contractor, he shall provide regular and appropriate training to personnel in emergency preparedness procedures.

END OF SECTION 01730

DIVISION 2.

SITE WORK

Section 02060

Demolition

Part 1 General

1.01 Description

This section includes all demolition required on the Works. Principle items are as follows:

1. Demolition of the existing on-site buildings and structures shown on the plans, which includes dismantling, removal, and off-site disposal of all existing facilities complete including steel frames, wood structures, electrical poles, concrete footings, fencing, piping, fittings, concrete foundations and concrete slabs.
2. Arranging with affected utility providers for removal of equipment owned by them and disconnection, capping or plugging of utility services to those building to be removed.
3. Obtain all necessary permits, licenses and/ or inspections and pay all fees and/or provide all bonds required for work under this section if required by any governing authority.

1.02 Title To Property

A All materials resulting from demolition work, except as indicated or specified herein, shall become the property of the Contractor, which shall be removed from the Site and disposed legally. Rubbish, materials and debris shall be removed daily so as to not accumulate on the Site.

1.03 Submittals

A. Procedures proposed for the accomplishment of demolition work shall be submitted for approval by the Engineer. The procedures shall provide for the safe conduct of the work, removal and deposition of materials, protection of property outside the limits of the work site, coordination with other work in progress, timely disconnection of utility services and provision of a temporary water supply. Methods and equipment to be used as well as the sequence of operations shall be included.

B. The Contractor shall record with the Employer, the condition of structures and other facilities adjacent to or within the areas of work which are not to be disturbed. Such record shall include the elevations at the top of foundations, location and extent of existing cracks and other damage, and the description of surface conditions that exist prior to the start of work. Any cost to record by video the existing conditions including that of surveying for elevations is to be included in the price for demolition. Submit two copies of the video tape record.

1.04 Condition of Structures

A. The Employer assumes no responsibility for actual conditions of the buildings and structures to be demolished. No plans exist on any of the existing facilities. Walls, foundations and base dimensions and embedded rebar sizes if any, are not known. The Contractor shall carefully examine the Site and make all inspections necessary in order to determine the full extent of the work required. The Contractor shall satisfy himself as to

the nature and location of the work, conditions of the facilities upon the ground surface and subsurface materials or obstacles to be encountered.

B. A soil investigation report is available for review at the office of the Employer. The report and related information depict subsurface conditions only at the specific locations and at the particular time designated on the boring logs. Soil conditions and ground water levels at other locations may differ from those occurring at the boring locations.

1.05 Salvage

Items of salvageable value to the Contractor may be removed from the work as it progresses. Salvaged items shall be transported from the Site as they are removed. Storage or sale of removed items on the Site is not permitted.

1.06 Protection

A. The Contractor shall conduct demolition operations and removal of debris to ensure minimum interference with existing water supply (or temporary water supply installed by the Contractor), bridges, roads, streets and other adjacent occupied or used facilities including those on-site. The Contractor shall not close or obstruct public streets without written permission from authorities having jurisdiction; provide temporary barricades, fences, canopies, railings or other safeguards to eliminate hazards to persons and property without interference to use of adjacent property, public rights-of-way, utilities and structures, and also provide any signs or lights deemed necessary by the Engineer.

B The Contractor shall prevent the spread of dust and flying particles and sprinkle rubbish and debris with water to keep dust to a minimum during dry conditions.

C The Contractor shall maintain adequate fire protection, including operative water hose lines from the temporary water supply during demolition.

1.07 Safety

A The use of explosives is not permitted.

B Materials and debris shall not be disposed of by burning at the demolition sites.

Part 2 – Not used

Part 3 – Execution

3.01 General

A After the Date of Commencement for the Works and after temporary water supply facilities have been erected, The Contractor shall assume responsibility for buildings, structures and items shown to be demolished and removed, until such work is completed.

B Notices to the effect that demolition is in progress and that structures may be in a dangerous state shall be placed at the site of demolition so that they are clearly visible.

C Work shall be performed by personnel experienced in this type of work and in such a manner as to eliminate hazards to persons and property without interference with new work and without use of adjacent areas, public rights-of-way, utilities and structures. Shoring and bracing shall be provided as necessary.

D Except as otherwise indicated or directed, salvageable items, rubbish and debris resulting from demolition shall become property of the Contractor, be disposed of off-site and will not be allowed to accumulate or be buried on site.

E The Contractor shall coordinate fully with work of other trades, and perform all work in conformance to applicable requirements of the Safety Orders herein specified.

3.02 Utilities

A The Contractor shall issue written notices of planned demolition operations to owners of utilities having on-site facilities.

B The Contractor shall arrange with utility owners and the Employer to remove any equipment owned by them on the property to be demolished, and also request them for removal, disconnection, capping or plugging of their services to facilitate demolition work. Unless otherwise indicated by the utility owners, the Contractor shall take appropriate measures to seal and cap all utilities at the property line, if not done by the utility owners in accordance with their rules and regulations. Existing water faucets and taps may be left for use during demolition work, but shall be removed prior to final completion, and the water lines sealed and capped. Water services existing below ground need not remove from the Site, but shall be capped with a minimum of 300mm below the surface. Remove completely all electrical poles and wires from the Site once disconnected by the power authority and if not removed by them.

C Unless otherwise noted by the utility owners, the Contractor shall preserve in operating condition all active utilities traversing the Site, and repair damage to such utilities caused by demolition work to the satisfaction of the utility owner(s).

3.03 Demolition

Concrete walls, foundations and slabs in small sections shall be demolished in continuously wetting down debris to prevent creation of dust, and all debris or materials shall be hauled from site promptly as they accumulate.

B The existing buildings and structures shown to be removed shall be totally demolished and removed to the depth of the foundation, footings or slabs. Any resulting voids or openings below the existing adjacent finish grade shall be filled to the level of the finish grade to provide surface water drainage with clean, uncompact dirt from the same property and to 95 percent compaction. Prior to placement of fill material, the Contractor shall ensure that areas to be filled are free of standing water, trash and debris. Concrete slabs shall be broken up and removed.

3.04 Cleaning roads

Precautions shall be taken to maintain cleanliness on roadways and other public areas. The Contractor shall be responsible for immediate removal of all spillage.

3.05 Clean-up

The Contractor shall remove from the site all rubbish and debris, as well as all materials found thereon, and all materials and debris resulting from demolition and shall leave site in safe and clean condition.

END OF SECTION 02060

Section 02200

Earthwork and Site Preparation

Part 1 General

1.01 Description

Principal work in this Section includes requirements for earthwork including site preparation. The entire area within the limits of earthwork, as indicated, shall be constructed to the lines, grades, elevations, slopes, and cross sections indicated on the Drawings. Slopes shall present a neat uniform appearance upon completion of the work and shall be approved by the Engineer. Excavated materials meeting the requirement of fill materials may be conserved for subsequent use or placed as earth fill immediately after excavation upon approval of the Engineer. If not re-used within one day, the storage in streets for sub-sequent use as back-fill will not be permitted. Large rocks, unacceptable as earth fill material, may be stockpiled for use as riprap, if required in the works, subject to all requirements specified for riprap in the Specifications. The Engineer shall determine suitability of all excavation materials for specific purposes. The Contractor shall not waste or otherwise dispose of suitable excavated materials unless otherwise directed by the Engineer. All excavation shall be performed under the limitations and requirements set out in the relevant sections of the Specifications pertaining to control of water.

1.02 Definitions

The following terms shall have the meanings assigned to them:

1	"Topsoil"	means any surface materials suitable for use in areas to be grassed or cultivated.
2	"Bulk Excavation"	means excavation in open cut in all material of whatever nature encountered (excluding Trench and Structure Excavation) down to levels specified on the Drawings or otherwise as being the general levels after completion of excavation other than Incidental Excavation.
3	"Trench Excavation"	means excavation of trenches in all material of whatever nature encountered into which pipes, ducts or cables are to be laid and appurtenances constructed to levels and limits specified on the Drawings or otherwise.
4	"Structure Excavation"	means excavation in all material of whatever nature encountered for the construction of pump stations, tanks, structure and building footings and other structures to levels and limits specified on the Drawings or otherwise.
5	"Incidental Excavation"	means excavation in all material of whatever nature encountered (generally in small quantities) below or outside the limits of Bulk Excavation, Trench and Structure Excavation, but excluding Excess Excavation.
6	"Excess Excavation"	means excavation in all material of whatever nature encountered outside the limit specified for Bulk, Trench, Structure or Incidental Excavation.
7	"Rock Excavation"	means excavation of a natural material that is so hard

that, in the opinion of the Engineer, it cannot be removed by the ordinary methods of hand or machine excavation without undue difficulty, or without preliminary work to break or loosen the material by use of blasting, impostors, or similar procedures.

"Rock" shall include "hard material" that is similarly defined as artificial material such as brickwork or concrete that, in the opinion of the Engineer, is so hard that it cannot be removed by the ordinary methods of hand or machine excavation without undue difficulty or without preliminary work to break or loosen the material.

Use of such preliminary procedures, however, will not in itself justify rock or hard material classification. The Contractor shall notify the Engineer as soon as he encounters rock or hard material for which he intends to claim payment to permit an assessment to be made as work proceeds.

1.03 Quality Assurance

Testing of all materials shall be carried out by an approved, independent, laboratory which is fully equipped to carry out site, and laboratory, testing. Details of the proposed laboratory shall be submitted for the Engineer's review and approval at least 15 days before commencing earthwork.

1.04 Earthwork

Earthwork shall include all site preparation to the lines, elevations and grades, indicated on the Drawings, including the following:

1 excavation of all materials of whatever nature encountered; handling, hauling and compaction of required fill materials; disposal of all excess excavated material;
2 bracing, shoring and protection work;
3 preparation of subgrade;
4 dewatering as necessary;
5 protection of adjacent property;
6 backfill;
7 surface reinstatement;
8 riprap;
9 embankment.

1.05 Site Investigation

A The soils investigation report prepared for the Project is available for inspection at the office of the Employer or Engineer by prior appointment. This report is for information only and without any warranty as to the correctness of the information contained therein. Availability of this report to the Contractor does not relieve him of his obligation to thoroughly investigate for himself the nature of the Site and the sub-soil conditions therein and his obligations and responsibilities under the terms and conditions of the Contract.

B The Contractor shall be deemed to have visited the Site prior to submitting his Tender and made all necessary inspections and investigations and shall be deemed to have allowed for these in his Tender, including:

1 means of access and working space;
2 clearing and grubbing;
3 natures of the ground and sub-soils;

4 presences of existing buildings, structures and foundations or other hidden obstructions;
5 level of the water table;
6 extent of rock;
7 support to neighbouring properties and structures;

All factors affecting the work, including any information made available to the Contractor, either in these documents or by any other source, will not relieve the Contractor of his responsibility to decide for himself the nature and extent of the work nor will it guarantee that similar conditions will apply on other parts of the Site. The Contractor shall be deemed to have contacted the relevant statutory bodies to establish the existence of any existing, live or redundant services adjacent to or passing through the Works and shall be deemed to have allowed in his Tender for their diversion or removal. Boring logs and related information depict subsurface conditions only at the specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at the boring locations. The passage of time may result in a change of the subsurface conditions or water levels at the boring locations. The Employer does not guarantee any statements, opinions, or conclusions contained in the report. The Contractor shall assume all responsibility for deductions and conclusions made by him regarding the nature of the materials to be excavated; the difficulties involved; dewatering; maintaining the required excavations; and carrying out the work affected by the subsurface conditions at the site of the works. Neither the Employer nor the Engineer shall be liable for any loss sustained, indicated by or deduced from said borings, samples, tests, and/or reports, and the actual conditions encountered during progress of the work.

1.06 Levels to be Recorded

Before the surface of any part of the Site is disturbed or the works thereon are begun, the Contractor shall take and record levels of such part, in the manner specified or as agreed with the Engineer. Two (2) working days notice is to be given to the Engineer so that the recording of levels can be performed in the presence of the Engineer.

1.07 Explosives and Blasting

Blasting is not permitted unless authorized by the appropriate authorities.

1.08 Temporary Fencing

A Unless otherwise directed by the Engineer, all open excavations and other hazardous areas shall be totally enclosed on all sides by temporary fencing.

B In all cases, locations of the temporary fencing proposed by the Contractor shall be submitted to the Engineer for approval prior to installation. The Contractor shall not commence any works until the associated temporary fencing is erected and the installation has been approved by the Engineer.

C Damaged sections of temporary fencing shall be repaired or replaced promptly to maintain at all times the standard of fencing and installations as initially approved at no extra cost to the Employer. Temporary fencing shall not be removed from any location without the prior written approval of the Engineer. The name of the Contract and Contractor shall be affixed at regular intervals on these temporary fences.

1.09 Temporary Works

A The Contractor shall protect all property and utilities, shall maintain them during the course of the work and shall repair all damage caused by construction activity. The Contractor shall comply with all local rules and regulations for the use of streets.

B The Contractor shall include for all temporary works to maintain and protect existing power, lighting, water and telephone services while the works are being executed. Temporary

shutdown of the services shall only be made with the prior approval of the Engineer and the owner of the services. The Contractor shall allow for protecting and maintaining all pipes, culverts, ducts and cables crossed by, or parallel to, his excavations; for keeping all ditches, gullies and channels clear and unobstructed and making good any damage caused to public or private wastewater systems and roads, paths, kerbs and drains and paying all costs and charges incurred.

C The Contractor shall provide protection against rain, wind, storms, or heat to maintain the works, materials, apparatus, and fixtures free from injury or damage. Work likely to be damaged shall be covered at the end of each day's work.

D The Contractor shall ensure that all temporary installations are executed in accordance with the requirements of the authorities concerned. All temporary works are to be properly and adequately maintained and on completion of the Contract, or when directed by the Engineer, shall be cleared away by the Contractor. Damage to new, or existing, works that arises as a result of failure by the Contractor to provide proper protection, shall be repaired, or replaced, as directed by the Engineer, at the Contractor's expense.

1.10 Bracing and Shoring

A Excavated surfaces shall be supported as necessary to safeguard: work and workmen; to prevent sliding or settling of the adjacent ground; to avoid interruptions in existing services; damage to existing improvements and utilities infrastructure.

B The width of the excavation shall be increased, if necessary, to provide space for sheeting, bracing, shoring, and other supporting installations.

C The Contractor shall furnish, place and subsequently remove such supporting installations unless ordered otherwise by the Engineer.

D Before commencement of excavation for trenches or any structure, the Contractor shall furnish three copies of drawings showing details of the bracing he proposes to use, together with all relevant calculations prepared by a qualified engineer. One copy of the drawings indicating modifications which in the Engineer's opinion are required for the safety of personnel and/or works will be returned to the Contractor.

E Where the Contractor proposes to excavate with battered side slopes instead of providing sheeting, shoring, etc., as aforementioned, the Contractor shall furnish three copies of a report by a competent soils engineer, together with all relevant calculations, demonstrating the sufficiency of the proposals. Generally the sloping of trench sides is not permitted.

F No excavation work shall commence until the Engineer's consent has been obtained and such consent shall in no way relieve the Contractor from any of his contractual obligations and responsibilities.

1.11 Inspection by the Engineer

A When the specified levels of trench or structure excavation are reached, the Engineer shall inspect the ground exposed and if he considers that any part of the ground is by its nature unsuitable, he may direct the Contractor to excavate further and to refill the further excavation with such materials as he may direct.

B Should the bottom of any trench or structure excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the work, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. In this case the cost of the extra excavation and of the additional foundation materials required will be the Contractor's responsibility if necessitated by his negligence.

1.12 Standard Earthwork Compaction Procedure

A All compacted earth fill medium dry density (MDD) shall equal or exceed 95 percent as determined by BS 1377, Method 3.5/3.6. This method will be used to determine the maximum dry density of each type of soil used in compacted fills, backfills, and embankments, and to measure the relative compaction at optimum moisture content of compacted fills, backfills, embankments, and sub-grades.

B During the course of the work, the Contractor, under supervision of the Engineer, shall perform such tests as are required by the Engineer, to identify materials; determine compaction characteristics; determine moisture content; and determine density of fill in place. These tests performed by the Contractor will be used to verify that the fills conform to the requirements of the Specifications.

C Testing shall be performed by qualified staff of the Contractor or an independent testing laboratory approved by the Engineer when, where, and as directed by the Engineer. The costs of all compaction testing and other tests as stated above shall be borne by the Contractor. The Contractor shall adjust his operations so as to permit time to make tests and shall excavate and fill such holes as may be required for sampling and testing. Compaction tests shall be made prior to removal of dewatering systems. A subsequent layer shall not be placed until the compaction density of the preceding layer has been approved by the Engineer. The Contractor shall maintain, with copy to the Engineer, a daily log of tests carried out. From time to time the Engineer may, at his discretion, instruct the Contractor to perform tests at an independent laboratory to confirm the results of his own testing facilities, the costs of these tests shall be borne by the Contractor.

1.13 Anti-termite Treatment

Anti-termite treatment shall be carried out through persons, agencies and/or a subcontractor who possess acceptable experience in this field and who can provide references of successful guaranteed work having been carried out earlier.

1.14 Trial Holes

Trial holes shall be excavated well ahead of excavation to such depths as necessary to determine and confirm the alignment for the excavation, soil condition and location of underground utilities and structures. The Contractor shall arrange for the refilling and reinstatement of trial holes to be carried out immediately after the required information is obtained and reinstatement of trial holes shall be carried out to the approval of the Engineer.

Part 2 - Products

2.01 Borrow Material

A When the quantities of suitable materials obtained from specified excavations are insufficient to construct the specified fills, additional materials shall be obtained from approved borrow areas. The material selected shall meet the approval of the Engineer and conform to the following requirements:

TEST	STANDARD	LIMIT
Liquid limit	BS 1377 : Part 2 : Test 4.5	max 25%
Plasticity Index	BS 1377 : Part 2 : Test 5	max 6%
Organic Impurities	BS 1377 : Part 3 : Method 3	max 2%
Acid Soluble Sulfate Content	BS 1377 : Part 3 : Method 5	min 2%
Acid Soluble Chloride Content	BS 1377 : Part 3 : Method 7	max 2%

TEST	STANDARD	LIMIT
Compaction Test	BS 1377 : Part 3 : Method 3.5/3.6	
CBR at 95% MDD (soaked)	BS 1377 : Part 4 : Test 7	Min. 25% for structural fill Min. 15% for non-structural fill
In-situ Density Test	BS 1377 : Part 9 : Method 2.1/2.2	

B Borrow pits shall be excavated and finally dressed in a manner to eliminate steep or unstable side slopes or other hazardous or unsightly conditions and to prevent erosion or drainage problems, including ponding of water. The extent and depth of borrow pits within the limits of the designated borrow areas shall be approved by the Engineer. The Contractor shall be responsible for the arrangement and also the payment of charges for all borrow materials.

C Any excavated material not required, or not suitable, for use as refilling as aforesaid or use elsewhere in the works is considered as excess material and shall become the property of the Contractor, and he shall be entirely responsible for its removal from the Site and for its ultimate disposal.

2.02 Rock for Riprap

Rock for rock riprap shall conform to the following requirements:

1 Individual rock fragments shall be dense, sound, and free from cracks, seams and other defects conducive to accelerated weathering. The fragments shall be angular to sub-round in shape. The least dimension of an individual rock fragment shall be not less than one-third of the greatest dimension of the fragment.
2 Absorption of water shall be not more than 3 percent and the bulk specific gravity (saturated surface-dry) not less than 2.5 as determined by BS 1377.
3 Weight loss in 5 cycles shall be not more than 20 percent when sodium sulphate is used or 25percent when magnesium sulphate is used. The test for soundness shall be performed according to the procedure in ASTM C88.
4 Rock that fails to meet the requirements stated above, may be accepted only if similar rock from the same source has been demonstrated to be sound after 5 years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed under this specification.

2.03 Anti-termite Treatment

Solution used shall be a 2 to 4 percent Basement TR solution applied strictly as per manufacturer's instructions and shall be capable of offering a minimum of 20 years warrantee against termite attack. Equal alternative chemical solutions can be proposed by the Contractor for the Engineer's approval.

Part 3 Execution

3.01 Clearing and Grubbing

A The Contractor shall clear the Site of all vegetation, rubbish, debris and other objectionable materials. He shall also clear the access routes to the Site and any other areas deemed necessary by the Engineer to facilitate the construction of the Works. When clearing vegetation, the Contractor shall ensure that the roots of the trees, bushes, shrubs, etc. are fully removed. The Contractor shall dispose of all cleared vegetation, rubbish, debris and other objectionable materials in a controlled manner off-site to a location approved by the relevant authorities. The Contractor shall be responsible for the proper upkeep and maintenance of the Site and the Works and shall remove from the Site rubbish and other waste as it accumulates.

B The Contractor shall check with the relevant authorities to determine what existing services are present in the Site area. The Contractor shall locate and effectively seal off drain ends. When necessary, the Contractor shall divert services still in use and provide all temporary works necessary to maintain such services in fully functional order. He shall reinstate such services to the approval of the relevant authorities at the earliest opportunity and comply with regulations and obtain necessary permits.

3.02 Protection

A Bench marks and other permanent structures in the Site shall be protected from damage or displacement.

3.03 Control of Water

A The Contractor shall furnish, install and operate all necessary machinery, appliances, and equipment to keep excavations and borrow areas free from water during construction and shall remove all water so as not to cause damage to private property, or to cause a nuisance or menace to the public all as specified herein. Berms shall be provided to prevent surface water from draining into structural excavations. Earth banks shall be suitably protected from damage by erosion during construction. The Contractor shall ensure that, at all times, during construction no groundwater shall come into contact with any pipeline, concrete surface or reinforcement forming part off the permanent works and that any structure shall be capable of withstanding any hydrostatic pressure to which it may be subjected during construction and until completed.

B Drainage ditches, diversions, and temporary pipes shall be constructed as required to maintain drainage of the work areas and shall be constructed with cross-sectional area at least equal to that of the intercepted watercourses, as approved by the Engineer.

C The Contractor shall perform dewatering as required so that all work under the Contract is installed on dry areas and excavations, including without limitation the construction of all structures and underground piping. The Contractor shall ensure that dewatering is carried out only to a depth sufficient for the required excavation.

D When extensive dewatering is required, and if, in the opinion of the Engineer, the Contractor is not fully qualified to perform the dewatering operations, the Contractor shall furnish the services of an experienced, qualified, and equipped Dewatering Subcontractor to design and operate the dewatering and groundwater recharging systems required for the work, all subject to the Engineer's approval.

E Where required to do so by the Engineer, the Contractor shall establish a specified number of groundwater level monitoring stations at each site which will be observed during the work. These shall be located as directed by the Engineer and consist of acceptable open tube piezometers. As directed, settlement gages shall be provided to the approval of, and designated by, the Engineer at each site, times and locations to monitor settlement of new and existing facilities.

F Where deemed necessary by the Engineer, shop drawings and data shall be submitted for record purposes only, but not for review or approval showing the intended plan for dewatering and recharging operations. Details of locations and capacities of dewatering wells, well points,

pumps, sumps, collection and discharge lines, standby units, water recharge system, water disposal methods, monitoring and settlement measuring equipment, and data collection and dissemination shall be included. These shall be submitted not less than 30 days before start of dewatering operations.

G The Contractor shall furnish, install and operate all necessary pumping, well-point dewatering appliances and equipment to keep excavations free from water during construction. He shall dewater and dispose of water so as not to cause injury to public or private property, or to cause a nuisance or a menace to the public. He shall at all times have on hand sufficient pumping equipment and machinery in good working condition for all ordinary emergencies, including power outage. The Contractor shall have available at all times competent workmen for the operation of the pumping equipment. Excavations shall be kept free of water during excavation, construction of chambers, etc.; installation of pipelines; placing of structural and trench backfill and placing and setting of concrete. The Contractor shall control surface runoff so as to prevent entry or collection of water in excavations. Static water level shall be drawn down a minimum of 300 mm below the bottom of the excavation to maintain the undisturbed state of the foundation soils and allow the placement of any fill or backfill to the required density.

H All required operations shall continuously maintain the level of the water table outside the dewatered areas to prevent damage to structures, pipelines, etc., adjacent to the excavations. A water injection recharging system shall be maintained to replenish the groundwater supply, as required, to maintain the water table, including pumps, piping, well points, standby units, other required equipment, and a source of water sufficient to meet the recharge requirements. At his expense, the Contractor shall repair and make good all damage, or resettlement, to foundations, or other portion of any existing facilities or structures, damage to existing works caused by permanent or temporary failure or operation of the dewatering or recharging systems, or failure to maintain the existing groundwater level outside the dewatered areas.

I Water not injected back into the ground shall be disposed of lawfully without damage to new and existing facilities or adjoining properties.

J Release of groundwater to its static level shall be performed to maintain the undisturbed state of the natural foundation soils; prevent disturbance of compacted fill or backfill and prevent flotation or movement of structures, pipelines and sewers. Equipment shall be removed when no longer required, but monitoring and settlement measurement systems shall be maintained in operation until removal is approved by the Engineer. To the extent approved by the Engineer, well-points and like items may be abandoned in place.

3.04 Disposal of Material from Earthworks

A Subject to any specific requirements of the Contract, the Contractor shall make his own arrangements for the temporary storage of any excavated material which is required for use in refilling trench or structure excavations, including any necessary double handling. Any permitted temporary material storage alongside the excavation shall be to stable slopes and heights.

B Storage in streets of excavated material not to be reused within one day in the backfill of trenches or structures will not be permitted. In this connection the Contractor shall have regard to the working areas available to him for the construction of the Works particularly where this is located in roads or in other places to which the public has free access.

C Where the nature of the excavated material is suitable, the Contractor's temporary storage, as aforesaid, shall include for separate storage as the Engineer may direct of any of the various grades of materials hereinafter specified for the refilling and surface reinstatement of trench or structure excavation, namely, soft material, coarse material, hard material and topsoil.

D Any excavated material not required for or not suitable for use as refilling as aforesaid or use

elsewhere in the works shall become the property of the Contractor who shall be entirely responsible for its removal from the Site and for its ultimate, legal disposal and all related costs.

3.05 Excess Excavation to be Made Good

A At his own expense the Contractor shall remove from the Site all material resulting from excess excavations below that required for the foundation, lining, paving, road base or bedding and shall make good the same with concrete as may be required by the Engineer.

3.06 Anti-termite Treatment Application

A Site shall be well drained and cleared of shrubs, tree roots and debris that could provide termite food. Timber used during construction of the foundations, such as pegs, formwork, etc., must be removed. Termite nests if discovered shall be dug up and destroyed. Before constructing foundations for structures, the sides and bottom of excavations and the soil used for backfilling shall be sprayed with an anti-termite chemical solution approved by the Engineer.

B Foundations, top course of block masonry at ground floor level - Stage 1: After excavation of the earth for foundations and columns the bottom surface of the trenches shall be sprayed with chemical emulsion at a rate in accordance with the manufacturer's instructions. If the excavations have a rocky base and the surface does not retain the chemical emulsion, the top course of the block walls both externally and internally shall be sprayed soon after the blocks are laid.

C Soil under slabs at ground floor level - Stage 2: After earth filling, but before the dry rubble or hard core packing, the entire surface of the filled earth shall be treated with a chemical emulsion at a rate in accordance with the manufacturer's instructions. Light rodding may be necessary to facilitate spraying and absorption.

D Junction of walls and floors - Stage 3: Rodding to be carried out along the junction of plinth/basement walls and earth filling at 150 mm intervals with a chemical emulsion sprayed at a rate in accordance with the manufacturer's instructions so as to mix properly with the soil. Both the stages 2 and 3 to be carried out simultaneously to establish the chemical barrier.

E Soil along the external wall perimeter - Stage 4: After levelling and before flagging or ground floor protection is laid, soil along the external wall perimeter of the building up to a depth of 30 mm to be treated at a rate in accordance with the manufacturer's instructions. If necessary, rodding at 300 mm intervals may be carried out to facilitate spraying and absorption.

F Precautions must be taken not to disturb the treated areas by re-levelling digging or earth filling, as this will break the chemical barrier. In case such a situation arises, area shall be treated again to restore the chemical barrier.

3.07 Placement of Embankment Fill

A Embankments shall be placed in a manner such that they meet the following additional requirements:

1 The distribution of materials throughout each layer shall be essentially uniform and the fill shall be free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material.

2 If the surface of any layer becomes too hard and/or smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth not less than 75 mm before the next layer is placed.

3 The top surface of all embankments shall be approximately level during construction except that a crown or cross-slope (super elevation) of not less than 2 percent shall be maintained for effective drainage. If not shown on the drawings, all finish grade

embankment top surfaces shall be finished with a 2 percent crown or cross-slope as applicable for the site drainage.

B All engineered fills shall be compacted to not less than 95 percent maximum dry density (MDD), including areas to receive future structures, and to a line and grade at least 2 m outside the structure area. All fills shall be moistened or aerated to control the moisture content to within 2 percent of optimum and then compacted. Uniform moisture distribution shall be obtained by disking, blading or other approved methods prior to the compaction of the layer. If the top surface of the preceding layer of compacted fill or foundation becomes too dry or wet to permit suitable bond it shall be scarified and moistened by sprinkling or aerated to acceptable moisture content prior to the placement of the next layer.

3.08 Testing of Backfill

A Tests to determine the optimum dry density of the backfill material shall be carried out as directed, the frequency depending on consistency of material and test results. Unless directed otherwise on site testing for density and moisture content of in situ soils shall be at the rate of:

1 one test per backfill layer for each structure or one test per 500 m^2, whichever is more stringent,
2 one test per backfill layer for every 100 linear metres of pipeline trench.

3.09 Foundation Preparation

A Foundations for earth fill shall be stripped to remove all obstructions, vegetation, debris, or other unsuitable materials. Except as otherwise specified; foundation surfaces shall be graded to remove surface irregularities and shall be scarified and loosened to a minimum depth of 100 mm. The moisture content shall be controlled as specified for engineered fill and the surface materials of the foundation shall be compacted and bonded with the first layer of earth fill as specified for subsequent layers of earth fill.

B All rock foundation and abutment surfaces shall be cleared of all loose materials by hand or other effective means and shall be free of standing water when fill is placed. Rock foundations shall be excavated to 150 mm below finished grade shown on the drawings and a lining shall be placed as specified herein. Fill placed immediately adjacent to such rock foundations or where not accessible with large compaction equipment shall be compacted to the specified density by means of hand tamping or manually directed power tampers or plate vibrators.

C Where the slope of existing soils to receive fill exceeds 1 to 4, horizontal benches shall be cut to key the new fill material to the existing soils. At least 600 mm of existing soil normal to the original slope shall be removed and re-compacted as the new fill is brought up in layers.

3.10 Rock Riprap

A This work shall consist of the construction of rock riprap blankets for purposes of embankment protection from erosion. The subgrade surfaces on which the riprap is to be placed shall be cut or filled and graded and compacted to the lines and grades shown on the Drawings. The cross sections shown on the Drawings are the limits for cuts and engineered earth fills. Gravel bedding where specified or shown on the Drawings shall be placed on top of cut or filled surface. Gradation of bedding material shall be as shown on the Drawings. Bottom of the riprap bed shall be taken as top of the gravel bedding. Where no gravel bedding is shown or specified, it shall be taken as the embankment surface line shown in the cross-sections. Riprap shall not be placed until the foundation preparation is completed and the finished engineered fill surfaces have been inspected and approved by the Engineer.

B Rock shall be placed by equipment on the surfaces and to the depths specified. The riprap shall be constructed to the full course thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials. The rock shall be delivered and placed in a manner that will ensure that the riprap, in place, shall be reasonably homogeneous with

the larger rocks uniformly distributed and firmly in contact one to another with smaller rocks and spalls filling the voids between the larger rocks. Riprap shall be placed in a manner to prevent damage to structures.

C Hand placing will be required to the extent necessary to prevent damage to the permanent works. Rock shall be placed by hand on the surfaces and to the depths specified and in accordance with the above Specification. Smaller rocks shall not be grouped as a substitute for larger rock.

D Riprap placed in ditches, channels, or alongside structures for erosion protection shall be about 150 mm nominal diameter, while riprap placed on embankments shall range from 150 to 350 mm. All riprap layers unless otherwise specified shall be a minimum of 375 mm in depth. The finished grade shall be reasonably homogeneous in appearance and depth and be free from moulds, dips, or windows.

E All suitable rock obtained during job site excavation may be conserved for riprap and additional rock shall be obtained from sites to be located by the Contractor and approved by the Engineer. Quarries approved by the Engineer shall not relieve the burden upon the Contractor of ensuring that all rock utilized meets all requirements specified herein.

F All riprap designated as slush grouted shall be grouted with grade 20 concrete using 20 mm aggregate. Slush grout concrete shall be placed to fill all voids in the riprap blanket to a minimum depth of 100 mm into the blanket. The grout shall be placed, consolidated and finished with a shovel or it may be broom finished. Slush grout concrete exposed to air after placing shall be sprayed with an approved curing compound, or shall be cured in a manner approved by the Engineer.

3.11 Completion

A Upon final completion of the Works, the Contractor shall clear away and remove from the Site all remaining constructional plant, surplus materials, rubbish, and temporary works of every kind and leave the whole of the site clean to the satisfaction of the Engineer. The Contractor shall obtain any local authority clearance permits required.

End of Section 02200

Section 02221

Trench Excavation and Backfill

Part 1 General

1.01 Description

A Principal work in this section includes:
1 trench excavation, granular pipe bedding, concrete protection of pipe, backfill, compaction, and temporary reinstatement,
2 provision of new protection ducts of split unplasticised polyvinylchloride (uPVC) pipes, concrete encased, to protect existing utility mains or cables where excavations cross such utility mains or cables, and
3 non-disruptive pipeline installation.

1.02 Definitions

A "Trench excavation" is as defined in Section 02200 hereof.

B “Pipe” means pipe or pipes, bends, fittings, junctions, other specials, and includes joints, gaskets, flanges, nuts, bolts, washers and lubricants.

1.03 Non-disruptive Pipeline Installation

A The Contractor or subcontractor, which will perform the work, shall be experienced in the performance of boring and jacking work under similar conditions. The work shall be undertaken from within a shield equipped with steering jacks for adjusting the alignment and face boards shall be provided for boarding up the exposed excavation.

B The Contractor shall monitor line and grade with a laser beam or other suitable equipment as approved by the Engineer. Extreme care shall be exercised to maintain line and grade during jacking operations. Modifications in the manner in which the jacking operation is being conducted may be required to correct any deviation when deemed necessary by the Engineer. The Engineer shall have safe access to the jacking pit and such use of the Contractor's facilities as are necessary to monitor and verify accuracy of conductor pipe line and grade. A maximum tolerance in the line and grade combined of 200 mm in 100 m shall be required. Monitoring of line and grade shall be carried out every 8 m of conductor pipe installed with a minimum of once daily during jacking operations.

C Unless otherwise specified in other sections of the Specifications, the methods and equipment used in jacking the conductor pipe shall be at the option of the Contractor, provided that the proposed method is approved by the Engineer. Such approval, however, shall in no way relieve the Contractor of the responsibility for making a satisfactory installation meeting the criteria set forth herein. It shall be understood that, even when a change in construction method or an increase in jacking limits as specified herein or shown on the Drawings is requested by the Contractor, and authorized by the Engineer, no additional payments will be made. Once the jacking operation has commenced, it shall be continued in an expeditious manner until the conductor pipe has been jacked between the specified limits.

Part 2 Products

2.01 Pipe Bedding Material

A Granular bedding shall be free draining, hard, clean, chemically stable gravel or crushed stone to BS 882, graded in accordance with BS 882 as follows:

Sieve Size (mm)	% Weight of Passing	
	For Pipes of Dia 400 mm and above	For Pipes of Dia 300 mm and below
37.5	-	-
20	100	-
14	85 - 100	100
10	0 - 50	85 - 100
5	0 - 10	0 - 25
2.36		0 - 25

1 total acid soluble content of the material when tested in accordance with BS 1377 shall not exceed 0.3 percent by weight of sulphate expressed as SO_3.

2 for uPVC pipes only rounded aggregates will be permitted but for all other pipe materials crushed aggregates may also be used.

B Concrete bedding or surround shall be Grade 20 in accordance with Section 03300 hereof.

2.02 Selected Fill Material

A Selected fill material for pipes, to a minimum of 300 mm above the top of the pipe, shall be suitable material selected from the excavated material. Suitable material shall be free from stones greater than 4 mm in size for pipes without coatings and 25 mm for pipes with coatings. The material shall have a liquid limit not more than 25 percent and a plasticity index of not more than 6 percent.

2.03 Remaining Trench Backfill

A The remainder of the trench fill material shall be selected from the excavated material and be as specified in Section 02200 hereof for borrow material, provided, in the opinion of the Engineer, the required densities can be achieved.

2.04 Service Protection Ducts

A Protection ducts shall be split, unplasticized polyvinylchloride (uPVC) pipe extruded from 100 percent virgin materials and 150 mm diameter unless otherwise approved by the Engineer. All pipes and fittings shall be new and unused. The pipes shall be homogenous and free from visible cracks, holes, foreign materials, blisters, deleterious materials, wrinkles, and dents. Plastic pipe shall be delivered to the site in unbroken bundles or rolls, packaged in such a manner as to provide adequate protection of pipe and pipe ends, either threaded or plain, from damage or exposure to sunlight. All plastic pipe fittings to be installed to PVC pipe shall be moulded fittings manufactured of the same material as the pipe and shall be suitable for solvent weld. No site-made bends or fittings will be permitted.

2.05 Conductor or Casing Pipe

A Pipe to be placed by jacking methods shall be of sufficient thickness and axial strength to withstand the forces to be encountered during the jacking process. The diameter of the jacking pipe shall be the transmission pipe outside diameter plus 450 mm or the socket diameter plus 150 mm, whichever is greater as a minimum.

B It shall be the Contractor's responsibility to provide stress transfer, which is capable of resisting the jacking forces, involved across the conductor pipe joints.

C All transmission pipe installed in jacked conductor pipe shall have socket and spigot with rubber gasket or mechanical compression joints, except where restrained joint pipe is required. Skids for supporting the transmission pipe inside the conductor pipe and blocking, shall be a hardwood adequate to withstand high bearing stresses and treated by painting with pentachloro-phenol.

Part 3 Execution

3.01 General

A The line, level, grade, elevation, slope and cross-section of trenches shall be as shown on the Drawings, specified or as may be directed by the Engineer. Before commencing trench excavation, the route of the trench shall be surveyed and marked in the field by the Contractor accurately and the natural ground levels shall be agreed with the Engineer. Strong sight rails shall then be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary. On these rails shall be marked the level to which the excavation is to be carried out and rails shall be not more than 20 m apart. Alternate methods to maintain line and level of pipelines shall be to the approval of the Engineer. The Contractor shall protect and maintain the sight rails until backfill is placed.

B Trench excavation shall be carried out by such methods and to such lines, dimension and depths as shall allow for the proper construction of the works, provided always that, unless the Engineer permits otherwise, no trench excavation shall be less than 600 mm in width. Notwithstanding the foregoing, any rock in trench excavation shall be so excavated that the clearance between the pipe, when laid, and the rock sides and bottom of the trench is kept to the minimum limits necessary to provide for the specified thickness of bedding and/or concrete protection of the pipe.

C Excavation shall be carried out by mechanical methods except where required to ensure the stability of utilities or structures encountered during excavation work. Excavation at these locations shall be by hand (manual) methods.

D The bottom of the trenches shall be properly trimmed off and a compacted granular bed of thickness as shown on the Drawings shall be placed and prepared to provide a firm and uniform bearing throughout the length of the pipe. The bedding shall be lightly raked prior to placing the pipes on it. Holes and depressions for couplings, fittings and the like shall be excavated the same distance below these installations.

E Materials excavated shall be used in the backfill or removed and disposed of by the Contractor to an approved location, as required by the Engineer and as specified. The trench shall be dug only so far in advance of pipe laying as the Engineer shall permit. No length of trench excavation shall be started until the pipes and fittings to be laid in that length are available on the Site. Trenches shall have vertical sides unless otherwise authorized by the Engineer.

F If obstructions not shown on the Drawings are encountered during the progress of the work and these will require alterations to the Drawings, the Engineer shall change the plans and order the necessary deviation from the line and/or grade. The Contractor shall not make any deviation from the specified line and/or grade without approval by the Engineer. Should any deviations in line and/or grade be permitted by the Engineer for convenience to the Contractor, any additional costs for the trench work and thrust blocks, valves, air and vacuum assemblies, washout assemblies, extra pipe length, valve chambers, manholes or other appurtenances shall be borne by the Contractor. A sufficient number of air release and vacuum installations and wash out assemblies have been shown on the Drawings at high and low points, respectively. Should the pipeline be constructed in a manner that the points are not located at the stations shown on the plans or in a manner that additional high or low points are caused in

the profile for the convenience of the Contractor, the Contractor shall relocate or add additional installations and assemblies at his own expense and as directed by the Engineer.

G Unless otherwise specified or instructed, the minimum trench width shall be as required to meet the design requirements and for the proper assembly and joint inspection. To meet design requirements and to minimize disruption of traffic, disturbance of other services or installations and risk to adjacent buildings or structures and where the trench width is not specified elsewhere or shown on the Drawings or where the Engineer gives instructions concerning trench widths, the following trench widths shall normally apply:

1 For rigid Pipes (RC, VC etc.) the maximum width at 300 mm above crown of pipe shall be the outside pipe diameter plus 600 mm. The maximum width for 100 mm and 150 mm pipes shall be 600 mm. If these maximum widths are exceeded, the Contractor shall, at his own expense, provide concrete surround to the full trench width as directed by the Engineer,

2 For ductile iron pipes, the maximum trench width at 300 mm above top of pipe shall be the outside pipe diameter plus 600 mm except for 100 and 150 mm pipes where the maximum trench width shall be 600 mm. If this maximum width is exceeded, the Contractor shall, at his own expense, provide concrete surround to the full trench width as directed by the Engineer,

3 For flexible pipes (uPVC, GRP, HDPE etc.) the minimum trench widths for these pipelines depend on the deformation modulus of the bedding material (E_B) and of the native soil (E_S) at the springing or axis level of the pipe. The deformation modulus of the native soil (E_S) at axis level of the pipe is variable depending on the location of the pipe. The deformation modulus of the bedding material shall be as recommended by the pipe manufacturers. Before, and as the work proceeds, both deformation moduli shall be determined by static cone penetrometer tests. To determine E_B a short length of trench shall be excavated, filled with bedding material, compacted and tested at the start of the Contract. If, in the Engineer's opinion, the E_B value is satisfactory, normal compaction procedures for granular bedding and surround shall be adopted. If the E_B value is unsatisfactory, the Engineer will issue instructions for either a change in the bedding material or additional compaction procedures, at no extra cost to the Contract. To determine E_S, static cone penetrometer tests shall be carried out in trial holes at formation level at intervals along the pipe line to be determined at site which, in variable ground conditions, may be for every pipe length. The costs of cone penetrometer tests shall be included in the rates for pipeline construction. When the values of E_B and E_S have been determined, the Engineer will determine the minimum width of excavation necessary for a particular location. This minimum width may vary from three to a maximum of five times the nominal outside diameter, depending on the E_S value. If, due to space limitations or other practical considerations, the minimum trench widths cannot be attained, or as shown on the Drawings, the Engineer will direct the Contractor to adopt either: Using a pipe of higher stiffness value; changing the bedding to concrete bed and surround or leave in the trench sheeting.

3.02 Supporting Trench Excavations

A Contractor shall well, and effectively, support the sides of all trench excavation in accordance with the submittals required by Section 02220 hereof. Support shall include the use of steel sheet piles, where necessary, to prevent any fall or run from any portion of the ground outside the excavation into the trench and to prevent settlement of, or damage, to structures adjacent to the excavation.

B When concrete encasement of pipeline, or granular or selected fill is required in pipe trenches the supporting installation shall be designed to permit gradual withdrawal during the placing of the encasement or fill. This shall be affected in such manner as to minimize the danger of

collapse and all voids formed behind the supports shall be carefully filled and compacted.

C The Contractor shall be deemed to have made his own allowance for shoring up the sides of trenches and any extra excavation necessary to provide space for such support and for any other working space.

D If, for any, reason any portion of trench excavation shall give way, the Contractor shall, at his own expense, take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed.

E Where the Contractor elects and is permitted by the Engineer to execute trench excavations with battered sides instead of providing support as aforesaid they shall be excavated to stable slopes and heights from a point of 300 mm above the top of the pipe. Drawings and data shall be provided in accordance with Section 02220 hereof.

3.03 Trimming Trench Excavation

A When excavating to specified levels for trench excavation, or to specified limits for the face of any structure or thrust block therein required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing construction work except where the Engineer permits otherwise. Should the Contractor have excavated to within 150 mm above these specified levels, or to within 150 mm of these specified limits, before he is ready, or able, to commence the construction work he shall, where required by the Engineer, excavate further so as to remove not less than 150 mm of material immediately before commencing the constructional work. Any such further excavation and additional foundation material ordered by the Engineer shall be at the cost of the Contractor. Where no bedding material is specified, the bottom of trench excavations shall be carefully boned in and trimmed true to grade with the aid of a straight-edge at least 6 m long so as to ensure a continuous support for the pipes. Any stones or flints, greater than 25 mm in size, likely to cause the pipe to bed unevenly or to damage the pipe and its coating shall be picked out of the trench bottom. Any holes so formed shall be filled in with soft material and trimmed to the correct level. Where bedding material is specified, all shattered and loose material shall be removed from the bottom of the trench excavations so that the bedding material rests on a solid and clean foundation.

3.04 Pipe Bedding

A After trimming, granular bedding material shall be spread in the trench bottom. If, through the Contractor's neglect, any trench bottom is excavated below the grade shown on the plans, it shall be refilled to grade of pipe invert with bedding material, thoroughly compacted into place, or concrete at the Contractor's expense and at the Engineer's discretion. Concrete barriers shall be formed in granular bedding and/or surround to pipes to prevent the bedding acting as a sub-soil drain. Barriers shall be provided at a maximum spacing of 100 m with one at each manhole or valve chamber and at least one barrier between two adjacent structures. Concrete barriers shall be of Grade 20 concrete, and shall be installed across the full cross-section of the granular bedding material and shall be at least 300 mm in thickness along the axis of the pipeline.

B Where indicated on the Drawings, or ordered by the Engineer, pipe shall be encased, haunched and/or backfilled with concrete in accordance with the details shown on the drawings. Concrete shall not be placed until the joints at each end of the pipe have been completed. Each pipe to be encased or haunched shall be supported on at least two purpose made precast concrete blocks, which shall be left in place. Concrete encasement shall be placed to the required depth in one operation. Pipe shall be prevented from floating or otherwise moving during concreting. Except where shown otherwise or ordered by the Engineer, the continuity of concrete backfill or encasement to pipe with flexible joints shall be broken at each joint. Flexible joints in concrete beds and surrounds to pipes shall be formed as shown on the Drawings with suitable compressible fibrous board or other similar approved

material.

C. Where soil is completely unstable, and if, in the opinion of the Engineer, large settlements in the pipe line are expected, special arrangements are to be made after proper site investigation and structural calculations. These special arrangements shall be: improvement of mechanical properties of the soil; replacement of soil by other soil or concrete; addition of crushed rock; pile foundations or R.C. slab foundation. Where such conditions occur, a report shall be submitted to Engineer, or his representative along with all the site data and contractor's proposal for approval. Where hard rock occurs in the bed just before or after compressible soft bed, the Contractor shall provide a flexible joint at the junction of two materials to allow rotation of pipe pieces without damage in case of settlement of soft bed. In the case of pipelines laid under the slope of an embankment, any longitudinal tensile or bending stress occurring in the pipe shall be taken into account.

3.05 Trenches not to be Left Open

A The Contractor will not be permitted to excavate trenches in more than one location in any one road at a given time without the Engineer's permission. Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of trench excavations shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and jointed. Pipe laying shall follow closely upon the progress of trench excavation. The Contractor shall not permit unreasonably excessive lengths of trench excavation to remain open while waiting testing of the pipeline but not more than 30 m ahead of the pipe laying operation or greater lengths if approved by the Engineer. Excess trench lengths in which pipe cannot be installed during the approved working period(s) shall be backfilled and re-excavated during the next work period, all at the cost of the Contractor.

B The Contractor shall take precautions to prevent flotation of pipes in locations where open trench excavations may become flooded and these precautions may include the partial refilling of the trench leaving pipe joints exposed for tests of the joints.

C If the Engineer considers that the Contractor is not complying with any of the foregoing requirements, he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trench excavation.

3.06 Control of Water

A All excavation and placement of bedding and backfill shall be carried out in the dry as described in Section 02200 hereof.

3.07 Trench Excavation in Roads

A Where open cut excavation is used as a construction method, all trench excavation and other work carried out within the limits of any existing road or highway shall be completed as rapidly as possible and not more than half of the width of the carriage way shall be obstructed at any one time. This may require hauling away excavated material and returning as backfill as required. The Contractor shall programme his work in such a manner that the minimum inconvenience is caused to those persons using the road.

B If, in the opinion of the Engineer, the amount of traffic using a road which is completely or partly obstructed by the works is sufficiently great to make it necessary, the Contractor shall operate a system of traffic control to the approval of the Engineer, local authority and the traffic police. Any such system of control shall require appropriate large letter warning signs at the approaches (1, 0.5 and 0.25 km) to sections of road in which, or adjacent to, which work is being executed. These signs shall be removed immediately the dangers of which they provide a warning have been removed. If the Contractor wishes to stop traffic completely for any significant period of time, he shall submit a plan in advance for the approval of the Engineer and traffic police for permission to do so. Obstruction of the road shall not begin

until the Contractor receives the Engineer's permission in writing. Such permission will not, in general, be granted for roads which have more than two traffic lanes or for those sections of roads for which satisfactory alternative routes do not exist. Appropriate lighting shall be provided for protection of the Works and road users during periods of darkness. Costs incurred by the Contractor in respect of all aspects of work in roads including maintaining access past the works, the provision of a traffic control system and warning signs and the like shall be included in the rates for excavation and pipe laying. The Employer will not be liable to pay any compensation to the Contractor for traffic control or should permission to close any road to traffic not be granted for any reason.

C Where trenches are open cut in asphalt or concrete roads, the roads shall be saw cut 200 mm back from the edge and along the edges of the trench, prior to excavation.

D Road drains and channels shall be kept free from obstruction at all times and flows therein diverted away from pipe trenches.

E Normally trench excavation along roads will be located in the service reserves or verges adjacent to the road rather than in the carriageway itself. Trench excavation shall wherever practicable, be carried out in such a way that the excavation is at least 1 m clear of the existing edge of the carriageway. In such event, the Contractor shall take special precautions, which shall include the continuous support of the sides of the excavation, from the time when excavation is begun until the refilling of the trench is placed, to ensure that there is no disturbance of the adjacent road construction or foundation.

F The Engineer may direct the trench excavation to be realigned from that shown on the Drawings in order to avoid interference with existing utilities and structures or to facilitate smooth traffic flow.

G Where trench excavation, or any other part of the Works, obstructs any footpath or right-of-way, the Contractor shall provide, at his own cost, a temporary footpath around the obstruction to the satisfaction of the Engineer to maintain access at all times. Where applicable, this temporary footpath shall include stout bridges of wooden planks with handrails or other approved construction methods across any open trenches.

3.08 Trench Excavation in Surfaces Other than Roads

Trench excavation in surfaces other than roads shall include all surfaces except those asphalt surfaces which require road reinstatement. These surfaces include, but are not limited to, cultivated areas, undeveloped areas, footpaths, verges, non-asphalted roads, lanes, alleys, and all private lands. Trench excavation shall, if the Engineer so requires, have temporary fencing erected around that length, at no extra cost to the Employer. Temporary fencing shall not be removed without the Engineer's permission, which will not normally be given until the trench excavation has been refilled, compacted and reinstated. The Contractor shall have particular regard to the safety of animals which may encroach upon the areas, and shall ensure that all open excavation, access routes and steep or loose slopes arising from the Contractor's operations are adequately fenced and protected.

3.09 Installation of Service Protection Ducts

After the split uPVC pipe has been placed around the existing utility mains or cables to a minimum length of pipe trench excavation width plus 300 mm on each side, the pipe shall be wrapped twice with polyethylene film, 150 microns thick, to prevent fresh concrete from entering the duct. Protection ducts shall be supported on suitable non-corrosive spacers before placing concrete encasement around the duct. All concrete work shall be in accordance with Section 03300 hereof and concrete encasement shall be with Grade 20 concrete.

3.10 Backfilling Trench Excavation

A Selected fill material for pipe surround shall be deposited in layers of not greater than 150 mm

compacted thickness and thoroughly rammed with suitably shaped rammers working alternately on either side of the pipe (particular care being taken to avoid damage to the pipe and any sheathing) until the select fill has been carried up at least 300 mm above the top of the pipe.

B The remainder of the trench fill material shall be spread in layers of not greater than 150 mm compacted thickness and shall be thoroughly rammed by an approved mechanical rammer. Depths greater than 150 mm shall be allowed; provided that it is demonstrated that the compaction equipment can achieve the required density through the depth of the backfill layer. Backfilling is to be carried up to the level at which (in roads and footpaths) surface reinstatement or temporary pavement is to commence or (elsewhere) to such level as with the surface reinstatement of the whole of the topsoil will leave the finished work sufficiently "proud" to allow for future settlement to the original ground level.

C Where necessary, the Contractor shall adjust the moisture content of the refill material either drying out or by adding water to assist the compaction of the material. During compaction, the backfill shall have a uniform moisture content to within 2 percent of optimum moisture content recorded in the Compaction Test. Backfill shall be compacted to a dry density of not less than 90 percent maximum dry density (MDD) in landscaped, open areas and areas outside of road reserves and 95 percent MDD elsewhere, when tested in accordance with these specifications.

D Should the material being placed as backfilling, while acceptable at the time when approved, become unacceptable to the Engineer due to exposure to weather condition, or due to flooding, or have become puddled, soft or segregated during the progress of works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material.

E To permit the proper consolidation of backfill into the voids behind trench sheeting and supports, trench sheeting shall be withdrawn gradually as backfill progresses in depth and along the trench. On no account shall any excavated material be pushed back into the trench when refilling trenches in roads. No backfilling shall be carried out unless in the opinion of the Engineer, sufficient mechanical rammers are in operation on that portion of the work.

F Where directed by the Engineer, trench excavation shall be refilled with concrete.

G Where, in the opinion of the Engineer, sufficient supplies of the aforesaid material for trench refilling cannot reasonably be obtained from excavations the Engineer may order the Contractor to carry out such work as may be necessary to sieve out stones, or excavate material from suitable borrow areas and transport it to the length of trench to be refilled. The Contractor shall do any or all of these things as directed and all costs for borrow material shall be borne by the Contractor.

3.11 Pipeline Identification

A All lines shall be marked with a high quality acid and alkali resistant yellow polyethylene tape with a minimum width of 150 mm placed, during backfilling, 300 mm below finished surface, or as directed by the Engineer. The tape shall be clearly marked in black lettering as appropriate with a maximum longitudinal spacing of 2 m.

3.12 Surface Reinstatement in Asphalt Paved Roads

A Temporary reinstatement shall be provided immediately after backfilling and compacting the trench and compacted as specified to enable the road to be used for vehicular traffic. Temporary reinstatement shall be one of the following alternatives:

1 an adequately thick layer of asphalt mix to provide a minimum consolidated thickness of 100 mm when well compacted by an 8000 kg power driven roller. The edges of the broken surface of existing paving shall be scarified and trimmed to straight lines before the smooth continuous surface matching the existing surface in level shall result.

2 after scarifying and trimming the broken edges of the existing surface, a base of crusher run rock fill, or gravel, graded from 3 mm to 75 mm shall be spread over the area to be reinstated. The thickness of the layer shall be such as to provide a consolidated thickness of 100 mm when well compacted by a power driven 8000 kg roller. A tack coat of emulsified bitumen shall then be applied at a rate of 1 litre per 2 sq. metres and a layer of clean sand shall then be spread over the bitumen. The surface shall finally rolled with an 8000 kg power driven roller to provide a surface that matches the level of the existing paved surface.

3 as required by the concerned authority.

B Any road markings damaged or destroyed by the work shall be replaced on the temporary surface to the satisfaction of the local authority.

C Permanent Reinstatement shall be as specified in the Particular Specifications.

3.13 Reinstatement of Surfaces Other Than Asphalt Paved Roads.

The Contractor shall restore all non-asphalt road and all other surfaces to their original condition and this reinstatement is deemed to be entirely covered by the Contractor's rates for pipe installation.

3.14 Appurtenant Structures in the Pipeline

The Contractor shall carry out further excavation as may be necessary to accommodate structures such as manholes and valve chambers and such excavation shall include for disposal of surplus material and, where appropriate, for backfilling around the structures.

3.15 Fill Adjacent to Structures

No fill materials shall be placed, and no compaction shall be permitted, adjacent to concrete for a minimum of fourteen days following placing of the concrete. Fill materials adjacent to structures shall be placed in such a manner as will ensure that they can be satisfactorily compacted without damage to the structures. Compaction adjacent to structures shall be carried out by hand or by suitable hand operated plant as soon as the fourteen day period has ended.

3.16 Existing Services

A Not-withstanding any relevant information furnished by the Employer or Engineer, the Contractor shall be responsible for ascertaining, from his own inspection of the Site and the respective utility authorities and other public bodies, the position of all mains, pipes and cables whether underground or overhead, within or near the Site.

B Where trench excavation is carried out close to, or across, the line of sewers, pipes, cables and other services, the Contractor shall, where necessary, provide temporary supports or slings. Where such sewer, pipe, cable or other service is temporarily disturbed it shall be replaced.

C Where specified on the Drawings, or by the relevant Utility Authority, split ducts shall be provided as specified in paragraph 3.09 hereof.

D Where, in the opinion of the Engineer, construction of the pipeline cannot reasonably be carried out unless the sewer, pipe or other major service is permanently severed, permanently diverted or permanently supported by concrete, he shall order the Contractor to undertake such work (metered water service connections are not included under this). Any relocation of existing services shall be done in accordance with the requirements of the responsible authorities. The repair or replacement of existing water service connections shall be considered as part of the Contractor's work and included in the rates.

3.17 Fences and Walls

A Where trench excavation crosses surface barriers such fences and walls the Contractor, as a temporary measure during construction of the pipeline, shall provide temporary fencing for

any parts of such barriers that have to be removed. After trench excavation has been reinstated, the Contractor shall carry out such work as the Engineer may order for permanent restoration of such barriers.

3.18 Crossing Watercourses

A The Contractor shall be deemed to have allowed for all the additional measures necessary for the proper construction of the pipeline where it crosses under or over streams, culverts and other watercourses, including maintaining the full flow of water in the watercourses.

3.19 Nuisance from Noise and Dust

A The Contractor shall take all precautions which, in the opinion of the Engineer, are necessary to minimize nuisance arising from noise and dust when working in the vicinity of residences, schools, hospitals, clinics, religious areas and offices. All engine-driven machines shall be fitted with efficient silencers which are not necessarily those supplied by the manufacturers of the engines or plant and if necessary, plant shall be screened with acoustic materials. If, in the opinion of the Engineer, it is unreasonable or undesirable for pumps, or concrete mixers to be driven by combustion engines, the Contractor shall, when so required, provide electric motors to operate the plant. Driver shall minimize the use of horns.

B Compressed air operated equipment, tools, and ventilation equipment shall be effectively muffled or shall be of a design having a low noise frequency.

C The Contractor shall utilize submersible pumping plant which is electrically powered so as to avoid any nuisance or disturbance to the general public. The pumping plant may be supplied with power from a diesel engine generator which shall be acoustically insulated so that the emitted noise level shall not exceed 65 dBA measured at a distance of 3 m from the equipment. The noise level near houses, and sound insulation procedures to keep the noise nuisance to the minimum, shall be approved by the Engineer.

D The Contractor shall keep all streets affected by construction, or by construction equipment, free from dust and excavated material. Streets shall be washed or swept daily, or as otherwise required by the Engineer.

3.20 Non-disruptive Pipeline Installation

A The leading section of conductor pipe shall be equipped with a jacking head securely anchored thereto to prevent any swaying or variation in alignment during the jacking operation. Excavation shall be performed entirely within the jacking head and no excavation in advance thereof shall be permitted. Every effort shall be made to avoid any loss of earth outside the jacking head.

B Excavation shall be kept to a minimum, but shall be of sufficient dimensions for satisfactory completion of the work. If so required, bracing and shoring, steel sheet piles or such other material as may be approved by the Engineer shall be provided to adequately protect the workmen and to protect the surface finish at no extra cost to the Employer.

C Excavated material shall be removed immediately and continuously from the conductor pipe as excavation progresses. The method of removal will be at Contractor's selection and no accumulation of excavated material within the conductor pipe shall be permitted.

D Ventilation shall be furnished in the conductor pipe and at the working face as necessary to protect the men and meet safety requirements.

E After jacking is completed; the Contractor shall tap the conductor pipe with a hammer to locate ground loss or other voids outside the pipe. Holes shall be drilled in the conductor pipe at suspected locations and ground shall be forced in to fill voids to refusal at pressures determined by the Engineer, but not to exceed 396 kPa. Should appreciable loss of ground occur during the jacking operation, the voids shall be backpacked promptly to the extent

practicable with soil cement consisting of a slightly moistened mixture of one part cement to five parts granular material. The cement mixture shall be thoroughly mixed and rammed into place as soon as possible after the loss of ground.

F After grouting, the conductor pipe shall be cleaned and the transmission pipe installed. The transmission pipe shall be supported on concrete blocks and timber wedge with a bearing area of one quarter of the transmission pipe circumference with of sufficient thickness to prevent the pipe sockets from touching the conductor pipe and to align the pipe to meet the line and level specified.

G Concrete shall then be placed to provide a minimum concrete bedding to half pipe height and care shall be taken to ensure the transmission pipe does not move. After the concrete cradle is set the remaining annulus shall be filled with concrete to within 150 mm of the soffit of the conductor pipe. The voids will then be pressure grouted to refusal. All concrete bedding, filling and grouting shall be carried out between shutters and the whole annulus shall be filled completely with concrete for the whole length between shafts.

H If other pipe boring methods are to be used they shall be approved by the Engineer.

3.21 Clean-up

A Upon completion of work of this section, all rubbish, debris, and excess or waste material shall be removed from the Site. All construction tools, equipment and items left from construction shall be removed and the entire area involved shall be left in a neat, clean and acceptable condition. Any road markings damaged or destroyed by the work shall be replaced to the satisfaction of the concerned authority.

END OF SECTION 02221

Section 02222

Structure Excavation and Backfill

Part 1 General

1.01 Description

A Principal work in this Section includes:
1 Excavation for Structures
2 Structural backfilling

1.02 Requirements

A Definitions of terms are as defined in Section 02200 hereof.

B The line and level of structural excavations shall be as shown on the drawings or as may be directed by the Engineer. Before commencing excavation, the structure shall be staked out accurately and natural ground levels shall be agreed with the Engineer. Excavations shall be of sufficient size to permit the placing of structures or structure footings of the full width and length indicated. Where any sloped excavations infringes on, or potentially endangers existing facilities or structures, shoring, sheeting and bracing shall be incorporated as designed by a qualified engineer and a copy of the design (calculations and drawings etc.) shall be submitted to the Engineer. Boulders, rocks, and any other objectionable material encountered during excavation shall be removed. In the event that during the progress of the work, loose or improperly compacted soil is encountered at the bottom of structure foundation levels, or adjacent thereto, such material shall be completely removed within the limits as directed by the Engineer and shall be backfilled with suitable fill material or concrete as directed by the Engineer.

C All structural backfills shall be placed in dry conditions. Equipment for placing of backfill shall produce the specified compaction and shall be of the type and capacities as required and approved by the Engineer. Heavy equipment shall not be operated within 1 m of any structure. Vibration rollers shall not be used within 1.5 m of any structure. All working areas shall be protected from damage by water and site drainage shall be maintained at all times.

Part 2 - Products

2.01 Backfill

A Structural fill material shall be obtained from the excavations and/or from suitable off-site sources and shall have a liquid limit not more than 25 percent and a plasticity index not more than 6 percent. The material shall consist of uniform readily compactible material free from vegetable matter, building rubbish and frozen material, or materials susceptible to spontaneous combustion. It shall be free from plastic fines and weakly cemented lumps of sand and have a smooth grading curve within, and sensibly parallel to, the grading envelope below:

Sieve Size	% by Mass Passing
75 mm	100
37.5 mm	85 - 100
10 mm	45 - 100

5 mm	25 - 85
0.6 mm	8 - 45
0.075 mm	0 - 10

2.02 Water

A Water used for compacting fill, or for washing crushed stone shall be clean and free from oil, grease, organic matter, suspended fine sediment and other deleterious substances.

Part 3 Execution

3.01 Control of Water

A All excavation and construction of structures and backfill shall be carried out in the dry as described in Section 02200 hereof.

3.02 Excess Excavation to be Made Good

A The Contractor, at his own expense, shall remove from the Site all material resulting from excess excavations below that required for the foundation, or bedding and shall make good the same with concrete or suitable fill material as may be required by the Engineer.

B Where, due to site conditions, an alternative method for supporting the foundations or beddings may be possible the Contractor shall provide three copies of a design report by a competent engineer together with all calculations demonstrating the sufficiency of the proposals. No alternative proposals shall be undertaken except with the Engineer's consent and such consent shall in no way relieve the Contractor from any of his contractual obligations and responsibilities.

3.03 Supporting Structure Excavations

A Suitable and practically watertight cofferdams shall be used wherever water or water-bearing strata are encountered above the elevation of the bottom of the excavation. The Contractor shall submit shop drawings showing his proposed method of cofferdam construction at least two weeks prior to starting excavation.

B The Contractor shall employ a qualified engineer to prepare the shop drawings who is registered in the Project country or who is acceptable to the Employer. The engineer who prepares the shop drawings shall be familiar with cofferdam construction and shall include his qualifications for the preparation of such a submittal. The shop drawings shall be complete with all details, design calculations, and description of construction and include all necessary particulars.

C Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottoms of the footings; or when footings are to be founded on or in rock, the cofferdam construction shall be placed at least to the level of top of rock or the bottom of excavation in rock to suitably develop a stable cofferdam and shall be well braced and as watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

D When conditions are encountered which render it impracticable to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as directed by the Engineer. The

foundation shall then be dewatered and the footing placed. In the event that weighted cribs are employed and the weight is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level.

3.04 Backfilling

A Earth fill shall not be placed until the required excavation and foundation preparation have been completed and the foundation and/or structure to be backfilled has been inspected and approved by the Engineer. Fill shall be placed in approximately horizontal layers of thickness that can be uniformly compacted by the equipment used but of maximum 200 mm loose thickness. Hand compacted fill including fill compacted by manually directed power tampers shall be of maximum 100 mm loose thickness. Fill adjacent to structures shall be placed in a manner which will prevent damage to the structures and will allow structures to assume the loads from the fill gradually and uniformly. The height of the fill adjacent to a structure shall be increased at approximately the same rate on all sides of the structure.

B Backfill shall be compacted to not less than 95 percent of maximum dry density, as determined by BS 1377 (4.5kg hammer).

3.05 Inspection by the Engineer

A When the specified levels of structure excavation are reached, the Engineer will inspect the ground exposed. If he considers that any part of the ground is by its nature unsuitable, he may direct the Contractor to excavate further and to refill the further excavation with such materials as he may direct. Such further excavation will not be held to be excess excavation. Should the bottom of any trench or structure excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. In this case the cost of the extra excavation and of the additional foundation materials required will be the Contractor's responsibility if necessitated by his negligence.

END OF SECTION 02222

Section 02300

Geosynthetic Material and Prefabricated Vertical Drain

Part 1 General

1.01 Description

A This section gives additional requirements for geosynthetic materials to be used for separation of sand mat layers, slope protection of earth fill, etc. This work shall comprise manufacturing, testing, supply and installation, all in accordance with this and other relevant sections of the Specifications and to the details shown on the Drawings.

Part 2 Products

2.01 Material

A. Geosynthetic material shall be labelled to identify the roll number, batch number, brand, mass per unit area, machine and cross-machine directions and polymer type, and shall be wrapped in robust cylindrical cardboard or dark plastic sheets to protect them from sunlight.

B. Geosynthetic material shall be inert to all chemicals naturally found in soils and shall have no solvents at ambient temperature. They shall not be susceptible to hydrolysis and shall be resistant to aqueous solutions of salts, acids and alkalis. They shall also be non-biodegradable and have an optimum quantity of carbon black to inhibit damage by ultra violet light.

C. Mono-oriented geosynthetic material shall be of a plane monolithic structure with a uniform distribution of long shaped apertures that distinguish longitudinal and transverse bars.

D. Biaxial-oriented geosynthetic material shall be of a plane monolithic structure with a uniform distribution of rectangular apertures that distinguish longitudinal and transverse ribs.

E. Geosynthetic material shall have undergone a process of molecular orientation to improve the mechanical characteristics to ensure long term performance under sustained loading.

F. The Contractor shall be responsible for preventing damage to geosynthetic materials. In the event that a section of geosynthetic material is damaged, the Contractor shall replace the damaged section at his own expense.

2.02 Geotextile Fabrics (Separators and Filters)

A. Geotextile fabrics as separators or filters as shown on the Drawings shall comply with the properties listed in Table 1 hereof.

B. Type A geotextile fabric shall be needle-punched continuous filament non-woven geotextile and shall be used as a separator between residual soft soils and the suitable fill material as shown on the Drawings.

C. Type B fabric shall be non-woven geotextile and shall be used in subsoil drains, weep holes and other drainage works as shown on the Drawings.

D. Where geotextile fabric is to be joined by sewing, a double chain stitch with high tenacity polyester thread forming a 'Prayer' seam shall be used. The minimum number of stitches per 25mm shall be 3 with 2 rows of stitching. The minimum lap of adjacent fabric to be joined by sewing shall be 50mm. The polyester thread shall have a breaking load of not less than 200 Newtons.

Table 1 - Properties of Geotextile Fabrics

Property	Unit	Type A	Type B	Test Standard
Minimum Mass	g/m^2	280	125	ASTM D5261-92
Maximum Apparent Pore Size (0_{90})	Micron	125	150	BS 6906: Part 2 1995
Minimum Permeability under 100mm head	$l/m^2.sec$	100	180	BS 6906: Part 3 1995
Minimum Wide Width Tensile Strength	KN/m	20	9	BS EN ISO 10319: 1996
Minimum Trapezoidal Tear Strength Or Minimum CBR Puncture Resistance	N N	500 3,000	200 1,500	ASTM D4533-91 BS EN ISO 12236:1996
Geotextile Type		Needle-punched, non-woven	Non-woven	
Polymer Composition		PE/PP/PET *	PE/PP/PET *	

* PE - Polyethylene, PP – Polypropylene, PET - Polyester

2.03 Geotextile Reinforcement

A. Geotextile reinforcement shall be provided as shown on the Drawings.

B. Geotextile reinforcement shall be manufactured from high modulus polyester yarns resistant to ultra-violet light degradation such that the loss of tensile strength does not exceed 10% after 500 hours of exposure to sunlight. The material shall also be resistant to chemical attack in the range of pH2 to pH9.

C. No seams are permitted in the direction of tension. In the case of overlaps, the Contractor is required to demonstrate, to the satisfaction of the Engineer, that the designed forces are transferred across the joint without additional deformation.

D. Where geotextile reinforcement is to be joined by sewing, a double chain stitch with high tenacity polyester forming a double ‘J’ seam shall be used. The minimum number of stitches per 25 mm width shall be 3 with 2 rows of stitching. The minimum lap of adjacent reinforcement to be joined by sewing shall be 50 mm. Each polyester thread shall have a breaking load of not less than 200 Newtons.

E. Geotextile reinforcement shall comply with the properties listed in Table 2 below:

Table 2 - Properties of Geotextile Reinforcement

Property	Unit	Type 1	Type 2	Type 3	Test Standard
Minimum Mass	g/m^2	450	800	1,150	ASTM D5261-92
Minimum Wide Width Tensile Strength a) Warp b) Weft	 kN/m kN/m	 200 50	 400 50	 600 50	BS EN ISO 10319: 1996
Maximum Elongation at Ultimate Load a) Warp b) Weft	 % %	 13 15	 13 15	 13 15	BS EN ISO 10319: 1996
Maximum Creep at 50% of Ultimate Load after 2 years	%	2	2	2	ASTM D5262-92
Geotextile Type		Woven	Woven	Woven	
Polymer Composition		Polyester	Polyester	Polyester	

2.04 Geogrid Reinforcement

A. Geogrid reinforcement shall be provided as shown on the Drawings.

B. Geogrid reinforcement material shall be integrally extruded high-density polyethylene or polypropylene (HDPE/HDPP) to form a plane monolithic structure and shall contain a minimum of 2% finely divided carbon black content. The material shall be;

1 resistant to chemical attack in the range of pH2 to pH9;
2 resistant to attack by bacteria and fungi, unattractive to vermin;
3 stable over a temperature range of 10°C to 60°C; and
4 resistant to ultra-violet degradation such that the loss of strength does not exceed 20% after 10 years of exposure to sunlight.

C. A minimum overlap of 300 mm is required between adjacent strips of geogrid reinforcement. Lapped joints within the length of a strip shall develop the full tensile strength of the geogrid and in no case shall it be less than 1,000mm.

D. Geogrid reinforcement material shall comply with the properties listed in Table 3 below:

Table 3 - Properties of Geogrid Reinforcement

Property	Unit	Type BG 1	Test Standard
Minimum Wide Width Tensile Strength a) Longitudinal b) Transverse	 kN/m kN/m	 40 40	BS EN ISO 10319: 1996
Aperture Size a) Longitudinal b) Transverse	 mm mm	 20 - 40 20 - 40	

Property	Unit	Type BG 1	Test Standard GRI - GG2
Minimum Junction Strength			
a) Longitudinal	kN/m	30	
b) Transverse	kN/m	30	
Polymer Composition		HDPE/HDPP*	

* HDPE - High Density Polyethylene; HDPP - High Density Polypropylene

2.05 Prefabricated Vertical Drain (PVD)

A. Prefabricated vertical drain (PVD) shall comprise the supply and installation of prefabricated vertical drains for accelerated drainage and consolidation of underlying soft compressible soils. Prefabricated vertical drains shall be installed in accordance with dimensions shown on the Drawings and these Specifications.

B. Prefabricated vertical drains shall comply with the following:

1 The drain core shall be of a continuous plastic material made of high-density polyethylene or polypropylene resin. It shall be flexible and shall have multiple channeled section which does not pinch off when bent back or folded on itself so that flow of water may be uninterrupted. Rigid drains such as those shall not be used.

2 The entire drain core shall be fully filtered and located within an approved geotextile fabric filter jacket. The geotextile fabric shall be non-woven, thermally bonded and comprise long chained synthetic polymer of polypropylene, polyethylene or polyester or any combinations of these materials. Drains without geotextile fabric filter jacket shall not be used.

3 Properties of prefabricated vertical drain shall be in accordance with Table 4 below.

Table 4 - Properties of Prefabricated Vertical Drain

Description	Specification	Unit	Test Method
A Core			
Fungus Resistance	No Growth	-	-
Chemical Resistance	Excellent	-	-
Width	> 98 ± 2	mm	-
Thickness	> 5.0	mm	-
Compressive strength	> 450	KPa	-
B Filter			
Structure	Non-woven Fabric	-	-
Material	PET/PP/PE	-	-
Pore Size O_{95} (AOS)	< 100	micron	ASTM D 4751
Permeability	> 1 x 10^{-4}	m/s	ASTM D 4491
Permittivity	> 0.5	s^{-1}	ASTM D 4491
Grab Tensile Strength	> 500	N	ASTM D 4632
Puncture Resistance	> 1,200	N	ASTM D 4533
Composite PVD			
Equivalent Drain Diameter	> 50	mm	-
Tensile Strength	> 8.0	kN	ASTM D 1682
Elongation	> 25	% at speed of 305 mm/min	-

Description	Specification	Unit	Test Method
C Drain			
Discharge capacity at Hydraulic gradient of 1 Under 350 kPa vertical Pressure and under Deformation (at 30% Relative compression)	60×10^{-6}	m^3/sec	ASTM D 4716
Free Volume	$> 200 \times 10^3$	mm^3/m	-
Elongation	> 30	% at speed of 100 m/min	ASTM 1682-75
Free Surface area	$> 150 \times 10^3$	mm^3/m	

2.06 Certification of Geosynthetic Materials

A The Contractor shall submit to the Engineer for approval details of geosynthetic materials to be incorporated in the Works as described in the following sub-clauses:

B Manufacturer's certificates accompanied by samples, stating:
1 the name of the manufacturer;
2 product name and type; and
3 details of international accreditation.

C Test certificates from a laboratory accredited by the relevant authority of the Project country or approved by the Engineer, stating:

1 mass per unit area;
2 tensile strength (longitudinal/transverse);
3 elongation (longitudinal/transverse);
4 apparent pore size (0_{90});
5 trapezoidal tear strength;
6 minimum permeability under 100mm of head;
7 CBR puncture resistance;
8 creep properties; and
9 other details deep pertinent by the manufacturer.

D Testing shall be carried out in accordance with codes of practice and standards as described in Tables 1 to 4 herein.

E Prior to the installation of geosynthetic materials, samples shall be selected for testing at an approved laboratory. Where an individual sample fails to satisfy the specified properties, the roll from which the sample was obtained shall be rejected. Two further samples shall then be selected from rolls in the same production batch as that from which the failed sample was selected. If either of these two samples fails to satisfy the specified properties, the whole batch represented by the samples shall be rejected.

F At least one sample to be selected by the Engineer for each batch of production shall be subjected to the prescribed tests.

Part 3 Execution

3.01 Storage of Geosynthetic Materials

A The Contractor shall store geosynthetic materials in a manner recommended by the manufacturer or in the following manner, whichever is the more stringent.

B Geosynthetic materials shall be stored away from direct sunlight to give protection against exposure to ultra-violet light. If stored out of doors, geosynthetic materials shall be elevated above the ground and protected by a waterproof and opaque cover.

3.02 Placement of Geosynthetic Materials

A Geosynthetic material shall be laid in accordance with the manufacturer's recommendations and the provisions in the Clauses herein. In the event of inconsistencies, the more stringent requirement shall prevail.

B Geosynthetic materials shall be unrolled in the machine direction and the receiving surface shall be prepared in accordance with the Specification, free from any voids, debris, sharp objects or any other material that may cause damage to the geosynthetic material.

C To prevent local bending and uplifting of a geosynthetic material during the spreading of fill material over it, the geosynthetic material shall be pulled taut and temporarily fixed with steel staples. Special care shall be taken to prevent waving in the geosynthetic material layers. If any wave or ripple occurs along a geosynthetic material layer during fill spreading, the wave or ripple shall be immediately eliminated and the geosynthetic material fixed to avoid further occurrence.

D Exposure of geosynthetic material to natural elements between placement and the laying of suitable fill material shall be an aggregated maximum period of 7 days or in accordance with the manufacturer's recommendations, whichever is the more stringent.

E During filling operations, no construction equipment shall be permitted to pass directly over unprotected geosynthetic material. A minimum of 150 mm of fill material or such greater depth in accordance with the manufacturer's recommendation shall be placed prior to trafficking over the geosynthetic material to mitigate damage to the geosynthetic material.

3.03 Placement of Prefabricated Vertical Drain

A The installation procedure of the prefabricated vertical drain shall ensure that the vertical plastic drains are not damaged, kinked or distorted. When installing prefabricated drains by the displacement method, the drain shall be located within a mandrel that is guided along the leader of a mobile crane. Installation shall be carried out in a single stroke and no alternate raising and lowering of the mandrel shall be permitted. The cross-section area of the mandrel shall not exceed 70 cm^2.

B The drain shall be anchored by flexible steel or plastic shoe which acts as a barb and engages the soil when the mandrel is withdrawn, leaving the drain in place. All drains shall be driven vertically into the ground at each position and within a vertical tolerance of 1 in 75. If the contractor encounters any stump or hard objects during the driving works, he will be permitted to drive a replacement drain at an offset position located not more than 0.75m away. Otherwise, the tolerance of the spacing between drain centres shall not exceed 0.3m.

C Vibratory machine shall be used to penetrate hard crust or interbedded dense layers only with the approval of the Engineer. The vertical drains are to be driven to penetrate the stiffer foundation layer by 300 mm.

D After driving to the required depth and retracting the mandrel, excess length of drain will be cut off at the height of 150+50mm above the ground level. Any debris around the drain position shall be cleared so as not to contaminate the granular drainage layer or the protruding drain section.

E If any drain is rejected due to its incorrect position, the Contractor shall replace it with another drain installed adjacent to it in a position determined by the Engineer.

F Any splicing of the drain shall be carried out the Contractor by a method approved by the Engineer. The splice shall be carried out with at least 150 mm of the core of the drain enclosed within the filter and fully secured with metal staples. External overlaps or splices are strictly not permitted.

G Drains that would cause large soil displacement during installation shall not be permitted. If a non-displacement drains where drain holes have to be pre-formed is adopted, the Contractor shall dispose all materials removed from the drain hole promptly so as to avoid contamination of the exposed section of drains or the granular drainage layer.

END OF SECTION 02300

Section 02310

Geotechnical Instrumentation and Monitoring

Part 1 General

1.01 Description

A This section gives additional requirements for geotechnical instrumentation to be used for monitoring soil movement, settlement, groundwater pressure, etc. This work shall comprise manufacturing, testing, supply, installation, monitoring, calibration and maintenance of instrumentation, and reporting of the results of measurement, all in accordance with this and other relevant sections of the Specifications and to the details shown on the Drawings.

Part 2 Products

2.01 General

A Geotechnical instrumentation shall be provided to monitor the performance of the Works. It shall form part of the Permanent Works and shall remain operational up to the end of the Defects Liability Period.

B The Contractor shall be responsible for and shall comply with the recommendations of the instrument manufacturers and these specifications in the calibration, installation and testing of all instruments required for the geotechnical instrumentation works.

C The Contractor shall employ suitably qualified and experienced staff in adequate numbers for the installation of the instruments and the subsequent monitoring thereof. The Contractor's engineer in charge shall be a professional engineer with at least 10 years of postgraduate working experience in geotechnical engineering works. The Contractor shall submit the names and curriculum vitae of proposed personnel to carry out the instrument installation and subsequent monitoring works, and a programme of their attendance, for the approval of the Engineer. Any changes to the proposed personnel or any deviation from the approved programme of attendance shall require prior approval of the Engineer.

D The Contractor shall inform the Engineer of his proposed instrumentation installation plan, proposed personnel and programme of attendance at least seven days before commencing the installation of any instruments.

2.02 Rod Settlement Gauge

A Rod settlement gauge is required to measure settlements taking place beneath and adjacent to embankments during and after construction. The Contractor shall provide and install rod settlement gauges in the quantities as shown on the Drawings and at locations approved by the Engineer.

B. Equipment and Installation

1. Details of rod settlement gauges and quantities required shall be as shown in the Drawings. The locations shall be selected by the Engineer.

2. The base plate and first length of rod shall be placed as soon as possible during filling works at the base plate level. The next extension shall be installed when the level of compacted embankment is 250 mm below the top of the preceding length.

3 Should a rod settlement gauge be damaged or should the Contractor fail to extend the gauge when required, he shall stop all filling in the vicinity of the gauge until the necessary remedial works have been carried out.

C. Method of Monitoring

1 The Contractor shall monitor the rod settlement gauges. Levels shall be taken of the top of the rod and of the fill adjacent to the gauge.

2 When rods are extended, levels shall be measured immediately before and after the extension.

2.03 Magnetic Extensometer

A Magnetic extensometer provides a method of measuring settlement at a point or a series of points below the ground surface. The Contractor shall install magnetic extensometer in the quantities shown on the Drawings and at locations and depths approved by the Engineer.

B. Equipment and Installation

1 Magnetic extensometer shall consist of an access tube and a series of magnetic targets which are free to slide down the tube, together with a datum magnet which is fixed to the tube near its base. The access tube shall be of rigid PVC of 33 mm external diameter and 24 mm internal diameter with threaded ends which provide both an internal and an external flush coupling.

2 A rigid PVC end cap shall be fixed to the lower end of the series of tubes. Compression/extension tubes shall be provided where required. All joints shall be sealed with suitable PVC solvent cement.

3 A datum ring magnet shall be fixed approximately 2 m above the lower end of the tube. Spider magnets shall be used within the subsoil and plates magnets within fill where magnets can be placed during construction.

4 The tubes and magnets shall be assembled prior to installation in such a way that the magnets remain in the correct position in relation to the tube. The tube shall be coated with thick grease over its upper part where it passes through compressible subsoil.

5 The tube shall then be lowered together with all magnets and necessary accessories fixed in position into a 100mm diameter borehole backfilled with a suitable bentonite and cement grout mix. Once in position the spider magnets shall be released.

6 Where the access tube passes through upper stiff crusts or fill material, it shall be shall have a larger diameter sleeve tube so that it can pass freely through these materials as settlement takes place.

7 Where the access tube passes through fill which is being placed, the access tube and outer sleeve shall be extended as filling progresses. The top of the access tube and the larger diameter sleeve where provided, shall be protected with a suitable cover.

C. Readout Device

1 The readout device shall consist of a nickel-plated brass probe containing a reed switch encapsulated in silicone rubber. The probe shall be connected via a nylon coated steel tape to a reel and buzzer.

D. Method of Monitoring

1 Magnetic extensometer shall be monitored by lowering the probe down to the base of the access tube. The probe shall then be pulled upwards measuring the position of each magnet from the top of the tube.

2 The position of each magnet shall be measured twice, once while moving upwards and once while moving downwards towards the magnet. Immediately before or after taking a series of readings, the level of the top of the access tube shall be measured by standard levelling techniques.

2.04 Inclinometer

A Inclinometer provides a method of measuring a continuous profile of horizontal deflection both at the surface of and within a mass of soil. The Contractor shall install inclinometers in the quantities as shown on the Drawings and at locations and with depths and details as selected by the Engineer.

B. Equipment and Installation

1 Inclinometer access tube shall consist of broached PVC tubing with four key ways set at right angles to each other and shall be supplied in 3 m lengths with 0.3 m long couplings and end caps. The spiral twisting of the key-ways shall not exceed 0.75° per metre length of the tubing.

2 Where necessary, the Engineer may require the Contractor to obtain spiral metric measurements of the key-ways in the inclinometer tubing after installation. After assembly joints and rivets shall be coated in sealing mastic and wrapped in sealing tape. The tube shall be coated with thick grease over its upper part when it passes through compressible subsoil.

3 The assembled tube shall be lowered into a minimum 150 mm diameter borehole backfilled with a suitable bentonite and cement grout mix. Alternatively the tube may be placed in an open borehole and grout placed afterwards. In granular material, the backfill may be sand or pea gravel. The key-ways shall be orientated such that movements are measured parallel to and at right angles to the embankment axis.

4 Where the access tube passes through upper stiff crusts or fill material, it shall have a larger diameter sleeve tube so that it can pass freely through these materials as settlement takes place.

5 Where the access tube passes through fill which is being placed, the access tube and outer sleeve shall be extended in lengths that are multiples of 0.5m as filling progresses. The top of the access tube and the larger diameter sleeve where provided shall be protected with a suitable cover.

C. Readout Device

1 Angular movements shall be measured by an inclinometer torpedo which shall be a

biaxial type with a gauge length of 500 mm and the system shall be capable of measuring lateral deformation to an accuracy of ±10 mm over a depth of 30 m. The casing of the inclinometer probe shall be constructed of stainless steel and the probe shall be fully waterproof and corrosion proof.

2 The inclinometer probe shall be supplied with a rigid carrying case fully lined with shockproof padding. The cable supplied for use with the inclinometer probe shall be polyurethane sheathed with a minimum length of 40 m, incorporating a central Kevlar straining wire.

3 The cable shall be graduated in intervals of 500 mm and shall be supplied complete with a portable cable reel.

4 The inclinometer data logger unit shall display the readings from the inclinometer torpedo on an alphanumeric display. The readout unit shall be powered by a re-chargeable battery with a minimum life of 12 hours continuous use between charges. A suitable automatic battery charger shall be supplied with the readout unit.

5 The readout unit shall incorporate an RS232C port and a solid-state data storage unit with the capacity to store at least 30,000 readings directly from the inclinometer probe together with time and date of reading. The following facilities are also required within the readout unit:

1 scan stored data;
2 display of face errors as readings are being obtained;
3 display of mean deviation and cumulative deviation of any one set of readings;
4 graphical display of displacement profile between any two sets of readings; and
5 back lit LCD display.

6 A calibration frame shall be supplied by the Contractor to enable the inclinometer calibration to be checked at vertical and 10° either side of vertical.

D. Method of Monitoring

1 Immediately before or after taking a series of readings, the level of the top of the access tube shall be measured by standard levelling techniques. Before passing the torpedo down the access tube, a dummy torpedo shall be lowered to the base of the tube and pulled up to check for obstructions or constrictions.

2 The inclinometer torpedo shall then be lowered to the base of the access tube and raised taking readings every 0.5 m until the torpedo reaches the top of the access tube. The readings shall be read by and stored in the data logger. The procedure shall be repeated on the opposite face following the manufacturer's recommendation and sign convention.

2.05 Pneumatic Piezometer

A The Contractor shall install pneumatic piezometer in the quantities shown on the Drawings and at locations with depths approved by the Engineer.

B. Equipment

1 Pneumatic piezometer tips shall be of high air entry ceramic type with an average pore diameter of 1 micron using marine brass or stainless steel bodies. The piezometer system shall be capable of measuring water pressures to an accuracy of ±0.2 m head of

water in the range of 0 to 35 m head of water.

2 Piezometer shall be connected to tubing comprising suitably coded twin 1.9 mm internal diameter and 3.2 mm external diameter Type 11 nylon tubes and covered with a polythene sheath 1 mm thick. Joints in the tubes other than at the piezometer tip or at the terminal panel shall not be permitted.

3 Tubes from individual piezometer shall be colour coded and marked every 3 m. The tubing shall be connected either to suitable quick release couplings or a terminal panel which shall be housed in a lockable steel cabinet.

4 The arrangement of the equipment and the methods of installation are shown on the Drawings.

C. Installation in a Sand Pocket

1 Pneumatic piezometer shall be installed in a 150 mm diameter borehole and backfilled with graded sand filter material.

2 Where there is water in the borehole the Contractor shall allow sufficient time for all the sand to settle.

3 The porous element shall be placed in the hole and the remaining sand filter shall then be added. The final elevation of the top of the sand filter shall be measured by a flat-end sounding rod.

4 Seals consisting of bentonite pellet shall be placed above, and if deemed necessary by the Engineer, below the sand filter as well. The remainder of the hole shall be filled with bentonite and cement grout of 1:1.

D. Installation by Pushing into the Base of the Borehole

1 The 150 mm diameter borehole shall be terminated 300 mm above the required position of the piezometer tip. The piezometer tip with cable attached shall be pushed into the base of the borehole to the required depth using an arrangement of sufficiently stiff tubes. The borehole shall then be sealed with bentonite pellet and bentonite and cement grout of 1:1 as shown on the Drawings.

E. Installation in the Drainage Blanket

1 For pneumatic piezometer installed in the bottom of a blanket layer, an arrangement shall be made as shown on the Drawings. The piezometer tip shall be placed in a container filler with graded sand filter material and water.

2 The water level shall be up to the top of the container that shall be open. The container shall be placed at the base of the drainage blanket and sand shall be placed immediately around and above the container.

F. Terminal Arrangements

1 The piezometer leads shall either be connected to quick release couplings set inside a suitable cover or be taken to a terminal panel fixed inside a lockable steel cabinet, epoxy coated for corrosion protection. The cabinet shall be set on a concrete plinth typically 0.6×1.0×0.3 m thick (plan dimensions may be adjusted to suit the cabinet size) and shall at all times be protected from construction work.

2 Where cables are laid in trenches the backfill material shall either be sand or the arising if it is a suitable material. The cable shall be laid with sufficient slack to take up any lateral movements that are expected to occur due to settlement of embankments or structures.

G. Readout Equipment

1 The pneumatic readout unit shall be capable of storing 500 readings and shall incorporate:

1 an electronic pressure transducer;
2 back lit digital display;
3 RS232C interface and cable link;
4 rechargeable battery providing at least 12 hours continuous use between charges;
5 a rechargeable gas reservoir bottle;
6 a reservoir pressure gauge;
7 return and flow indicators;
8 flow control valve; and
9 quick release self sealing leads for connection to the supply and return manifolds of the terminal panel.

2 The readout unit shall be housed in a rigid weatherproof case with carrying handles and shall be capable of resolving readings to 1 kPa. An automatic charger for the readout unit battery shall be supplied suitable for 240 volt, 50 Hz electricity supply.

3 The Contractor shall make facilities available for recharging the gas reservoir with nitrogen.

4 Readings shall be taken by and stored on the readout device. Care shall be taken to ensure that the flow and return leads are connected correctly.

H. Commissioning

1 Before installation and taking initial readings, the Contractor shall conduct pressure test on the pneumatic piezometer tip in a container of water after connection to the tubing with a pressure of 500 kPa to check for leaks or poor connections. The ceramic element shall be de-aired under vacuum and precautions shall be taken to ensure that it remains saturated during installation.

2 During installation, readings shall be taken:

1 when the piezometer tip is lowered down the borehole;
2 when it is pushed in or placed in the sand pocket; and
3 at various times after installation; to check the response of the piezometer and to determine the static pressure value before initial base readings are taken.

Part 3 Execution

3.01 Protection and Maintenance of Instruments

A The Contractor shall take all necessary precautions to protect the instruments and maintain the instruments in good working order before and after installation. For instrument which

project through and above any soil surface, special precautions shall be taken to protect them from damage by vehicles, plant or any other cause.

B Heavy compaction equipment shall not approach within 1.5 m of instruments projecting above any soil surface. The Contractor shall carry out regular checks to ensure the integrity of instrumentation and repair or replace damaged instruments within seven days of any damage having been identified.

C In the event of any damage caused by the Contractors, machinery or workmen, the Contractor shall restore or replace them to their original condition and to the satisfaction of the Engineer.

3.02 Stabilising Electronic Readout Devices

All electronic readout devices and transducers shall be shaded from direct sunlight. Probes to be placed inside access tubes shall be in place for at least 10 minutes or for such durations recommended by the manufacturer, whichever is the more stringent, to allow the temperature of the probes to stabilise before any measurement is made.

3.03 Boreholes for Instruments

A Boreholes for installation of instruments shall be clean and stable and of the required diameter and depth. Boreholes shall be cased to their full depth unless the hole will stay open under both dry and wet conditions.

B Boreholes shall be drilled using clean water. Drilling mud or polymer additives may only be used with the approval of the Engineer. Where piezometer is to be installed, drilling mud or polymer additives shall not be permitted.

C Care shall be taken during drilling to ensure that minimum amount of material is lost from the outside of the casing. Surging of the casing shall not be permitted and flushing of drilling water up the outside of the casing shall be minimised.

D Before commencement of the boring works for installation of instruments, the Contractor shall submit to the Engineer for approval, a method statement detailing his proposals for forming boreholes, including the procedure for advancing borehole casings.

3.04 Grouting of Boreholes

A For all instruments placed in boreholes, grouting to part or the entire borehole shall be as shown in the Drawings. If not shown on the Drawings, it shall be as recommended by the instrument manufacturer.

B Grout shall be bentonite and cement mixture with sufficient water to achieve a consistent mix. The mix proportions shall result in a mixture which approach the strength or consistency of the adjacent natural soils. The Contractor shall conduct trials on different mixes of bentonite and cement (in the proportion range of 4:1 to 8:1) to ascertain the relationship of the mix proportion with strength. Specimens shall be stored and then tested for undrained triaxial compression strength after 1 day, 2 days, 7 days, 14 days, 1 month and 3 months of curing.

C Three specimens for each curing age, as specified in B above, shall be prepared and tested. The sources of the bentonite and cement used in the tests shall be the same as those to be used for eventual borehole grouting. On the basis of the trials, the Contractor shall submit

to the Engineer for approval, the bentonite and cement proportions to be used in the mixture. Different mixture proportions may be proposed for different applications.

D Grout shall be poured or pumped into boreholes using a tremie pipe.

3.05 Labelling and Marking of Instruments

A All installed instruments shall be indelibly marked, using a method and material approved by the Engineer. Reference numbers identifying the type of instrumentation and the location of the instrument shall be indicated by the marking.

B For instruments which are located beneath a sand drainage layer where vertical drains are later to be installed, their locations and the locations of any connecting tubes or cables shall be marked using 1.6 m lengths of 20 mm steel bar. The bars shall be driven vertically 0.9 m into the ground as close as practicable to the instrument before the sand drainage layer is placed. The top of each steel bar shall be painted in bright colours, in accordance with an approved colour coding to indicate the instruments buried.

C During the placing of the sand drainage layer around the bars the Contractor shall ensure that the bars remain vertical and are clearly visible on completion of the sand drainage blanket.

3.06 Survey Equipment

A All surveying equipment to be used for the monitoring and measurement of instrumentation results, including measuring tapes, levels and theodolites shall be maintained and calibrated in accordance with the manufacturer's recommendations.

3.07 Displacement Markers, Settlement Markers and Survey Stations

A Settlement markers shall be set up in the form and quantities shown on the Drawings. The locations shall be selected by the Engineer.

B Survey stations shall be established on undisturbed ground, clear of the embankment and any ground movement effects, to monitor both the vertical and horizontal movement of the markers. The nearest survey station from any marker shall not be more than 1,000 m and the locations of such survey stations shall be subjected to the approval of the Engineer. The co-ordinates and levels shall be established from approved government survey stations and their accuracy shall be checked at not more than 6-month intervals.

3.08 Deep Levelling Datum

A Deep levelling datum shall be required to facilitate measurement of ground levels in soft ground areas. The datum shall be fixed into firm ground and isolated from any soft and compressible overlying strata. The Contractor shall be responsible for establishing at least 2 deep levelling datum at each section where replacement of soft unsuitable foundation material or where foundation treatment is specified. Such datum shall be installed before the commencement of any work for the related section and shall be installed in locations approved by the Engineer.

3.09 Equipment and Installation

A Deep levelling datum shall be as shown on the Drawings. The installed depths of such datum shall be approved by the Engineer.

B Concrete plinth of deep levelling datum shall be marked with the respective reference number and the reduced level of the datum.

C The datum level shall be established by levelling from approved government benchmarks and its accuracy shall be checked at not more than 6-month intervals.

3.10 Instrumentation Records

A After installation, the correct proper operation of each instrument shall be demonstrated to the Engineer, including the recording of measurements. As part of the commissioning exercise, three sets of readings shall be taken and compared. When instruments are installed before earthwork starts, these three sets of readings shall also be taken just before earthwork starts.

B If there are significant differences or anomalies, then further readings shall be taken. Once three sets of comparable readings have been taken, these shall be averaged to form the base readings, representing conditions before earthwork starts.

C In cases where instruments are installed during earthwork operations, three sets of readings shall be taken in quick succession and the results compared. These results shall be used to provide base readings in a manner approved by the Engineer.

3.11 Records

A All records of instrumentation, either installation, readings or monthly summaries, shall contain the following information:

1 project name;
2 contract name and number;
3 instrument reference number and type;
4 name of instrument reader;
5 name of manufacturer and details of local supplier;
6 dates of installation, reading or summary;
7 times of installation or reading;
8 chainage and offset (or co-ordinates if appropriate);
9 responsible personnel; and
10 relevant comments or remarks.

3.12 Installation Records

A The Contractor shall prepare an installation record sheet for each instrument installed and the Contractor shall submit the sheet at least one week before installation commences. The format of the installation record sheet shall have prior approval of the Engineer. The record sheet shall provide for entry of the following information in addition to the general information required:

1 existing ground level at the time of installation, measured at 5-metre intervals in the case of hydrostatic profile gauges;
2 location in plan and elevation;
3 orientation;

4 intended lengths, widths, diameters, depth and volumes of backfill;
5 plant and equipment used, including diameter and depth of any drill casing used;
6 spaces for necessary measurements or readings required during installation to ensure that all previous steps have been followed correctly, including acceptance tests;
7 a simplified log of ground conditions (obtained during rotary wash boring);
8 type of backfill used;
9 as-built location in plan and elevation;
10 as-built orientation;
11 as-built lengths, widths, diameters, depths and volumes of backfill;
12 weather conditions;
13 space for notes, including problems encountered, delays, unusual features of the installation and any events that may have a bearing on instrument behavior;
14 commissioning information and readings; and
15 any colour coding used.

B The Contractor shall submit to the Engineer two copies of each installation record sheet, referred to in A. above within 24-hours of completion of the installation, including the taking of base readings.

3.13 Installation Report

The Contractor shall submit, to the Engineer two copies of an installation report once installation of all instruments is completed. Submission shall be within four weeks of completion including taking of all base readings. The report shall include:

1 a description of the scope of works, the site of works and the types of instrument installed;
2 all installation record sheets;
3 plans and cross section drawings at a scale of 1:200 showing the locations, elevations and details of all instruments;
4 photographs of all the instruments used, illustrating installing and method of reading; and
5 values of all base readings taken together with any subsequent readings up to the time of submission.

3.14 Readings

A On each occasion that readings are taken from an instrument or set of instruments, the measured values shall be recorded on a record sheet. The format of the record sheet for each type of instrument shall be approved by the Engineer and the Contractor shall submit the record sheet at least one week before readings commence. For readings that are recorded on data loggers, a record sheet shall be required giving references to the data stored.

B The format of plotted results shall be submitted to the Engineer for approval. Details of information and values to be stored on each record sheet, in addition to the general information required, are given in Table 1 below:

Table 1 -Information to be Recorded

Instrument	Data Required
Settlement marker	– reduced level of top of rod (mRL) – change in reduced level of top of rod relative to base readings and previous readings (mm)

Instrument	Data Required
Deep datum	– reduced level of datum (mRL)
Rod settlement gauge	– reduced level of top of rod (mRL) – original ground level at gauge location (mRL) – reduced level of ground adjacent to gauge (mRL) – record of fill placed (m) – total thickness of fill (m) – record of extensions (m) – settlement of plate relative to base readings and previous reading (mm)
Magnetic extensometers	– reduced level of top of access tube (mRL) – reduced level of ground adjacent to access tube (mRL) – distance of each magnet from top of tube (m) – reduced level of each magnet (mRL) – settlement of each magnet relative to base readings (mm)
Inclinometers	– reduced level of top of access tube (mRL) – reduced level of ground adjacent to access tube (mRL) – file name of data stored in data logger – file name of data after transfer to floppy disk – listing of deflection values and face errors every 0.5 m – graph and listing of horizontal movement of access tube relative to base reading against depth
Pneumatic piezometers	– water pressure reading (m water) – file name of data stored in data logger – file name of data after transfer to floppy disk – reduced level of piezometer tip as installed (mRL) – estimated or measured settlement of piezometer tip (m) – water head (mRL) – change in water head relative to base readings (m)

C The Contractor shall submit to the Engineer two copies of each record sheet with necessary listings and graphs within 24 hours of taking the readings.

3.15 Frequency of Readings

A Each instrument shall be read immediately before and after each change in loading (that is each layer of fill). Notwithstanding this requirement each instrument shall be read at intervals not greater than three days during the 12 days after a change in loading and seven days thereafter. Any instruments found to be faulty shall be promptly brought to the Engineer's attention. The Contractor shall at the same time ensure that the instruments are repaired expeditiously, in order that remedial measures can be undertaken.

B The Contractor shall monitor water levels in standpipes and standpipe piezometer once daily for the first seven days after the piezometer are installed. Thereafter water levels shall be monitored at intervals of seven days. During periods of continued rainfall, the water levels shall be monitored once daily for duration as directed by the Engineer.

C Reading frequencies may be reduced with the approval of the Engineer.

3.16 Anomalous Readings

The Contractor shall compare measured sets of data with any previous sets of data. If anomalous readings are present which differ from the expected value or trend, then the Contractor shall inform the Engineer and shall take further readings immediately. If the anomalous values persist, then the Engineer shall be notified and an investigation shall be carried out to find the reasons for the anomalous readings.

3.17 Monthly Monitoring Report

The Contractor shall submit a monthly monitoring report. A proposal for the format of the report shall be submitted to the Engineer including all graphical presentations for approval at least one month before submission of the first monthly report. Each monthly report shall include:

1 a description of monitoring works which have been in operation during the preceding month;
2 information on reading anomalies or corrections and factors that may influence measured data;
3 observations or remarks;
4 diagrams showing installed locations of instruments (taken from installation report); and
5 Data tabulations or plots of instrument readings as given in Table 2 below.

Table 2 - Plots of Instrument Readings Required

Instruments	Plots and Summaries Required
Displacement marker	– Deflection v. time indicating direction of movement (tabulation and plot)
Settlement marker	– settlement v. time (tabulation and plot)
Survey station	– chainage, offset co-ordinates and reduced level (tabulation)
Deep datum	– reduced level (tabulation)
Rod settlement gauge	– thickness of fill and settlement of plate v. time (tabulation and plot)
Hydrostatic profile gauge	– file name of data on floppy disk – latest graph of settlement of access tube relative to base readings and fill thickness against distance along the tube – maximum gauge settlement and corresponding fill thickness v. time (tabulation and plot)

END OF SECTION 02310

Section 02400

Piling

Part 1 General

1.01 Description

This Section is concerned with all works associated with installation of piles by driving techniques.

1.02 References

The following standards and codes of practice are referred to in this Section:

BS 5228	Noise control on construction and open sites. Part I, Code of practice for basic information and procedures for noise control. Part IV, Code of practice for noise and vibration control applicable to piling operations.
BS 5573	Code of practice for safety precautions in the construction of large diameter boreholes for piling and other purposes.
BS 8004	Code of practice for foundations.
BS 7613	Hot rolled quenched and tempered weldable structural steel plates
BS 3100	Steel castings for general engineering purposes
BS 2789	Spheroidal graphite or nodular graphite cast iron
BS 8110	Structural use of concrete

1.03 Submittals

A The Contractor shall order the piles to suit the construction programme and seek the Engineer's approval before placing the order. When preliminary piles are specified, the approval of the piles for the main work will not necessarily be given until the results of the driving and loading tests on preliminary piles have been received and evaluated.

B The Contractor shall supply for approval all relevant details of the method of piling and the plant he proposes to use. Any alternative method to that specified shall be subject to approval.

C The Contractor shall submit to the Engineer on the first day of each week, or at such longer periods as the Engineer may from time to time direct, a progress report showing the current rate of progress and progress during the previous period on all important items of each section of the Works.

D The Contractor shall inform the Engineer each day of the intended programme of piling for the following day and shall give adequate notice of his intention to work outside normal hours and at weekends.

1.04 Records

A The Contractor shall keep records, as indicated by an asterisk in the table below, of the installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after the pile is installed. The signed records will form a record of the work. Any unexpected driving conditions shall be noted briefly in the records.

Data	Driven Steel, precast concrete and steel sheet piles	Driven segmental concrete piles
Contract	*	*
Pile reference number (location)	*	*
Pile type	*	*
Nominal cross-sectional dimensions or diameter	*	*
Length of preformed pile	*	*
Date and time of driving, re-driving	*	*
Ground level/sea bed level at pile position at commencement of installation of pile (commencing surface)	*	*
Working elevation of pile driver	*	*
Depth from ground level at pile position to pile tip	*	*
Tip elevation	*	*
Pile head elevation, as constructed	*	*
Pile cut-off elevation	*	*
Type, weight, drop and mechanical condition of hammer and equivalent information for other equipment	*	*
Number and type of packing used and type and condition of dolly used during driving of the pile	*	*
Set of pile or pile tube in millimetres per 10 blows or number of blows per 25 mm of penetration	*	*
If required, the sets taken at intervals during the last 3 m of driving	*	*
If required, temporary compression of ground and pile from time of a marked increase in driving resistance until pile reached its final level	*	*
If required, driving resistance taken at regular intervals over the last 3 m of driving	*	*
Soil samples taken and *in situ* tests carried out during pile installation	*	*
All information regarding obstructions delays and other interruptions to the work	*	*

B For pre-stressing operations:

1. The Contractor shall keep detailed records of times of tensioning, measured extensions, pressure gauge readings or load cell readings and the amount of pull-in at each anchorage. Copies of these records shall be supplied to the Engineer within such reasonable time from completion of each tensioning operation as may be required, and in any case not later than noon on the following working day.

2. The Contractor shall keep records of grouting, including the date, the proportions of the grout and any admixtures used, the pressure, details of interruption and topping up required. Copies of these records shall be supplied to the Engineer within such reasonable time after completion of each grouting operation as may be required, and in any case not later than noon on the following working day.

1.05 Ground Investigation Reports

A Factual information and reports on site investigations for the Works and on the previous known uses of the Site will be provided by the Engineer where they exist as part of the specific contract documentation. However, even if a full report is given, including interpretations,

opinions or conclusions, no responsibility is accepted by the Engineer for any opinions or conclusions which may be given in the reports.

B Before the start of work the Contractor shall be given a copy of any subsequent information which may have been obtained relating to the ground conditions and previous uses of the Site.

1.06 Unexpected Ground Conditions

The Contractor shall report immediately to the Engineer any circumstance which indicates that in the Contractor's opinion the ground conditions differ from those reported in or which could have been inferred from the site investigation reports or test pile results.

1.07 Materials and Workmanship

All materials and workmanship shall be in accordance with the appropriate standards, codes of practice and other approved standards current at the date of tender except where the requirements of these standards or codes of practice are in conflict with this Section in which case the requirements of this Section shall take precedence.

1.08 Sources of Supply

The sources of supply of materials shall not be changed without prior approval by the Engineer.

1.09 Quality Assurance

A After a pile has been cast, the date of casting, reference number, length and, where appropriate, the pre-stressing force shall be clearly inscribed on the top surface of the pile and also clearly and indelibly marked on the head of the pile. Lifting positions shall be marked at the proper locations on each pile.

B Any rejected piles shall be replaced by the Contractor at the Contractor’s own cost. Rejected piles shall be removed from the Site and disposed of at an approved disposal site at the Contractor’s own cost.

1.10 Safety

A A competent person, properly qualified and experienced, should be appointed to supervise the piling operations. This person should be capable of recognising and assessing any potential dangers as they arise; e.g., unexpected ground conditions that may require a change in construction technique, or unusual smells which may indicate the presence of noxious or dangerous gases.

B Safety precautions throughout the piling operations shall comply with BS 5573 and BS 8004.

C The Contractor shall provide and maintain on the Site sufficient, proper and efficient life-saving appliances to the approval of the Engineer. The appliances must be conspicuous and available for use at all times.

D Site operatives shall be instructed in the use of safety equipment and periodic drills shall be held to ensure that all necessary procedures can be correctly observed.

1.11 Driving

Before any pile driving is started, the Contractor shall supply the Engineer with two copies of the code of signals to be employed, and shall have a copy of the code prominently displayed adjacent to the driving control station on the craft, structure or site from which the piles will be driven.

1.12 Handling, Transportation and Storage of Piles

A The method and sequence of lifting, handling, and storage of piles shall be such as to avoid shock loading and to ensure that the piles are not damaged. Only the designated lifting and support points shall be used. During transport and storage, piles shall be appropriately supported under the marked lifting points or fully supported along their length.

B All piles within a stack shall be in groups of the same length. Packing of uniform thickness shall be provided between piles at the lifting points.

C Concrete shall at no time be subjected to loading, including its own weight, which will induce a compressive stress in it exceeding 0.33 of its strength at the time of loading or of the specified strength, whichever is the lesser. For this purpose the assessment of the strength of the concrete and of the stresses produced by the loads shall be subject to the agreement of the Engineer.

D A pile may be rejected when the width of any transverse crack exceeds 0.3 mm. The measurement shall be made with the pile in its working attitude.

Part 2 Products

2.01 Materials and components

A Fabricated Steel Components

In the manufacture of precast concrete piles, fabricated steel components shall comply with BS 7613 grades 43A or 50B, cast steel components with BS 3100 grade A, and ductile iron components with BS 2789.

B Pile Toes

Pile toes shall be constructed so as to ensure that damage is not caused to the pile during installation. Where positional fixity is required on an inclined rock surface or in other circumstances, an approved shoe may be required.

C Pile Head Reinforcement

The head of each pile shall be so reinforced or banded as to prevent bursting of the pile under driving conditions.

D Main Reinforcement

1. The main longitudinal reinforcing bars in piles not exceeding 12 m in length shall be in one continuous length unless otherwise specified. In piles more than 12 m long, lap splicing will be permitted in main longitudinal bars at 12 m nominal intervals, with no more than 25 percent of the bars lapped at one location, and laps staggered by a minimum of 1.2 m. Laps in reinforcement shall be such that the full strength of the bar is effective across the joint.
2. Lap or splice joints shall be provided with sufficient link bars to resist eccentric forces.
3. Sufficient reinforcement shall be provided for lifting and handling purposes.

E Concrete

1. Unless otherwise agreed by the Engineer, concrete shall be compacted with the assistance of vibrators. Internal vibrators shall be capable of producing not less than 150 Hz and external vibrators not less than 50 Hz. Internal vibrators shall operate not closer than 75 mm to shuttering.
2. Vibrators shall be operated in such a manner that neither segregation of the concrete mix constituents nor displacement of reinforcement occurs.
3. Immediately after compaction, concrete shall be adequately protected from the harmful effects of the weather, including wind, rain, rapid temperature changes and frost. It shall be protected from drying out by an approved method of curing.
4. Piles shall not be removed from formwork until a sufficient pile concrete strength has been achieved to allow the pile to be handled without damage.
5. The period of curing at an ambient temperature of 10 °C shall not be less than that shown below. If the temperature is greater or less than 10 °C, the periods given shall be adjusted accordingly and shall be approved.

Type of cement	Wet curing time after completion of placing concrete, d
Ordinary Portland	4
Sulphate-resisting Portland	4
Portland blast-furnace	4
Super-sulphated	4
Rapid-hardening Portland	3

6. When steam or accelerated curing is used the curing procedure shall be approved. Four hours must elapse from the completion of placing concrete before the temperature is raised. The rise in temperature within any period of 30 min shall not exceed 10 °C and the maximum temperature attained shall not exceed 70 °C. The rate of subsequent cooling shall not exceed the rate of heating.

F Formwork

1. The head of each pile shall be square to the longitudinal axis. If a pile is constructed with a shaped point or shoe, then the end of the pile shall be symmetrical about the longitudinal axis of the pile. Holes for handling or pitching, where provided in the pile, shall be lined with steel tubes; alternatively, approved inserts may be cast in.
2. Formwork shall be robust, clean and so constructed as to prevent loss of grout or aggregate from the wet concrete and ensure the production of uniform pile sections, free from defects. The piles are to be removed from the formwork carefully so as to prevent damage.

G Pre-stressing

1. Tensioning shall be carried out only when the Engineer is present, unless otherwise approved. In cases where piles are manufactured off site, the Contractor shall ensure that the Engineer is given adequate notice and every facility for inspecting the manufacturing process.
2. Pre-stressing operations shall be carried out only under the direction of an experienced and competent supervisor. All personnel operating the stressing equipment shall have been trained in its use.
3. The calculated extensions and total forces, including allowance for losses, shall be agreed with the Engineer before stressing is commenced.
3. Stressing of tendons and transfer of pre-stress shall be carried out at a gradual and steady rate. The force in the tendons shall be obtained from readings on a recently calibrated load cell or pressure gauge incorporated in the equipment. The extension of the tendons under the agreed total forces shall be within 5 percent of the agreed calculated extension.

H Concrete Strength

1. The Contractor shall cast sufficient cubes, cured in the same manner as the piles, to be able to demonstrate by testing two cubes at a time, with approved intervals between pairs of cubes, that the specified transfer strength of the concrete has been reached.
2. Unless otherwise permitted, concrete shall not be stressed until two test cubes attain the specified transfer strength.

I Post-Tensioned Piles

Ducts and vents in post-tensioned piles shall be grouted after the transfer of pre-stress.

J Grouting Procedure

1. Grout shall be mixed for a minimum of 2 min and until a uniform consistency is obtained.
2. Grout shall be injected near the lowest point in the duct in one continuous operation and allowed to flow from the outlet until the consistency is equivalent to that of the grout being injected.
3. Vents in ducts shall be provided in accordance with Clause 8.9.2 of BS 8110.

K Grout

1. Grout shall consist only of ordinary Portland cement, water and approved admixtures; admixtures containing chlorides or nitrates shall not be used.
2. Grout shall have a water cement ratio as low as possible consistent with the necessary workability, and the water cement ratio shall not exceed 0.45 unless an approved mix containing an expanding agent is used.
3. Grout shall not be subject to bleeding in excess of 2 percent after 3 h, or in excess of 4 percent maximum, when measured at 18^{o}C in a covered glass cylinder approximately 100 mm in diameter with a height of grout of approximately 100 mm, and the water shall be reabsorbed after 24 h.

2.02 Tolerances in Pile Dimensions

The cross-sectional dimensions of the pile shall be not less than those specified and shall not exceed them by more than 6 mm. Each face of a pile shall not deviate by more than 6 mm from any straight line 3 m long joining two points on that face, nor shall the centre of area of the pile at any cross section along its length deviate by more than 1/500 of the pile length from a line joining the centres of area at the ends of the pile. Where a pile is less than 3 m long, the permitted deviation from straightness shall be reduced below 6 mm on a pro rata basis in accordance with actual length.

Part 3 - Execution

3.01 Setting Out

Setting out of the main grid lines shall be by the Contractor. The installation of marker pins at pile positions, as required by the Contract, shall be located by the Contractor from the main grid lines of the proposed structure. Before installation of the pile, the pile position relative to the main grid lines shall be verified.

3.02 Position

For a pile cut off at or above ground level the maximum permitted deviation of the pile centre from the centre-point shown on the drawings shall be 75 mm in any direction. An additional tolerance for a pile head cut off below ground level will be permitted as detailed below.

3.03 Verticality

At the commencement of installation, the pile, or pile-forming equipment in the case of a driven pile, or the relevant equipment governing alignment in the case of the bored pile, shall be made vertical to a tolerance of within 1 in 100. The maximum permitted deviation of the finished pile from the vertical is 1 in 75.

3.04 Rake

As in clause 3.03, the pile, or driving or other equipment governing the direction and angle of rake shall be set to give the correct alignment of the pile to within a tolerance of 1 in 50. The piling rig shall be set and maintained to attain the required rake. The maximum permitted deviation of the finished pile from the specified rake is 1 in 25 for piles raking up to 1:6 and 1 in 15 for piles raking more than 1:6.

3.05 Tolerance Variations

In exceptional circumstances where these tolerances are difficult to achieve, the tolerances of Clauses 3.02, 3.03 and 3.04 hereof may be relaxed by the Engineer, subject to consideration of the implications of such action.

3.06 Forcible Corrections to Pile

Forcible corrections to concrete piles to overcome errors of position or alignment shall not be made. Forcible corrections may be made to other piles only if approved and where the pile shaft is not fully embedded in the soil.

3.07 Noise and Disturbance

A The Contractor shall carry out the work in such a manner and at such times as to minimise noise, vibration and other disturbance in order to comply with current environmental legislation.

B The Contractor shall endeavour to ascertain the nature and levels of noise produced by the mechanical equipment and plant that will be used. He shall than take steps to reduce either the level or the annoying characteristics, or both, of the noise. Reference should be made to BS 5228 Part 1 for prediction of noise level due to different types of mechanical equipment and plant, and to BS 5228 Part 4 for noise and vibration control techniques applicable to piling operations.

3.08 Damage to Adjacent Structures

If in the opinion of the Contractor, damage will be, or is likely to be, caused to mains, services or adjacent structures, he shall submit to the Engineer his proposals for making pre-construction surveys, monitoring movements or vibrations, and minimising or avoiding such damage.

3.09 Damage to Piles

The Contractor shall ensure that during the course of the work, displacement or damage which would impair either performance or durability does not occur to completed piles. The Contractor shall submit to the Engineer his proposed sequence and timing for driving piles, having the intent of avoiding damage to adjacent piles.

3.10 Temporary Support

The Contractor shall ensure that where required, any permanently free-standing piles are temporarily braced or stayed immediately after driving to prevent loosening of the piles in the ground and to ensure that the pile will not be damaged by oscillation, vibration or ground movement.

3.11 Rejected materials

Rejected materials shall be removed promptly from the Site.

3.12 Strength of Piles

Piles shall not be driven until the concrete has achieved the specified strength.

3.13 Leaders and Trestles

At all stages during driving and until incorporation into the substructure, the pile shall be adequately supported and restrained by means of leaders, trestles, temporary supports or other guide arrangements to maintain position and alignment and to prevent buckling. These arrangements shall be such that damage to the pile does not occur.

3.14 Performance of Driving Equipment

A The Contractor shall satisfy the Engineer regarding the suitability, efficiency and energy of the driving equipment. Where designated, dynamic evaluation and analysis shall be provided.

B Where a drop hammer is used, the mass of the hammer shall be at least half that of the pile unless otherwise approved by the Engineer. For other types of hammer the energy delivered to the pile per blow shall be at least equivalent to that of a drop hammer of the stated mass. Drop hammers shall not be used from floating craft in such a manner as to cause instability of the craft or damage to the pile.

3.15 Length of Piles

The length of pile to be driven in any location shall be approved prior to the commencement of driving.

3.16 Driving Procedure and Redrive Checks

A The driving of each pile shall be continuous until the specified depth or resistance (set), or both, has been reached. In the event of unavoidable interruption to driving, the pile will be accepted provided it can subsequently be driven to the specified depth or resistance (set), or both, without damage. A follower shall not be used unless approved, in which case the Engineer will require the set where applicable to be revised in order to take into account reduction in the effectiveness of the hammer blow.

B The Contractor shall inform the Engineer without delay if an unexpected change in driving characteristics is noted. A detailed record of the driving resistance over the full length of the nearest available pile shall be taken if required.

C A detailed record of the driving resistance over the full length of each pile shall be kept. The log shall record the number of blows for every 300mm of pile penetration.

D The Contractor shall give adequate notice and provide all necessary facilities to enable the Engineer to check driving resistance. A set or resistance measurements shall be taken only in the presence of the Engineer unless otherwise approved.

E Re-drive checks, if required, shall be carried out to an approved procedure.

F On completion of all piling works the Contractor shall prepare and submit to the Engineer three sets of complete drawings showing details of all piles driven at the site with reference to the site co-ordinates. The drawings shall also be submitted in AutoCAD format or an alternative electronic format if approved by the Engineer

3.17 Final Set

A When driving to a set criterion, the final set of each pile shall be recorded either as the penetration in millimetres per 10 blows or as the number of blows required to produce a penetration of 25 mm.

B When a final set is being measured, the following requirements shall be met:

1. The exposed part of the pile shall be in good condition without damage or distortion
2. The helmet, dolly and any packing shall be in sound condition
3. The hammer blow shall be in line with the pile axis, the impact surfaces shall be flat and at right angles to the pile and hammer axis, and the head of the pile shall be protected against damage from hammer impact
4. The hammer shall be in good condition, delivering adequate energy per blow, and operating correctly
4. The temporary compression of the pile shall be recorded, if required. If pre--boring is specified, the diameter and depth of pre-bore shall be as designated.

3.18 Jetting

Jetting shall be carried out only when the Contractor's detailed proposals have been approved.

3.19 Risen Piles

Piles shall be driven in an approved sequence to minimise the detrimental effects of heave and lateral displacement of the ground. When required, levels and measurements shall be taken to determine the movement of the ground or of any pile resulting from the driving process. When a pile has risen as a result of adjacent piles being driven, the Engineer may call for re-driving or other testing to demonstrate that the performance of the pile is unimpaired. If required, the Contractor shall make proposals for correcting detrimentally affected piles and for avoidance or control of heave effects in subsequent work.

3.20 Repair of Damaged Pile Heads

If it is necessary to repair the head of a pile during driving, the Contractor shall carry out such repair in an approved way which allows the pile-driving to be completed without further damage. If the driving of a pile has been accepted but sound concrete of the pile is below the required cut-off level, the pile shall be made good to the cut-off level, using an approved method so that it will safely withstand the imposed design load.

3.21 Lengthening of Reinforced and Prestressed Concrete Piles

Any provision for lengthening piles incorporated at the time of manufacture shall be as designed or approved. If no provision for lengthening piles was incorporated at the time of manufacture,

any method for lengthening shall be such that splices are capable of safely resisting the stresses during driving and under service load and shall be subject to approval.

3.22 Driving Repaired or Lengthened Piles

Repaired or lengthened piles shall not be driven until the added concrete has reached the specified strength of the concrete of the pile.

3.23 Cutting off Pile heads

A Unless otherwise directed by the Engineer, when the driving of a pile has been approved the concrete of the head of the pile shall be cut off to the designated level. The length of splice reinforcing bars projecting above this level shall be as designated.

B Care shall be taken to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and the pile repaired in an approved manner to provide a full and sound section at the cut-off level.

Part 4 Testing

4.01 General

This Part deals with the testing of a pile by the controlled application of an axial load. It covers vertical and raking piles tested in compression (i.e. subjected to loads or forces in a direction such as would cause the piles to penetrate further into the ground) and vertical or raking piles tested in tension (i.e., subjected to forces in a direction such as would cause the piles to be extracted from the ground).

4.02 References

BS 1881, Methods of testing concrete is referred to in this Part.

4.03 Submittals

When required, the design and full details of the proposed load application system shall be submitted to the Engineer prior to the commencement of testing. The load application system shall be satisfactory for the required test.

4.04 Definitions

A Allowable pile capacity: a load which is not less than the specified working load and which takes into account the pile's ultimate bearing capacity, the materials from which the pile is made, the required factor of safety, settlement, pile spacing, down drag, the overall bearing capacity of the ground beneath the piles and any other relevant factors. The allowable pile capacity indicates the ability of a pile to meet the specified loading requirements.

B Compression pile: a pile that is designed to resist compressive (downward) axial load.
Constant rate of penetration (CRP) test: a test in which the pile is made to penetrate the soil at a constant controlled speed, while the loads applied at the top of the pile in order to maintain

the constant rate of penetration are continuously measured. The purpose of the test is to derive the ultimate bearing capacity of a pile and not its load settlement characteristics.

C Constant rate of uplift (CRU) test: the same in principle as the CRP test, but the pile is subject to tension rather than compression. The purpose of the test is to determine the 'pull-out' capacity of a pile.

D Design verification load (DVL): a test load, in lieu of a specified working load, applied to a single pile at the time of testing to determine that site conditions conform to design assumptions. This load will be peculiar to each preliminary (test) pile and should equal the maximum specified working load for a pile of the same dimensions and material, plus allowances for soil-induced forces and any other particular conditions of the test.

E Kentledge: ballast used in a loading test.

F Maintained load test: a loading test in which each increment of load is held constant either for a defined period of time or until the rate of settlement falls to a specified value.

G Preliminary pile: a test pile installed before the commencement of the main piling works or a specific part of the Works for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimensions and bearing capacity.

H Proof load: a load applied to a selected working pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed the design verification load plus 50 percent of the specified working load.

I Raking pile: a batter pile, installed at an inclination to the vertical.

J Reaction system: the arrangement of kentledge, piles, anchors or rafts that provides a resistance against which the pile is tested.

K Specified working load (SWL): the designated load on the head of a pile

.

L Tension pile: a pile which is designed to resist a tensile (upward) axial force.

M Test pile: any pile, preliminary or part of the works, to which a test is applied.

N Ultimate bearing capacity: the load at which the resistance of the soil becomes fully mobilised through friction, end bearing or a combination thereof.

O Working pile: one of the piles forming the foundation of a structure.

4.05 Construction of a Preliminary Pile to be Tested

A The Contractor shall give the Engineer at least 48 hours' notice of the commencement of construction of any preliminary pile which is to be test-loaded.

B Each preliminary test pile shall be constructed in a manner similar to that to be used for the construction of the working piles, and by the use of similar equipment and materials. Any variation will be permitted only with prior approval.

C For each preliminary pile to be tested, a detailed record of the conditions experienced during boring, and of the progress during driving, shall be made and submitted to the Engineer daily, not later than noon on the next working day. Where the Engineer requires soil samples to be

taken or in situ tests to be made, the Contractor shall include that in the daily report, as well as the test results.

D In the case of concrete piles, four test cubes shall be made from the concrete used in the manufacturer of each preliminary test pile and from each 50 m3 of the concrete used in the manufacture of working piles. If a concrete pile is extended or capped for the purpose of testing, an additional four cubes shall be made from the corresponding batch of concrete. The cubes shall be made and tested in accordance with BS 1881.

E The pile test shall not be started until the strength of the cubes taken from the pile exceeds twice the average direct stress in any pile section under the maximum required test load, and the strength of the cubes taken from the cap exceeds twice the average stress at any point in the cap under the same load. Variation of procedure will be permitted only if approved by the Engineer.

F If a test is required on a working pile, the Contractor shall cut off or otherwise prepare the pile for testing as required by the Engineer in accordance with Clauses 4.05 and 4.06 hereof.

G The cut-off level for a preliminary test pile shall be approved by the Engineer.

H The setting-up of pile testing equipment shall be carried out under competent supervision and the equipment shall be checked to ensure that the set-up is satisfactory before the commencement of load application.

I All tests shall be carried out only under the direction of an experienced and competent supervisor experienced with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

4.06 Safety precautions

A Design, erection and dismantling of the pile test reaction system and the application of load shall be carried out according to the requirements of the various applicable statutory regulations concerned with lifting and handling heavy equipment and shall safeguard operators and others who may from time to time be in the vicinity of a test from all avoidable hazards.

B Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structure in such a manner that there will not be differential settlement, bending or deflexion of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it becoming unstable because of deflexion of the supports or for any other reason. When kentledge constitutes the principal component of a reaction system, its weight for each test shall be at least 25 percent greater than the maximum test load for that test. The weight may be determined by scale or the density and volume of the constituent materials. In adding kentledge, care shall be taken to properly position the centre of gravity of the stack.

C Where tension piles, reaction piles or ground anchorages constitute the principal components of a reaction system, they shall be so designed that they will resist the forces applied to them safely and without excessive deformation which could cause a safety hazard during the work. Such piles (which, unless approved, will not be working piles) or anchorages shall be driven in the specified locations, and all bars, tendons or links shall be aligned to provide a stable reaction in the direction required. Any welding employed to extend or to fix anchorages to a

reaction frame shall be carried out so that the full strength of the system is adequate and unimpaired.

D In all cases the Contractor shall ensure that when the hydraulic jack and load-measuring device are mounted on the pile head the whole system will be stable up to the maximum load to be applied.

E If in the course of carrying out a test any unforeseen occurrence should take place, further loading shall not be applied until a proper engineering assessment of the condition has been made and steps have been taken to rectify any fault. Reading of gauges should, however, be continued where possible and if it is safe to do so.

F Where an inadequacy in any part of the system might constitute a hazard, means shall be provided to enable the test to he controlled from a position remote from of the kentledge stack or test frame.

G The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a pressure of 1.5 times the maximum pressure used in the test without leaking. The maximum test load expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

H For a pile that is tested in compression, the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile, sufficiently large to accommodate the loading and settlement measuring equipment and adequately reinforced or protected to prevent damage from the concentrated load applied by the loading equipment. Any test pile cap shall be concentric with the test pile; the joint between the cap and the pile shall have a strength equivalent to that of the pile. Sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that, at the maximum expected settlement, load is not transmitted to the ground by the cap.

I For a pile that is tested in tension, means shall be provided for transmitting the test load axially without inducing moment in the pile. The connection between the pile and the loading equipment shall be constructed in such a manner as to provide a strength equal to 1.5 times the maximum load which is to be applied to the pile during the test.

4.07 Reaction systems

A The reaction for compression tests shall be provided by kentledge, tension piles or specially constructed anchorages. Kentledge shall not be used for tests on raking piles except where the test set-up has been specifically designed to conform to Clause 4.06 hereof, and has been approved by the Engineer.

B Where kentledge is to be used, it shall be supported on cribwork and positioned so that the centre of gravity of the load is as close as possible to the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack.

C The reaction for tension tests shall be provided by compression piles, rafts or grillages constructed on the ground. In all cases the resultant force of the reaction system shall be coaxial with the test pile.

D Where inclined piles or reactions are proposed, full details shall be submitted for approval prior to the commencement of testing.

E Working piles shall not be used as reaction piles without approval from the Engineer. Where working piles are used as reaction piles their movement shall be measured and recorded to with an accuracy of 0.5 mm, and recorded.

F Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall be not less than 1.3 m.

G The centre-to-centre spacing of vertical reaction piles from a test pile shall conform to Paragraph 1 above, but shall be not less than three times the diameter of the test pile or the reaction piles or 2 m, whichever is the greatest, except in the case of piles of 300 mm diameter (or equivalent) or less, where the distance may be reduced to 1.5 m. Where a pile to be tested has an enlarged pile cap, the same criterion shall apply with regard to the pile shaft, with the additional requirement that no surface of a reaction pile shall be closer to the pile cap of the test pile than one half of the pile cap plan dimension.

H Where ground anchorages are used to provide a test reaction for loading in compression, no section of fixed anchor length transferring load to the ground shall be closer to the test pile than three times the diameter of the test pile. Where the pile to be tested has an enlarged pile cap, the same criterion shall apply with regard to the pile shaft, with the additional requirement that no section of the fixed anchor transferring load to the ground shall be closer to the pile cap than a distance equal to one half the pile cap plan dimension.

I The reaction frame support system shall be adequate to transmit the maximum test load in a safe manner without excessive movement or influence on the test pile. Calculations shall be provided to the Engineer when required to justify the design of the reaction system.

J The method employed in the installation of the reaction system shall be such as to prevent damage to any test pile or working pile.

4.08 Equipment for Applying Load

The equipment used for applying load shall consist of a hydraulic ram or jack. The jack shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. Proposals to use more than one ram or jack will be subject to approval by the Engineer of the detailed arrangement. The complete system shall be capable of safely transferring the maximum load required for the test. The length of stroke of a ram shall be sufficient to account for deflexion of the reaction system under load plus a deflexion of the pile head by up to 15 percent of the pile shaft diameter unless otherwise specified or agreed prior to commencement of test loading.

4.09 Measurement of Load

A A load measuring device shall be used and in addition a calibrated pressure gauge included in the hydraulic system. Readings of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data the values given by the load measuring device shall normally be used; the pressure gauge readings are required as a check for gross error. The load measuring device may consist of a load measuring column, pressure cell or other appropriate system. A spherical seating of appropriate size shall he used to avoid eccentric loading. Care shall be taken to avoid any risk of buckling of the load application and measuring system. Load measuring and application devices shall be short in axial length in order to secure stability. The Contractor shall ensure that axial loading is maintained. The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The

pressure gauge and hydraulic jack shall be calibrated together. Certificates of calibration shall be supplied to the Engineer.

B The loading equipment shall enable the load to be increased or decreased smoothly or to be held constant at any required value.

4.10 Measuring Pile Head Movement

A In a maintained load test, movement of the pile head shall he measured by one of the methods described below and in the case of the raking piles, as required.

B In a CRP or a CRU test, the method in the following clauses shall be used. Check-levelling of the reference frame or the pile head shall not be required. The dial gauge shall be graduated in divisions of 0.02 mm or less.

C An independent reference beam or beams shall be set up to enable measurement of the movement of the pile to be made to the required accuracy. The supports for a beam shall be founded in such a manner and at such a distance from the test pile and reaction system that movements of the ground do not cause movement of the reference beam or beams which will affect the accuracy of the test. The supports of the beam or beams shall be at least three test pile diameters or 2 m from the centre of the test pile, whichever distance is the greater.

D Check observations of any movements of the reference beam or beams shall be made and a check shall be made of the movement of the pile head relative to a remote reference datum at suitable intervals during the progress of the test.

E The measurement of pile movement shall be made by four dial gauges rigidly mounted on the reference beam or beams, bearing on prepared flat surfaces fixed to the pile cap or head and normal to the pile axis. Alternatively, the gauges may be fixed to the pile and bear on prepared surfaces on the reference beam or beams. The dial gauges shall be placed equidistant from the pile axis and from each other. The dial gauges shall enable readings to be made to an accuracy of at least 0.1 mm and have a stem travel of at least 25 mm. Machined spacer blocks may be used to extend the range of reading. Equivalent electrical displacement-measuring devices may be substituted.

F An optical levelling method by reference to a remote datum may be used. Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5 mm. A scale attached to the pile or pile cap may be used instead of a levelling staff. At least two reliable independent datum points shall be established. Each datum point shall be so situated as to permit a single setting-up position of the level for all readings.

G No datum point shall be located where it can be affected by the test loading or other operations on the Site.

H Two parallel reference wires, one on either side of the pile, shall be held under constant tension at right angles to the test pile axis between supports. The wires shall be positioned against scales fixed to the test pile head in an axial direction and the movements of the scales relative to the wires shall be determined.

I Check observations of any movements of the supports of the wires shall be made and a check shall be made on the movement of the pile head at approved time intervals. Readings shall be taken to within an accuracy of 0.5 mm.

J The Contractor may submit for approval any other method of measuring the movement of the test pile head.

4.11 Protection of Testing Equipment

A Throughout the test period all equipment for measuring load and movement shall be protected from exposure to adverse effect of weather.

B Construction activity and persons who are not involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measuring apparatus. Full records shall be kept of any intermittent unavoidable activity that might affect the test set-up.

C The Contractor shall give the Engineer at least 24 hours' notice of the commencement of the test. No load shall be applied to the test pile before the commencement of the specified test procedure.

4.12 Test Procedures

A The maximum load which shall be applied in a proof test shall normally be the sum of the design verification load (DVL) plus 50 percent of the specified working load (SWL). The loading and unloading shall be carried out in stages as shown in Table 1. Any particular requirements given in the particular contract documentation shall be complied with.

B Following each application of an increment of load, the load shall be maintained at the specified value for not less than the period shown in Table 1 and until the rate of settlement is less than 0.25 mm/h and decreasing. The rate of settlement shall be calculated from the slope of the line obtained by plotting values of settlement versus time and drawing a smooth curve through the points. Each decrement of unloading shall proceed after the expiry of the period shown in Table 1 hereof.

C For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load, at not more than 5 min intervals up to 15 min; at approximately 15 min intervals up to 1 h; at 30 min intervals between 1 h and 4 h; and 1 h intervals between 4 h and 12 h after the application of the increment of load.

D Where the methods of measuring pile head movement given in these Specifications are used, the periods of time for which loads must be held constant to achieve the specified rates of settlement shall be extended as necessary to take into account the lower levels of accuracy available from these methods and to allow correct assessment of the settlement rate.

Table 1

Load *	Minimum time of holding load
25% DVL	1 h
50% DVL	1 h
75% DVL	1 h
100% DVL	1 h
75% DVL	10 min
50% DVL	10 min
25% DVL	10 min
0	1 h
100% DVL	6 h
100% DVL + 25% SWL	1 h
100% DVL + 50% SWL	6 h
100% DVL + 25% SWL	10 min
100% DVL	10 min
75% DVL	10 min
50% DVL	10 min
25% DVL	10 min

Load *	Minimum time of holding load	
0	1 h	
100% DVL	6 h	
100% DVL + 50% SWL	6 h	
100% DVL + 75% SWL	1 h	
100% DVL + 100% SWL	6 h	
100% DVL + 75% SWL	10 min	Applicable
100% DVL + 50% SW	10 min	to tests on
100% DVL + 25% SW	10 min	Preliminary
100% DVL	10 min	Pile only
75% DVL	10 min	
50% DVL	10 min	
25% DVL	10 min	
0	1 h	

* SWL denotes specified working load; DVL denotes design verification load.

E The procedure to be adopted for carrying out load tests on preliminary compression piles shall be either the extended proof load test procedure or the constant rate of penetration testing procedure given below. A normal proof load test will constitute the first stage of such a test unless otherwise specified.

F Where test pile is to be loaded up to the sum of design verification load (DVL) plus 100 percent of the specified working load, the loading procedure may be carried out as a continuation of the proof load testing procedure given above.

G Following the completion of the proof load test, the load shall be restored in two stages (DVL, DVL +50 percent SWL), and shall subsequently be increased by stages of 25 percent of the specified working load. Following each application of an increment of load, the load shall be maintained at the specified value for the period shown in Table 1 and until the rate of settlement is decreasing and is less than 0.25 mm/h.

H Where verification of required minimum factor of safety is called for or the pile is to be tested to failure, the loading procedure shall be continued after reaching DVL +100 percent SWL stage by increasing the load in increments of 25 percent of the specified working load or other specified amount until the maximum specified load of the test is reached. Following each application of increment of load, the load shall be maintained at the specified value for not less than 1 h and until the rate of settlement is decreasing and is less than 0.25 mm/h, or other approved rate appropriate to the stage of loading and its proximity to a failure condition. Permissible settlement at the load corresponding to the required minimum factor of safety called for in the design will not normally be specified.

I The rate of settlement shall be calculated from the slope of the line obtained by plotting values of settlement versus time and drawing a smooth curve through the points. Reduction of load at the end of the test shall be gradual and the final rebound of the pile head shall be recorded.

J Constant rate of penetration (CRP) testing procedure: Where it is required to determine the ultimate load of a preliminary compression pile, and particularly where piles are largely embedded in and bearing on clay soils, the CRP testing procedure will normally be specified.

K The rate of movement of the pile head shall be maintained constant in so far as is practicable and shall be approximately 0.01 mm/s.

L Readings of loads, penetration and time shall be made simultaneously at regular intervals; the interval chosen shall be such that a curve of load versus penetration can be plotted without ambiguity.

M Loading shall be continued until one of the following results is obtained
(a) the maximum required test load
(b) a constant or reducing load has been recorded for an interval of penetration of 10 mm
(c) a total movement of the pile base equal to 10 percent of the base diameter, or any other greater value of movement specified, has been reached.

N The load shall then be reduced in five approximately equal stages to zero load, penetration and load being recorded at each stage.

4.13 Testing of Piles Designed to Carry Load in Tension

The testing of piles designed to carry load in tension shall follow the same procedure as specified. In testing by the constant rate of uplift method, overall movements of the pile head will normally be less than those expected in a constant rate of penetration test. The rate of movement of the pile head shall be maintained at approximately 0.005 mm/s in so far as is practicable.

4.14 Presentation of results

A During the progress of a test, all records taken shall be available for inspection by the Engineer.

B Results shall be submitted as:
(a) preliminary report of the test results to the Engineer, unless otherwise directed, within 24 hours of the completion of the test, which shall show:
(i) for a test by maintained load: for each stage of loading, the period for which the load was held, the load and the maximum pile movement at the end of the stage;
(ii) for a CRP or CRU test: the maximum load reached and a graph of load against penetration or load against uplift.
(b) the final report of recorded data as prescribed within ten days of test completion.

C The Contractor shall provide information about the test pile in accordance with the following schedule where applicable.
(a) general;
site location contract identification;
proposed structure;
main contractor;
piling contractor;
engineer Employer/employer;
date and time of test;
(b) pile details;
all types of pile;
identification (number and location);
specified working load (SWL);
design verification load (DVL);
original ground level at pile location;
head level at which test load was applied;
type of pile;
vertical or raking, compression or tension;
shape and size of cross-section of pile, and position of any change in cross-section;

shoe or base details;
head details;
length in ground;
tip Elevation;
dimensions of any permanent casing;
concrete piles:
concrete mix/grade;
aggregate type and source;
cement type and cement replacement and type where used;
admixtures;
slump;
cube test results for pile and cap;
date of casting of precast pile;
reinforcement;
steel piles:
steel quality;
coating;
filling or core materials type and quality, if applicable;

(c) installation details:
all piles:
dates and times of boring, driving and concreting of test pile;
difficulties and delays encountered;
date and time of casting concrete pile cap;
bored piles:
type of equipment used and method of boring;
temporary casing - diameter, type and length;
full log of pile borehole;
method of placing concrete;
volume of concrete placed;
driven pre-formed and driven cast-in-place piles:
method of support of hammer and pile;
driven length of pile or temporary casing at final set;
hammer type, and size or weight;
dolly and packing, type and condition;
driving log (depth, hammer drop, blows per 250 mm, interruptions or breaks in driving);
final set in number of blows to produce penetration of 25 mm;
re-drive check, time interval and set in number of blows to produce penetration of 25 mm or other agreed amount;
at final set and at re-drive set, for a drop hammer or for a single acting hammer the length of the drop or stroke, for a diesel hammer the length of the stroke and the blows per minute, for a double acting hammer the operating pressure and the number of blows per minute;
condition of pile head or temporary casing after driving;
use of a follower;
use of pre-boring;
use of jetting;
lengthening;
method of placing concrete;

(d) test procedure:
mass of kentledge;
tension pile, ground anchorage or compression pile details;

plan of test arrangement showing position and distances of kentledge supports, rafts, tension or compression piles or ground anchorages, and supports to pile movement reference system;
jack capacity;
method of load measurement;
method(s) of penetration or uplift measurement;

(e) test results;
in tabular form;
in graphical form: load plotted against pile head movement;
ambient temperature records during test.
The test results shall be submitted in both paper print and electronic format.

4.15 Completion of a Test

A On completion of a test and subject to the approval of the Engineer, all measuring equipment and load application devices shall be dismantled and checked. All other test equipment, including kentledge, beams and supporting structures shall be removed from the test pile location. Measuring and other demountable equipment shall be stored in a safe manner so that it is available for further tests, or removed from the Site as approved by the Engineer.

B Temporary tension piles and ground anchorages shall be cut off below ground level, and materials removed from the Site. The ground shall be restored to the original contours.

C Unless otherwise specified, the head of each preliminary test pile shall be cut off below ground level, off-cut material shall be removed from the Site and the ground restored to the original contours.

D On completion of a test on a proof pile, the test pile cap shall be prepared as specified and left in a state ready for incorporation into the Permanent Works. Any resulting off-cut materials shall be removed from the Site.

END OF SECTION 02400

Section 02410

Bored Cast-in-place Piles

Part 1 General

1.01 Scope

A This Part applies to bored piles in which the pile bore is excavated by rotary or percussive means, or both, using short augers, buckets, grabs or other boring tools to advance the open bore. Where the open bore is unstable, temporary or permanent casing or bentonite suspension may be used to support the wall of the bore prior to concreting.

B Unless conflicted with this Section, the requirements of Section 02400 hereof apply throughout.

Part 2 Products

2.01 Casings

A Permanent casings shall be specified in the Particular Specifications.

B Temporary casing of approved quality or an approved alternative method shall be used to maintain the stability of a pile bore which might otherwise collapse. Temporary casings shall be free from significant distortion. They shall be of uniform cross-section throughout each continuous length. During concreting they shall be free from internal projections and encrusted concrete which might adversely affect the proper formation of piles.

2.02 Drilling Fluid Supply

A certificate shall be obtained by the Contractor from the manufacturer of the bentonite powder showing the properties of each consignment delivered to the Site. This certificate shall be made available to the Engineer on request. The properties to be given by the manufacturer are the apparent viscosity range (in Pascal seconds) and the gel strength range (in Pascal) for solids in water.

2.03 Drilling Fluid Mixing

A Bentonite shall be mixed thoroughly with clean fresh water to make a suspension which will maintain the stability of the pile bore for the period necessary to place concrete and complete construction. The temperature of the water used in mixing the bentonite suspension, and of the suspension when supplied to the borehole, shall be not lower than 5 °C.

B Where saline or chemically contaminated groundwater occurs, special precautions shall be taken to modify the bentonite suspension or pre-hydrate the bentonite in fresh water so as to render it suitable in all respects for the construction of piles.

2.04 Drilling Fluid Tests

A The frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor for approval prior to the commencement of the work. The frequency may subsequently be varied as required, depending on the consistency of the results obtained, subject to approval.

B Control tests shall be carried out on the bentonite suspension, using suitable apparatus. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed. The measuring device shall be calibrated to read to within 0.005 g/ml. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite supplied to the pile bore. For average soil conditions the results shall generally be within the ranges in Table 1 hereof.

C The tests shall be carried out until a consistent working pattern has been established account being taken of the mixing process, any blending of freshly mixed bentonite suspension and previously used bentonite suspension, and any process which may be used to remove impurities from previously used bentonite suspension. When the results show consistent behaviour, the tests for shear strength and pH value may be discontinued, and tests to determine density and viscosity shall be carried out as agreed with the Engineer. In the event of a change in the established working pattern, tests for shear strength and pH value shall be reintroduced for a period if required.

Table 1
Tests On Bentonite

Property to be measured	Range of results at 20 °C	Test method
Density	Less than 1.10 g/ml	Mud density balance
Viscosity	30 - 90 s or	Marsh cone method
	less than 0.020 Pa • s	Fann viscometer*
Shear strength	1.4-10 Pa or	Shearometer
(10 minute gel strength)	4-40 Pa	Fann viscometer
pH	9.5 - 12	pH indicator paper strips or electrical pH meter

Where the Fann viscometer is specified, the fluid sample should be screened by a number 52 sieve (300 μm) prior to testing.

Part 3 Execution

3.01 Inspection

Each pile bore which does not contain standing water or drilling fluid shall be inspected directly or indirectly prior to concrete being placed in it. This inspection shall be carried out from the ground surface in the case of piles of less than 750 mm diameter. Torches or other approved means of lighting, measuring tapes, and a means of measuring verticality shall be provided. For piles of 750 mm diameter or larger, equipment shall be provided, by the Contractor to enable his representatives and the Engineer to descend into the bore for the purpose of inspection. Any method of descent and the equipment used shall comply with the requirements of BS 5573.

3.02 Cleanliness of Pile Bases

On completion of boring and where inspection of a dry pile bore indicates the necessity, loose, disturbed or softened soil shall be removed from the bore. Where pile bores contain water or drilling fluid, a cleaning process shall be employed before concrete is placed. Large debris and accumulated sediment shall be removed using appropriate approved methods, which shall be designed to clean while at the same time minimising ground disturbance below the pile bases. Water or drilling fluid shall be maintained at such levels throughout and following the cleaning operation that stability of the bore is preserved.

3.03 Subsoil Samples and Testing

If required in the Contract, soil, rock or groundwater samples shall be taken or soil tests carried out *in situ* while the pile is being bored. The samples shall be taken for testing as specified at an approved laboratory.

3.04 Boring Near Recently Cast Piles

Piles shall not be bored so close to other recently completed piles as to damage them.

3.05 Temporary Casings

A The use of a vibrator to insert and withdraw temporary casing may be permitted by the Engineer to the extent and with a method that does not cause disturbance of the ground which will adversely affect the construction or the capacity of piles.

B Where piles are bored under water or bentonite suspension in an unlined state, the insertion of a full-length loosely fitting casing to the bottom of the bore prior to placing concrete shall not be permitted.

C Where permanent casing is specified to ensure the integrity of a pile, the Contractor shall submit to the Engineer for approval his proposals regarding the method of installation.

3.06 Stability of Pile

A Where boring takes place through unstable water-bearing strata, the process of excavation and the depth of temporary casing employed shall be such that soil from outside the area of the pile is not drawn into the pile section and cavities are not created outside the temporary casing as it is advanced.

B Where the use of drilling fluid is specified or approved for maintaining the stability of a bore, an adequate temporary casing shall be used in conjunction with the method so as to ensure stability of the strata near ground level until concrete has been placed. During construction the level of drilling fluid in the pile excavation shall be maintained within the cased or stable bore so that it is not less than 1.0 m above the level of external standing groundwater at all times.

C In the event of a rapid loss of drilling fluid from a pile excavation, the bore shall be backfilled without delay and the instructions of the Engineer shall be obtained before boring at that location is resumed.

3.07 Spillage and Disposal of Drilling Fluid

All reasonable steps shall be taken to prevent the spillage of bentonite suspension on the Site in areas outside the immediate vicinity of boring. Discarded bentonite shall be removed from the Site without undue delay. Any disposal of bentonite shall comply with the regulations of the local controlling authority.

3.08 Pumping from Pile Bores

Pumping from pile bores shall not be permitted unless the bore has been sealed against further water entry by casing or unless the soil is stable and will allow pumping to take place without ground disturbance below or around the pile.

3.09 Continuity of Construction

For a pile constructed in a stable cohesive soil without the use of temporary casing or other form of support, the pile shall be bored and the concrete shall be placed without such delay as would lead to significant impairment of the soil strength.

3.10 Enlarged Pile Bases

A mechanically formed enlarged base shall be no smaller than the dimensions specified and shall be concentric with the pile shaft to within a tolerance of 10 percent of the shaft diameter. The sloping surface of the frustum forming the enlargement shall make an angle to the axis of the pile of not more than 35 °.

3.11 Extraction of Casing

A Temporary casings shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted. During extraction the motion of the casing shall be maintained in an axial direction relative to the pile.

B When the casing is being extracted, a sufficient quantity of concrete shall be maintained within it to ensure that pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in section nor contaminated.

C The concrete level within a temporary casing shall be topped up where necessary during the course of casing extraction in such a way that the base of the casing is always below the concrete surface until the casting of the pile has been completed.

D Adequate precautions shall be taken in all cases where excess heads of water or drilling fluid could occur as the casing is withdrawn because of the displacement of water or fluid by the concrete as it flows into its final position against the walls of the pile bore. Where two or more discontinuous lengths of casing (double casing) are used in the construction the proposed method of working shall be approved.

E During extraction of temporary casings, where circumstances are such that newly placed un-set concrete is brought into contact with external groundwater, precautions shall be taken to ensure that the internal concrete pressure at all levels within the pile exceeds the external groundwater pressure.

3.12 Pile Head Casting Level Tolerances

A For piles cast in dry bores using temporary casing and without the use of a permanent lining, pile heads shall be cast to a level above the specified cut-off so that, after trimming, a sound concrete connection with the pile can be made. The casting level shall be within the tolerance above the cut-off level shown in Table 2 hereof, but shall not be above the original ground level. No pile shall be cast with its head below standing water level unless approved measures are taken to prevent inflow of water causing segregation of the concrete as temporary casing is extracted, and, where approved by the Engineer, the groundwater level for each pile shall be treated as the cut-off level for the purpose of calculating tolerance.

B For piles cast in dry bores within permanent lining tubes or permanent casings, or where their cut-off levels are in stable ground below the base of any casing used, pile heads shall be cast to a level above the specified cut-off so that, after trimming, a sound concrete connection with the pile can be made. The casting level shall be within the tolerance above the cut-off level shown in Table 3 hereof, but shall not be above the original ground level.

C For piles cast under water or drilling fluid, the pile heads shall be cast to a level above the specified cut-off so that, after trimming to remove all debris and contaminated concrete, a sound concrete connection with the pile can be made. The casting level shall be within the tolerance above the cut-off level shown in Table 4 hereof, but shall not be above the commencing surface level. Cut-off levels may be specified below the standing groundwater level, and where this condition applies the borehole fluid level shall not be reduced below the standing groundwater level until the concrete has set.

D Where the cut-off level of piles lies at depths greater than 10 m below the original ground level, then the tolerances given in Tables 2, 3 and 4 will be varied after discussion with the Contractor and before the commencement of the piling to take account of the special conditions which apply.

Table 2
Casting Tolerance above Cut-off Level for Piles Cast in Dry Bores Using Temporary Casing and Without the Use of a Permanent Lining

Cut-off distance below commencing surface, *H*, m	Casting tolerance above cut-off level, m
0.15-10.00	0.3 + *H*/12 + *C*/8 where *C*= length of temporary casing below the commencing surface*

If *H* is greater than *C*, then this tolerance is no longer applicable and the tolerances in Table 4 will apply.

Table 3
Casting Tolerance above Cut-off Level for Piles Cast in Dry Bores within Permanent Lining Tubes or Permanent Casings, or where Their Cut-off Levels are in Stable Ground below the Base of any Casing Used

Cut-off distance below commencing surface, *H*, m	Casting tolerance above cut-off level, m
0.15-10.00	0.3 + *H*/10

Table 4
Casting Tolerance above Cut-off Level for Piles Cast under Water or Drilling Fluid

Cut-off distance below commencing surface, *H*, m	Casting tolerance above cut-off level, m
0.15-10.00	+ *H* /12 + *C*/8 where *C*= length of temporary casing below the commencing surface

In cases where a pile is cast so that the cut-off is within a permanent lining tube, the appropriate tolerance is given by deletion of the casing term *C*/8 in the table.

3.13 Temporary Backfilling Above Pile Casting Level

After each pile has been cast, any empty bore remaining shall be protected and shall be carefully backfilled as soon as possible with approved materials.

3.14 Cutting off pile heads

When cutting off and trimming piles to the specified cut-off level, the Contractor shall take care to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and the pile repaired in an approved manner to provide a full and sound section at the cut-off level

END OF SECTION 02410

Section 02480

Slurry Diaphragm Foundation Walls
(Cast-In-Place Concrete Diaphragm Wall)

Part 1 General

1.01 Description

This section gives additional requirements for the construction of a cast-in-place concrete diaphragm wall. This work shall comprise trenching and boring and subsequently filling the trench with reinforced concrete to form the diaphragm wall, all in accordance with this and other relevant sections of the Specifications and to the details shown on the Drawings.

1.02 Workmanship

All materials and workmanship shall be in accordance with the appropriate current British Standards or Codes of Practice except where the requirements of the British Standards/Codes of Practice are in conflict with this specification in which case the content of this specification shall take precedence.

1.03 Approval of Proposal

Before the construction of the diaphragm wall, the Contractor shall submit to the Engineer for approval the description of the method he proposes to adopt for construction of the diaphragm wall giving full particulars of the method of excavation, plant and equipment to be employed. Notwithstanding the approval of the Contractor's proposals by the Engineer, the Contractor shall be and remain solely responsible for the successful construction of the diaphragm wall.

1.04 Width of Diaphragm Wall Panel

The width of each panel shall not be less than the specified designed width as shown in the Drawings, at any level along its depth. Appropriate stop ends must be installed to maintain the design width of each panel and shall be adequately restrained to prevent horizontal movement during concreting.

1.05 Depth of Diaphragm Wall Panel

The final depth of each panel shall be as shown in the Drawings. The depth of each panel shown in the Drawing is final. If the soil properties greatly differ from that for which the diaphragm wall panels have been designed for, then additional soil investigation may be carried out as directed by the Engineer.

1.06 Diaphragm Wall Layout

The diaphragm wall layout, the number of panels required and their respective depths are as shown in the Drawings.

1.07 Setting Out

Setting out shall be carried out using the data and reference points as shown on the Drawings. Immediately before construction of the diaphragm wall, the wall alignment shall be marked with suitable identifiable pins, pegs or markers.

1.08 Equipment

The Contractor shall provide all plant, tools, appliances and temporary works required for the construction of the diaphragm wall. All plant, materials and methods employed in the formation of the diaphragm wall shall be such as to ensure that the completed diaphragm wall panels are of the desired cross sections.

1.09 Soil Information

Results of soil investigation carried out are available with the Engineer. The Contractor shall, prior to starting the work, satisfy himself of the adequacy and accuracy of the information contained in the soil reports by such additional borings and other tests as he may deem necessary.

Part 2 Products

2.01 Material

A Guide Walls

Guide walls shall be of approved size and quality. They shall be free from significant distortion and shall have sufficient strength to withstand the movement of the grabs against it. They shall be of uniform cross section throughout each continuous length and shall be free from internal projections and encrusted concrete and lumps of soil which might prevent the proper formation of the diaphragm wall pane.

B Reinforcement

The reinforcement shall be as specified in the relevant section for Concrete Works in the Specifications.

C Concrete

Materials for concrete shall be as specified in the relevant section for Concrete Works in the Specifications. Where ready-mixed concrete is used, with the approval of the Engineer, it should be in accordance with BS 5328.

D Bentonite Suspension

1 Supply

The bentonite shall be of approved quality and shall comply with the specification No. DFCP4 of the Oil Companies Materials Association, London (Drilling Fluid Materials – Bentonite). A certificate shall be obtained by the Contractor from the manufacturer

of the bentonite powder, showing the properties of each consignment delivered to site. This certificate shall be made available to the Engineer on request.

2 Mixing

Bentonite shall be mixed thoroughly with clean fresh water to make a suspension which will maintain the stability of the excavated trench for the period necessary until the placement of concrete on completion of the trenching. Preparation of the suspension shall comply with the manufacturer's instructions.

Where saline or chemically contaminated groundwater occurs, special precautions shall be taken to modify the bentonite suspension or prehydrate the bentonite in fresh water so as to render it suitable in all respects for the construction of the diaphragm wall.

3 Tests

The frequency of testing the bentonite suspension and the method and procedure of sampling shall be proposed by the Contractor prior to the commencement of the work. The frequency may subsequently be varied as required, depending on the consistency of the results obtained.

Control tests shall be carried out on the bentonite suspension, using suitable apparatus. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed. The measuring device shall be calibrated to read to within 0.005 g/ml. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite supplied to the trenches and the results shall generally be within the ranges stated in table below. The tests shall be carried out until a consistent working pattern has been established, account being taken of the mixing process, any blending of freshly mixed bentonite suspension and previously used bentonite suspension and any process which may be used to remove impurities from previously used bentonite suspension. When the results show consistent behaviour, the tests for shear strength and pH value may be discontinued, and tests to determine density and viscosity shall be carried out as agreed with the Engineer. In the event of a change in the established working pattern, tests for shear strength and pH value shall be reintroduced for a period if required.

Property to be Measured	Range of Results at 20°C	Test Method
Density	Less than 1.10 q/ml	Mud Density Balance
Viscosity	30 – 90 s or Less than 20 cP	Marsh Cone Fann Viscometer*
Shear Strength (10 Minute gel strength)	1.4 – 10 N/m or 4 – 40 N/m	Shearometer Fann Viscometer
pH	9.5 – 12	pH indicator Paper Strips Or Electrical pH Meter

- Where the Fann viscometer is specified, the fluid sample should be screened by number 50 sieve (300 μm) prior to testing.

Part 3 Execution

3.01 Workmanship

A Setting Out

The Contractor shall check the position and alignment of the guide walls which is to be checked and approved by the Engineer or his Representative before the trenching starts.

B Method of Trenching

Trenching shall be carried down within the panel width to the depth required as shown in the Drawings. The trenching shall be carried out using either individually or in combination percussive, rotary and excavating tools. The Contractor shall advance the trenching by stabilising the trench with the use of bentonite suspension of appropriate properties. Where rock is encountered, percussive or rotary tools shall be used.

The Engineer or his representative shall be informed of any unforeseen ground conditions encountered during trenching.

Where hard stratum is encountered during trenching, the Contractor shall advance the trench by means of chiselling or use of pneumatic tools or other equivalent approved means with the approval of the Engineer.

Soil, rock or ground water samples shall be taken and appropriate soil identification tests carried out while trenching at every 18.5m intervals or change of strata as per the directions of the Engineer. The taking of samples and all subsequent handling, transportation and testing shall be carried out in accordance with BS 5930. The rate of trenching shall include for sampling and testing of soil samples.

C Use of Bentonite Suspension of Stabilize Trench

The level of the bentonite suspension used to stabilize the trench shall be maintained so that the bentonite suspension exerts a head in excess of that of the external ground water. The Contractor has to take precautionary measures so that the suspension shall be maintained at a level not less than 1.25m above the level of the external ground water. The Contractor should also make allowances for the variation in the level of the bentonite suspension during the trenching process.

The bentonite suspension for cohesioless soil for high permeability shall require a bentonite suspension of higher viscosity and higher gel strength than do well graded sands and gravels or clays. Inert fillers such as lightweight aggregate, plastic, sawdust etc. may be added to the suspension to avoid excessive loss of bentonite into the soil, applicable to highly fissured cohesive soils or rocks.

In the event of rapid loss of bentonite suspension from the trench, the excavation shall be backfilled without delay. Before resuming trenching at that location, the approval of the Engineer shall be obtained.

D Spillage and Disposal

All reasonable steps shall be taken to prevent spillage of bentonite suspension on the site in areas outside the immediate vicinity of the trenching. Discarded bentonite shall be removed from the site without undue delay. Any disposal of bentonite shall comply with regulations of the local controlling authority.

E Trenching Near Recently Cast Panels

Panel trenches shall be excavated in an alternate or further location away from a recently cast diaphragm wall panel which contains workable or unset concrete, such that a flow of concrete could be induced or damage caused to any of the panels. A minimum waiting period of at least seven (7) days shall be allowed before any panel trenching adjacent to a recently completed panel is permitted.

F Cleaning of Trench

On completion of trenching, loose, disturbed material or remoulded soil shall be removed from the base of the trench to the satisfaction of the Engineer or his Representative. On final approval of the trenching by the Engineer or his Representative, the final depth of trenching shall be measured.

G Inspection

Each trench shall be inspected and measured prior to the placing of concrete in it. The excavation must be examined by the inspector or any other representative of the Engineer and a suitable probe shall be provided to ascertain the evenness and cleanliness of the base of the trench. Permission shall be obtained by the Contractor before proceeding with concreting. The Contractor shall provide at his own cost all the apparatus necessary for inspection, including any electrical apparatus, if required.

If the Contractor prolongs the placing of concrete, he shall clean the hole again or advance the hole further to a stratum of at least the same soil characteristic as before. The additional cost for trenching, use of additional bentonite suspension and the additional concrete shall be borne by the Contractor.

H Disposal of Spoil

The Contractor shall be responsible for the disposal of the spoil removed from the trench as per the directions of the Engineer.

I Placing of Reinforcement

The reinforcing steel can be placed only in the form of prefabricated cages. As the cage is to be hoisted into the vertical position, before placing into the trench, precaution should be taken to avoid distortion of the cage under its own dead weight. Spacers off the sides of the trench for horizontal positioning and vertical positioning by support from the ground level shall be used to maintain correct alignment.

The reinforcement cage shall be made so that there is not relative displacement of the reinforcement during the construction of the pile and shall be sufficiently strong enough to withstand the impact of falling/discharging concrete.

3.02 Concreting

A Concrete mix for the diaphragm wall panel shall be Grade 35 A. The method of placing and workability of the concrete shall be such that a continuous monolithic concrete wall panel of full cross section is formed. The method of placing shall be by means of a tremie pipe approved by the Engineer.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in the trench. No spoil, liquid or other foreign matter shall be allowed to contaminate the concrete.

B Workability of Concrete

The workability of the concrete shall be determined by the slump test as described in the relevant section of the Concrete Specification.

The concrete shall have a slump of 150mm to 200mm for concrete placed by tremie under water or drilling fluid. The slump shall be measured at the time of discharge into the trench. The concrete is to be rejected if the required slump is not met.

C Minimum Cement Content

The cement content in any mix shall be not less than 400 kg/m^3 of OPC or SR cement. The water/cement ratio shall not exceed 0.6. The use of plasticisers, which include air-entraining agents and retarders, may be used when necessary.

The maximum size of aggregates shall be limited to 20mm with a grading curve showing evenly graded aggregates to prevent segregation.

D Cube Tests

Tests cubes shall be taken from each batch of the concrete used in the concreting or as required by the Engineer, to determine and control the strength of the concrete in the panel.

Test cubes shall be taken in accordance with the relevant section for Concrete Works. The Contractor shall submit certified copies of the result of all tests to the Engineer.

E Compaction

Internal vibrators shall not be used to compact concrete unless the method of use has been approved.

F Concreting Under Bentonite Suspension

Concrete to be placed under the bentonite suspension shall only be placed by means of a tremie pipe.

Before placing concrete, measures shall be taken in accordance with Clause 18.3.7 to ensure that there is no accumulation of silt or other material at the base of the trench and the Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the pipe of the tremie, has not accumulated in the bottom of the trench.

For the concrete to be tremied successfully, the concrete mix shall behave as a heavy fluid to be able to displace the bentonite suspension with which it is in contact. The mix shall be of a plastic consistency, cohesive and shall not bleed or disintegrate under self-weight as this may blockage to the tremie pipe or mix easily with the bentonite suspension. The concrete mix shall not set or stiffen quickly and shall remain workable until the panel is completely concreted. A sample of the bentonite suspension shall be taken from the base of the trench using an approved sampling device. If the specific gravity of the suspension exceeds 1.25 the placing of concrete shall not proceed. In this event the Contractor shall modify or replace the bentonite as approved to meet the Specifications.

During and after concreting, care shall be taken to avoid damage to the concrete from pumping and dewatering operations.

The pipe of the tremie shall be clean and watertight throughout. The tremie pipe shall extend to the base of the trench and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the tremie and the bentonite suspension. The pipe shall at all times penetrate the concrete which has previously been placed and shall not be withdrawn from the concrete until completion of concreting. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the bentonite suspension.

The internal diameter of the pipe of the tremie shall be not less than 150mm for concrete made with 20mm aggregate. The internal face of the pipe of the tremie shall be free from projections.

3.03 Construction of Capping Beam

A Water Level

In the event of ground water level being higher than the required capping beam casting level shown on the Drawings, the Contractor shall submit his proposals for approval prior to placing concrete. The capping beam shall not be left below the ground water level during construction unless approved precautions are taken.

B Preparation of Top Surface of Panel

The top surface of the panel wall shall be removed of all laitance and weak concrete to ensure that it can be properly encased into the capping beam. Capping beams shall be constructed to the details shown on the Drawings.

3.04 Monitoring Devices

In installing the following monitoring devices, the Contractors shall provide for the reference of the Engineer, all relevant manuals on the use of these devices.

A Inclinometers

The Contractor shall supply and install at least one inclinometer (minimum of 4 nos.) for every side of the diaphragm wall. The tubes shall be secured to the steel reinforcement cage with the bottom end adequately sealed against intrusion of concrete/bentonite suspension before lowering into trench.

The tube shall be filled with water and the top end adequately covered prior to tremie concreting of the wall panel. The Contractor shall provide all read-out equipment to assist the Engineer in recording any daily movement or at such intervals as may be agreed.

B Pressure Cells

The Contractor shall supply and install at least 4 numbers of pneumatic/hydraulic pressure cells in the internal and external faces of the diaphragm walls to record the water and soil pressures acting on the structural elements.

The Contractor shall provide the read-out unit and assist the Engineer in recording the data daily or at such intervals as may be agreed.

C Settlement Monitoring Points

The Contractor shall supply and install at least 8 numbers of settlement markers at locations to be determined by the Engineer.

Where markers on existing building have to be installed, this shall consist of permanent stainless steel studs grouted into holes predrilled into the columns of the building. Where this is not practical, chisel marks or paint marks shall be used instead.

Markers in the ground shall be steel rods at least 12mm in diameter. They shall be driven at least 1m into the ground.

The Contractor shall provide precise level and staff to assist the Engineer to take level readings on these monitoring points.

3.05 Tolerances

The diaphragm wall panel shall be installed with the tolerance on verticality less than 1 : 80 for the total length of the wall panel. The top elevation of the shaft shall not be 25mm above or 75mm below the plan elevation. Protrusions on the finished face of the wall shall be limited to a maximum of 100mm.

The maximum deflection of the diaphragm wall due to the excavation up to the base slab level shall not exceed 1 in 400.

The finished face of the guide wall towards the trench and on the side of the trench nearest to any subsequent main excavation shall be vertical and represent the reference line. No ridges or abrupt changes on the face and its variation from a straight line or specified profile shall exceed ± 15mm in 3m.

The minimum clear distance between the two opposite faces of the guide walls shall be the diaphragm wall thickness plus 25mm and the maximum distance shall be the specified diaphragm wall thickness plus 50mm.

Where recesses are to be formed by inserts in the wall, they shall be positioned within vertical and horizontal tolerances of ± 150mm.

In positioning the reinforcement cage, the head of the cage in relation to the top of the guide wall and measured along the trench shall have a vertical tolerance not more than ± 75mm. Also, the vertical tolerance at the cage head in relation to the top of the guide wall shall not exceed ± 50mm.

3.06 Safety Precautions

A Existing Services

Before the work commences the Contractor shall investigate the site for the presence of electrical cables, water mains and other services that may be damaged in the course of constructing the diaphragm wall panel.

B Tidying of Site

The Contractor shall keep the site clear of all unnecessary obstructions such as spoil heaps, discarded wire ropes and reinforcement rods, etc.

C Public Safety

The Contractor shall ensure that all excavations be adequately covered during non-working hours.

3.07 Daily Records

The Contractor shall supply to the Engineer or his representative in duplicate complete records of all diaphragm wall panels installed in the day signed not later than noon of the next working day after the panel has been installed. The record shall include the following:-

1 Identification No. of panel
2 Location
3 Ground level
4 Dimensions and level of top of guide wall
5 Preventive actions of wash out of soil beneath guide walls
6 Width, thickness, depth and trenching date of panel
7 Top and bottom elevation of panel and cut-off level.
8 Details of all strata trenched
9 Depth of water table
10 Depth of rock coring, RQD etc.
11 Details on in situ tests like SPT carried out at various levels and at bottom of trench
12 Details of bentonite suspension used
13 Delivery notes of quality, mix proportions and time of adding cement to the aggregates
14 Volume of concrete used in forming each diaphragm wall panel and Panel No.
15 Types of additives used in the concrete mix
16 Length, diameter and other details of reinforcement cage
17 Elevation of top of rebar cage before and after concrete is poured
18 Date and time of starting, stopping, delays, if any and finishing of diaphragm wall panel
19 Details of location, number and date of test cubes
20 Any unusual occurrences that could affect the integrity of the diaphragm wall panel construction

The signed record shall be part of the record for the Works.

END OF SECTION 02480

Section 02520

Road Works

Part 1 General

1.01 Description

A The work included in this Section comprises furnishing all plant, labour, equipment appliances and materials and performing all operations in connection with:
1 Precast Concrete Kerbs
2 Paving Blocks
3 Access Roads
4 Internal Roads
5 Public roads not to be reinstated by the Road Authority
6 Traffic Markings

1.02 Submittals

A The following product data shall be provided:
1 manufacturer's specifications, test certificates and installation instructions for geotextile fabric,
2 for precast concrete kerbs and paving blocks the manufacturer's specifications, installation instructions and test sheets for each consignment,
3 details of proposed sources for approval of aggregates,
4 for bitumen the manufacturer's specifications and test certificates,
5 for traffic marking paint an acknowledgment that products submitted meet requirements of standards referenced together with the manufacturer's application and surface preparation instructions.

B. The following samples shall be provided and the Contractor shall allow fourteen days for Engineer's review of samples:
1 geotextile fabric - three samples of materials proposed,
2 precast concrete kerbs - one sample for each type,
3 paving blocks - three samples of materials proposed,
4 aggregates - samples of all aggregates for testing and these shall be taken in the presence of the Engineer's Representatives,
5 traffic markings - 5 litres paint and 0.5 kg of glass beads proposed.

1.03 Delivery, Storage and Handling

A Materials shall be delivered in factory labelled packages indicating name, brand, type, size and colour. Deliveries shall be sequenced to avoid project delays and to permit proper co-ordination of the work.

B Geotextile fabric shall be protected against direct sunlight. The edges of precast concrete kerbs/paving blocks shall be protected to prevent staining, chipping or spillage of concrete.

1.04 Mock-up

A A 15 sq m mock-up of paving layout shall be provided and located where directed. It shall comprise sand setting bed, paving blocks and accessories to pattern-indicated showing

range of shades, colour, and texture of pavers. The accepted mock-up may become part of the work.

1.05 Quality Assurance

A The manufacturer of paving blocks and precast kerbs shall be a company specializing in manufacturing with at least three years experience. The installer shall be a specialist in installing exterior pavers with three years experience.

Part 2 Products

2.01 Sub-grade

All materials within the top 450 mm below sub-base level shall be an approved material of C.B.R. minimum 25 compacted as specified herein.

2.02 Geotextile Fabric

Fabric shall be needled polypropylene thermally bonded of approved grade. It shall be stabilized against ultra violet light, inert to commonly encountered chemicals and chemical properties of the in-situ soil and water. It shall conform to the following minimum requirements:

1	weight	140g/m^2
2	thickness under load (2kN/sq.m) 0.95 mm	
3	permeability at 10 cm water column	90 l/sq.m/s
4	tensile strength:	
	longitudinal direction	7 kN/m
	transverse direction	8 kN/m

2.03 Precast Concrete Kerbs

A Kerbs shall conform to BS 7263: Part 1: 1994 and materials shall conform to Section 03300 hereof. Concrete shall have a 28 days cube strength of 40 N/mm^2.

B Non-mountable kerb, dropped kerb, flush kerb and heel kerb elements shall only be precast from concrete produced in a fully automatic batching plant. Non-mountable and dropped precast kerbs shall be formed by elements 900 mm long where required to be laid in straight lines. These may be reduced to 250 mm long where required to be laid to curves depending on the radii of the curves. Units shall be fabricated using steel or other approved moulds in compliance with the approved manufacturing and testing procedures. Quality control recommendations and dimensional tolerance shall be in accordance with BS 7263:Part 1. Units shall be cured by either: low pressure steam; steam vapour; radiant heat and moisture; or other similar process.

C Exposed-to-view finish surfaces of precast concrete members shall be fair faced, uniform in colour and appearance. Blemishes such as non-uniformity, staining, or surface cracking shall be minimised. Small surface holes, normal form joint marks, minor chips, and spalls are acceptable. Major or unsightly imperfections, honeycombs, or structural defects are not acceptable. Defective items shall be repaired or replaced as directed by the Engineer. Tolerances of manufacture shall be 3 mm in any one dimension and end faces shall be truly perpendicular to the base.

2.04 Paving Blocks

A Materials shall conform to BS 6717: Part 1 and thicknesses shall be 60 mm on sidewalks and 80 mm on access roads and parking areas unless otherwise shown on the Drawings or instructed by the Engineer. The average strength of 10 blocks tested in accordance with BS 6717: Part 1 shall be not less than 49 N/mm^2 and the strength of any individual block shall be not less than 40 N/mm^2. The water absorption average of three specimens tested in accordance with ASTM C140 shall not be greater than five percent. No individual result shall be greater than seven percent.

B The sand setting bed, which shall be obtained from a single source, shall consist of sharp sand containing not more than three percent silt and clay by weight and 10 percent retained on 4 mm sieve. Permissible limits expressed as a percentage by weight shall be: sulphates (as SO_3) - max 0.3 percent and chlorides (as CI) - max 0.5 percent. The sand shall be allowed to drain before use and shall be covered with suitable sheeting to minimize moisture changes.

2.05 Access Roads

A Granular sub-base shall be hard, durable natural/screened gravel or crushed stone, free of clay balls or other deleterious substances. Grading shall be as follows, when tested in accordance with BS 812 : Part 103.

Sieve Size	% By Weight Passing
75 mm	100
37.5 mm	85 - 100
9..5 mm	40 - 85
4.75 mm	25 - 45
0.6 mm	8 - 25
0.075 mm	0 - 10

Materials shall conform to the following requirements. Minimum test requirements shall be one sample tested every 1000 cum supplied and one in situ density test shall be made every 500 sq m of granular sub base laid.

Test	Standard	Limit
Sampling	ASTM D75	--
Liquid Limit	BS 1377 : Part 2 : Test 4.5	max 25%
Plasticity Index	BS 1377 : Part 2 : Test 5	max 6%
Organic Impurities	BS 1377 : Part 3 : Method 3	max 0.15%
Acid Soluble Sulphate (by wt. of agg)	BS 812 : Part 118	max 0.5%
Acid Soluble Chloride (by wt. of agg)	BS 812 : Part 117	max 1%
Flakiness Index	BS 812 : Part 105.1	max 35%
Elongation Index	BS 812 : Part 105.2	max 35%
Ten Percent Fines Value	BS 812 : Part III	min 50 kN
Los Angeles Abrasion	ASTM C131/C535	max 30%
Soundness ($MgSo_4$)	ASTM C88	max 12%
Linear Shrinkage	BS 1377 : Part 2 :Method 6.5	max 3%
Compaction Test (Modified Proctor)	BS 1377 : Part 4 :Method 3.6	--
Field Density	BS 1377 : Part 9 : Test 2.2	min 95% MDD
C.B.R. at 95% of Modified Proctor Density (96 hour soaked)	BS 1377 : Part 4 Test 7	min 30%

B Granular road base material shall be hard, durable screens gravel or crushed stone, free from organic matter or other deleterious substances. Grading shall be as follows when tested in accordance with BS 812 : Part 103.

Sieve Size	% by Weight Passing
50 mm	100
37.5 mm	70 -100
28 mm	55 - 85
20 mm	50 - 80
10 mm	40 - 70
5 mm	30 - 60
2.36 mm	20 - 50
0.425 mm	10 - 30
0.063	5 - 15

Material shall confirm with the following requirements. Minimum test requirements shall be one sample tested every 1000 cum supplied and one in situ density test shall be made every 300 sq m of aggregate road base laid.

Test	Standard	Limit
Sampling	ASTM D75	--
Liquid Limit	BS 1377 : Part 2 : Test 4.5	max 25%
Plasticity Index	BS 1377 : Part 2 : Test 5	max 6%
Organic Impurities	BS 1377 : Part 3 : Method 3	max 0.15%
Acid Soluble Sulphate (by wt. of agg)	BS 812 : Part 118	max 0.5%
Acid Soluble Chloride (by wt. of agg)	BS 812 : Part 117	max 1%
Flakiness Index	BS 812 : Part 105.1	max 35%
Elongation Index	BS 812 : Part 105.2	max 35%
Sand Equivalent Valve	ASTM D2419	min 40
Los Angeles Abrasion	ASTM C131/C535	max 40%
Soundness ($MgSo_4$)	ASTM C88	max 12%
Linear Shrinkage	AASHTO T92	max 3%
Compaction Test (Modified Proctor)	BS 1377 : Part 4 :Method 3.6	
Field Density	BS 1377 : Part 9 : Test 2.2	min 98% MDD
Maximum Dry Density	BS 1377 : Part 4 : Test 3.6	min 2.0g/cc
CBR at 100% of modified proctor density (96 hr. soaked)	BS 1377 : Part 4 : Test 7	min 80%

C Bitumen paving courses shall consist of the construction of the following hot-mix bituminous courses which consist of coarse aggregates, fine aggregates, filler material and bitumen binder. Asphaltic concrete or dense bitumen macadam as indicated on the Drawings.

1 Coarse Aggregates:
   a material shall be retained on a 4.75 mm sieve,
   b consist of crushed rock or crushed gravel,
   c shall be clean, hard, tough, durable and sound,
   d shall be of uniform quality and free from decomposed stone, shale, clay, lumps and other deleterious substances,

e crushed gravel shall consist of the product obtained by crushing material that has first been screened in such a manner that not less than 90 percent of the material to be crushed is retained on an ASTM 10mm sieve,
f 100 percent by weight of each stockpile shall have one crushed face,
g at least 50 percent by weight of each separate stockpile of aggregate shall have all faces crushed,
h coarse aggregate shall have properties which comply with the following values:

Test	Standard	Base Course/ Binder Course	Wearing Course
Los Angeles Abrasion	ASTM C131/C535	max 30%	max 25%
Aggregate Crushing Value	BS 812 : Part 110	max 25%	max 20%
Soundness ($MgSo_4$)	ASTM C88	max 10%	max 10%
Flakiness Index	BS 812 : Part 105.1	max 30%	max 25%
Elongation Index	BS 812 : Part 105.2	max 30%	max 25%
Water Absorption	ASTM C128/127	max 2%	max 2%
Acid Soluble Chlorides (by wt. Of agg)	BS 812 : Part 117	max 0.06%	max 0.06%
Acid Soluble Sulphate (by wt. of agg)	BS 812 : Part 118	max 0.4%	max 0.4%
Organic Impurities	BS 1377 : Test 3 : Method 3	max 0.05%	max 0.05%

2 Fine aggregates:
a consist of the material passing a 4.75 mm sieve,
b fine aggregate including filler shall be obtained from 100 percent crushed gravel or crushed rock pre-screened to exclude natural uncrushed fine material or weathered unsound fines,
c use of dune sand shall not be permitted,
d fine aggregates shall have properties which comply with the following values:

Test	Standard	Limit
Soundness ($MgSo_4$)	ASTM C88	Max 10%
Plasticity Index	AASHTO T90	Non-Plastic
Acid Soluble Chlorides (by wt. of agg)	BS 812 : Part 117	Max 0.06%
Acid Soluble Sulphates (by wt. of agg)	BS 812 : Part 118	Max 0.4%
Sand Equivalent Value	ASTM D2419	min 40

3 Filler material
a when the combined grading of the coarse and fine aggregates is deficient in material passing the AASHTO No. 200 sieve, mineral filler shall be added as approved by the Engineer at the Contractor's expense,
b consist of finely ground particles of limestone or cement in accordance with ASTM D242,
c shall be thoroughly dry and free from organic substances and clay,
d shall meet the following grading requirements:

BS Sieve Size	ASTM Sieve Size	% By Weight Passing
600 micron	No. 30	100
300 micron	No. 50	95 – 100
150 micron	No. 100	90 – 100

75 micron	No. 200	70 – 100

4 Bitumen binder
- a shall be penetration grade 60 – 70,
- b bitumen shall be prepared by refining crude petroleum by suitable method,
- c shall be homogeneous and free from water,
- d shall not foam when heated to 175°C,
- e shall conform to the requirements of following values:

Test	Method		Min	Max
	AASHTO	ASTM		
Penetration at 25°C 100g, 5 sec.	T49	D5	60	70
Flash Point, Cleveland Open Cup, °C	T48	D92	232	-
Ductility at 25°C, cm	T51	D113	100	-
Solubility trichloroethylene, %	T44	D2042	99	-
Thin film oven test 3.2 mm, 163°C, 5 hr loss on heating, %	T179	D2872	-	0.80
Penetration of residue % of original	T49	D5	54	-
Ductility of residue at 25° C, 5 cm/min, cm	T51	D113	50	-
Kinetic Viscosity (centistokes) at 135° C	T201	D2170	240	-
Softening Point (Ring Ball apparatus)	-	D36	48	52

- f no bitumen, other than that represented by the approved sample, shall be used by the Contractor except with the written consent of the Engineer,
- g blending of bitumen from different refineries will not be permitted.

D Asphaltic Concrete

1 when tested according to ASTM C117 and ASTM C136, the mixes shall conform to the following grading:

ASTM Sieve Size	% By Weight Passing	
	Base Course	Wearing Course
37.5 mm	100	-
25.0 mm	80 - 100	100
19.0 mm	62 - 92	86 - 100
12.5 mm	-	69 - 87
9.5 mm	45 - 75	58 - 78
4.75 mm	30 - 55	40 - 60
2.36 mm	20 - 40	25 - 45
0.85 mm	15 - 30	15 - 30
0.425 mm	10 - 22	10 - 22
0.18 mm	6 - 15	6 - 15
0.075 mm	2 - 8	2 - 8

2 use of sand in mixes will not be permitted,

3 combined mineral aggregate shall meet the following requirements:

a sand equivalent value (ASTM D2419) determined after all processing except for addition of asphalt binder min 65
b plasticity index BS 1377: Part 2: Test 5 Non-plastic

4 grading given in the above Table represent the extreme limits which shall determine suitability of aggregate for use from all sources of supply,
a aggregate as finally selected for use in the work shall have a grading within the limits designated in the above table as appropriate,
b base course limit may vary from the low limit on one sieve to the high limit on the adjacent or vice-versa with the Engineer's approval,
c wearing course shall be uniformly graded from coarse to fine.

5 coarse aggregate, shall show no detrimental amount of stripping when tested in accordance with ASTM D 1664,
a minimum value of non-stripped area shall be 95 percent,
b if stripping occurs, the aggregate shall be rejected. Approved method of treatment shall be carried out as specified to change the material from a hydrophilic to a hydrophobic state as directed by the Engineer. Approved additive shall be used with the bituminous binder.

6 when necessary to improve the coating of aggregate by bitumen, additives of approved type will be added to the bituminous material in such percentage as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with ASTM D1664. Approved additive will be used in accordance with Technical Specifications issued by the manufacturer and approved by the Engineer after appropriate testing,

7 no extra payment will be made for required anti-stripping additives,

8 design criteria:

Properties	Base Course	Wearing Course
Bitumen Content (% of total mix)	3.2 - 4.4	3.4 - 4.4
Marshall Specimens:		
Number of Compaction blow at each end of specimen.	75	75
Voids in total mix (VTM %)	4 - 8	4 - 8
Voids in mineral aggregate (VMA %)	min 13	min 15
Voids filled with Bitumen (VFB %)	50 - 65	50 - 75
Stability (kg)	min 1000	min 1200
Flow (mm)	2 - 4	2 - 4
Stiffness (kg/mm)	min 500	min 500
Loss of Marshall Stability by submerging specimens in water at 60° C for 24 hours compared to stability measured after submersion in water 60° C for 30 minutes.	max 25%	max 25%
Filler/Bitumen Ratio	0.6 - 1.5	0.6 - 1.4

E Dense Bitumen Macadam.

1 when tested according to ASTM C117 and ASTM C136 the mixes shall conform to the following grading:
a base course

BS Sieve Size (Mm)	% By Weight Passing		
	Finished Thickness (Mm)		
	65 - 80	50 - 60	35 - 45

50	100	-	-
37.5	95 - 100	100	-
28	70 - 94	90 - 100	100
20	-	71 - 95	95 - 100
14	56 - 76	58 - 82	65 - 85
10	-	-	52 - 72
6.3	44 - 60	44 - 60	39 - 55
3.35	32 - 46	32 - 46	32 - 46
0.300	7 - 21	7 - 21	7 - 21
0.075	2 - 8	2 - 8	2 - 8

b wearing course

BS Sieve Size (Mm)	**% By Weight Passing**		
	Finished Thickness (Mm)		
	35 - 50	25 - 30	20
28	100	-	-
20	95 - 100	100	-
14	70 - 90	95 - 100	100
10	55 - 75	70 - 90	95 - 100
6.3	40 - 60	45 - 65	55 - 75
3.35	25 - 40	30 - 45	30 - 45
1.18	15 - 30	15 - 30	15 - 30
0.075	2 - 6	2 - 6	2 - 6

2 use of dune sand in mixes will not be permitted.

3 combined mineral aggregate shall meet the following requirements:

a sand equivalent value (ASTM D2419) determined after all processing except for addition of asphalt binder min 65.

b plasticity Index BS 1377: Part 2: Test 5 Non-plastic

4 grading given in Tables 9 & 10 represent the extreme limits which shall determine suitability of aggregate for use from all sources of supply. Aggregate as finally selected for use in the work shall have a grading within the limits designated in Tables 9 & 10 as appropriate. Combined grading which approach maximum limits on some sieves and minimum limits on other sieves shall not be permitted,

5 coarse aggregate, shall show no detrimental amount of stripping when tested in accordance with ASTM D1664. Minimum value of non-stripped area shall be 95 percent. If stripping occurs, the aggregate shall be rejected. Approved method of treatment shall be carried out as specified to change the material from a hydrophilic to a hydrophobic state as directed by the Engineer. Approved additive shall be used with the bituminous binder.

6 when necessary to improve the coating of aggregate by bitumen, additives of approved type will be added to the bituminous material in such percentage as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with ASTM D 1664. Approved additive will be used in accordance with Technical Specifications issued by the manufacturer and approved by the Engineer after appropriate testing.

7 no extra payment will be made for required anti-stripping additives.

8 design criteria:

Properties	**Base Course**	**Wearing Course**
Bitumen content (% of total mix)	3.2	3.5 - 4.1
Marshall specimens: No. of Compaction blow		

at each end of specimen	75	75
Voids in total mix (VTM %)	7 - 11	6 - 9
Voids in Mineral Aggregate (VMA %)	14 - 20	14 - 20
Voids filled with Bitumen (VFB %)	48 - 60	48 - 60
Stability (kg)	min 750	min 1000
Flow (mm)	2 - 4	2 - 4
Stability/Flow Ratio (kg/mm)	min 270	min 320

F. Prime Coat.

1 bituminous prime coat shall consist of supplying and applying liquid asphalt to a previously prepared and approved sub-grade; sub-base or aggregate base course in accordance with this Specification.

2 material

a medium curing cut back asphalt MC-70,

b conform to ASTM D2027 as modified by Table below or as directed by the Engineer:

Test	Method	Limits	
		Min	Max
Sybolt Furol Viscosity at 50° C, sec.	AASHTO T72	60	120
Flash Point, Tag open Cup, °C	AASHTO T79	38	-
Distillation:	AASHTO T78		
Distillate (% of total distillation to 360° C.)			
To 225° C		-	20
To 260° C		20	60
To 315° C		65	90
Residue from distillation to 360° C, % by volume difference	AASHTO T78	55	-
Tests on residue from distillation:			
Penetration at 25° C, 100g 5 sec.	AASHTO T49	120	250
Ductility at 25° C, cm	AASHTO T51	100	-
Solubility in trichloroethylene, %	AASHTO T44	99	-
Water content, % by volume	AASHTO T55	-	0.2

G Tack coat

1 bituminous tack coat shall consist of supplying and applying emulsified asphalt diluted with an equal quality of water (1:1) to a previously prepared:

a bituminous base course,

b binder course or,

c existing bituminous surface in accordance with this specifications,

2 material:

a slow setting emulsified asphalt,

b grade SS-1h (anionic) or CSS-1h (cationic),

c conform to ASTM D977:

Test	Method	Limits	
		Min	Max
Saybolt Furol Viscosity at 25° C, sec.	AASHTO T72	20	100
Storage Stability Test, 24 hrs, %	AASHTO T59	-	1
Residue by distillation	AASHTO T78	57	-
Tests on residue from distillation:			
Penetration 25° C, 100g 5 sec.	AASHTO T49	40	90
Ductility 25°, cm	AASHTO T51	40	-

Solubility in trichloroethylene, %	AASHTO T44	97.5	-

3 sampling shall be in accordance with ASTM D140.

2.06 Traffic Markings

A Thermoplastic materials shall conform to BS 3262 : 1989 : Part 1 except where modified in this Specification.

B Ballotini shall be in accordance with BS 6088 : 1981.

C Road marking material shall consist of:

1 light coloured aggregate,

2 pigment and extender bound together,

3 hard wearing resins, plasticised with oil as necessary,

4 composition of material:

5

a	aggregate	40 parts
b	Ballotini	20 parts
c	pigment and extender	20 parts
d	binder	20 parts

D Grading of various ingredients shall be such that the final product, when in a molten state, can be sprayed on the surface in accordance with BS 3262:1989.

E Aggregate shall consist of white silica sand; crushed calcite; calcined flint or quartz or other approved aggregate. Colour shall comply with the requirements laid down in paragraph 4b of BS 3262:Part I.

F Ballotini shall be reasonably spherical; free from flaws; not less than 80 percent shall be transparent glass and grading shall be in accordance with BS 6088:1981.

G Pigment shall be titanium dioxide in accordance with paragraph 6a(i) of BS 3262: Part 1 and shall be not less than 10 percent by weight of the mix.

H Extender shall be whiting in accordance with paragraph 6b of BS 3262: Part 1. The total content of pigment and extender shall be 18 to 22 percent in accordance with paragraph 6c of BS 3262: Part 1.

I Binder shall not contain more than 5 percent of resin or other acidic material and shall consist mainly of hydrocarbon resins plasticised with mineral oil.

J Resins shall be of a colour at least as pale as Grade WG resin; shall have an acid value not greater than 2 and must pass the heat stability test described below.

K Oil used as plasticiser shall be a mineral oil with colour and viscosity as defined in paragraph 7a (ii) of BS 3262: Part 1. It shall be at least as pale as grade 4 on the PRS shellac and varnish “A” disc; ½ to 3½ poises at 25° C viscosity. When heated for 16 hours at 150° C it shall not darken excessively.

L Softening point of the binder shall be used only as a guide to quality control.

M Behavior of the thermoplastic shall be judged from the performance tests described below. Viscosity of the melted binder at the spraying temperature must be such to produce a thermoplastic mix of the required spraying properties. Composition of the laid material as found on analysis shall comply with the requirements of Table 1 of BS 3262 : Part 1.

1 proportion of constituents

2

Constituent	By Weight	
	Minimum	Maximum
Binder	18	22
Aggregate, pigment and extender and ballotini	78	82

2 grading of combined aggregate pigment and extender:

Sieve Size	By Weight Passing	
	Minimum	Maximum
No. 20	100	-
No. 30	75	95
No. 52	35	65
No. 200	25	35

3 temperature limits imposed by BS 3262 : Part 1 for materials based on resin shall not apply. Temperatures up to 220° C may be used. At these temperatures the material shall not discolour in the time required for its use,

4 containers shall be made of a material which does not contaminate the contents and will protect the contents from contamination,

5 capacity of each container shall be not less than 25 kg or more than 100 kg.,

6 each container shall be clearly marked with the manufacturer's name, batch number and date of manufacture.

N Performance requirements

1 thermoplastic material shall meet the performance requirements of the following:

Property	Minimum	Minimum
Density (Mg/Cu.m)	2.0 (approx)	-
Open flashpoint °C	230	-
Softening point (Ring and ball ASTM D36) °C	95	-
Luminance	75	-
Flow resistance after 48 hours at 40° C	-	25
Abrasive wear, 9/100 revs	-	0.3
Skid resistance	45	-

O Testing of thermoplastic material

1 all specimens shall be prepared by carefully heating a representative sample to a temperature of (softening point + 50°C), stirring thoroughly to avoid segregation and used without delay,

a material shall be cast on to a suitable flat, glossy surface coated with a colourless release agent to give a slab 100 mm square by 3 mm thick. Luminance of the cast face, with reference to that of a block of magnesium oxide (luminance factor 100) shall be measured with the sample illuminated by a tungsten light source at an angle of 45° viewed at right angles by a selenium barrier layer phot-electric cell.

b for flow resistance, material shall be cast into a conical mould having an apex angle of 60° and a vertical height of 100 mm. After cooling and setting for 24 hours the cone shall be removed from the mould, placed on a flat level surface and maintained at a temperature of 23 $\pm$ 2°C for 48 hours.

c for impact resistance, a 3 mm thick coating of material shall be screeded on to a monel alloy panel 1.25 mm thick, previously coated with rubberised bitumen emulsion. The impact instrument, a 4.7 kg weight, shall be dropped vertically

through 250 mm on to the surface of the panel, striking the surface with a hemispherical indenter of radius 6 mm. Panel shall be retained by a metal block drilled to allow the indenter to strike the panel, with the depth of indentation limited to 2 mm. Five panels shall be tested and no fracture shall result from impact. A crack not longer than 2 mm will be accepted provided there is a smooth indentation in the material.

d for abrasion resistance, a 3 mm thick coating of material shall be screeded on to a monel alloy panel and subject to wet (water lubricated) abrasion at 23°C on a Taber model 503 standard abrasion tester using H-22 calibrate wheels, refaced between tests. Loss in weight after two successive tests of 100 revolutions shall be recorded and the average taken as the abrasive wear.

e for skid resistance, a 100 mm wide line of material 1.5 mm thick shall be screeded on to a flat, level base for a minimum length of 800 mm. After cooling to ambient temperature the skid resistance shall be measured using the TRRL Portable Tester as described in Road Note 27. Measurements shall be made on different parts of the specimen, corrected for temperature effects, and the average recorded.

2.07 Road Marking Paint (for Traffic Diversions, etc.)

A These shall be either chlorinated rubber, one pack epoxy or alykyd based and shall be suitable for applying by brush or mechanical means to cement concrete or bituminous pavement to give a chemically stable film of uniform thickness.

B White paint shall be contain not less than 6 percent by mass of titanium dioxide as a pigment and shall conform to type A (anatase) or type R (rutile) specified in BS 1851.

C Yellow paint shall be standard colour BS 381C No. 355, except where an alternative shade has been specified. It shall contain not less than 6 percent by mass of a suitable yellow pigment.

Part 3 Execution

3.01 Excavation

A Other Clauses of Division 2 apply except as modified hereunder. The Contractor shall include excavation as required to provide a smooth, gentle slope to meet the existing adjacent ground surface. For the sub-grade preparation Contractor shall scarify a layer of an adequate area and suitable depth not less than 300 mm. Soil shall be pulverized, mixed, shaped, compacted and finished, all in accordance with the Specifications.

B Unless otherwise specified or approved by the Engineer, no materials excavated shall be used as fill material but shall be disposed of by the Contractor. When unsuitable material is directed to be removed by the Engineer, the surface of the cut section shall be compacted to 95 percent MDD according to ASTM D1557 Method D, to a depth of 150 mm below surface of cut before placement of approved borrow material.

3.02 Placement of Borrow Materials, Backfilling and Filling

A Where borrow or fill materials are to be placed and compacted on hillsides, or where new fill is to be compacted against existing embankments, or where fill is built one-half width at a time on slopes steeper than three horizontal to one vertical, the slopes of the original hillside, old or new fill, shall be cut into as the work is brought up in layers (benching).

Grades shall slope according to the Drawings. Material thus cut out shall be incorporated and compacted with the new fill.

B Borrow materials or fills shall be formed in horizontal layers of uniform thickness. Work shall be carried out to adhere to the slopes, levels, depths indicated. After adjustment of the moisture content to that required to attain maximum density, the loose material shall be compacted to obtain the specified density.

C Placement of borrow materials or fills at points inaccessible to normal compaction equipment shall be made in horizontal layers of loose material not exceeding 100 mm in depth and thoroughly compacted by the use of mechanical tampers.

D Prior to the placement of any borrow materials, the Contractor shall construct trial compaction tests as directed by the Engineer. Borrow material used in the trials shall be with the proposed borrow material. Compaction equipment to be used shall be that specified and acceptable to the Engineer. The object of these trials shall be to determine the optimum moisture content and the relationship between the number of compaction equipment passes and density for the proposed borrow materials.

E Density to which borrow material or fill layers shall be compacted is as required to comply with the requirements of paragraph 3.03 herein.

F Borrow material which does not contain sufficient moisture to obtain the required compaction shall have additional water incorporated therein by the use of approved sprinklers and mixing.

G Material containing an excess of the amount of moisture required to obtain the necessary compaction shall not, without written approval of the Engineer, be incorporated in the fill until it has been allowed to dry prior to compaction. Drying of wet material may be expedited by disking or other approved methods.

H Compaction of borrow materials or fills shall be carried out at moisture content determined by the Engineer. In forming the embankments the Contractor shall ensure that the work can be drained free of rainwater and shall make allowances in the height and width of the work for any swelling or shrinkage.

I When an embankment or filled area has achieved settlement and requires additional material to bring it up to the required formation level, the top of the borrow or fill shall be thoroughly scarified before the placement of additional material when the depth of the additional material is less than 300 mm.

3.03 Compaction

A The Contractor shall carry out the compaction of borrow materials or fills as specified after grading and levelling the surface to be compacted. In areas to be filled, compaction shall include adding necessary fill, water, and other materials as required, and compacting the first layer in addition to subsequent layers up to the proposed levels. In areas already excavated down to the required level, compaction shall include adding the necessary water, etc., and compacting the surface, in accordance with the procedure outlined hereinafter. Procedure outlined below shall not relieve the Contractor of his duties to determine the most suitable procedure for compaction. All such procedures shall be subject to the approval of the Engineer.

B After carrying out the grading, levelling, scarifying, pulverizing, and other work as required, of the fill layer to be compacted as per specifications, the Contractor shall add the necessary amount of water to permeate the pulverized fill in the quantity required, all in accordance with the directions of the Engineer. Fill shall then be thoroughly turned over after adding each lot of water so as to achieve a homogeneous moisture content in the whole thickness of the layer.

C Before compacting, samples from the pulverized fill will be taken and tested according to laboratory testing, (field testing using "Speedy Moisture Device" or similar instrument giving direct readings for the filled moisture content may be used for guidance only), in order to establish the natural moisture content. In the event that it is more than Optimum Moisture Content, the area of sub-grade represented by this sample shall be scarified and aerated until the moisture content is within $\pm$ 2 percent of the Optimum Moisture Content. Then the fill shall be primarily levelled in order to commence fill compaction.

D After primary levelling compaction shall be commenced by means of approved rollers depending on the type of material being compacted in order to obtain 95 percent of maximum dry density. Placement of borrow materials or fills shall be in layers not exceeding 150 mm compacted thickness. When tested in place, borrow material shall have a minimum density of 95 percent of maximum dry density to a minimum depth of 300 mm below the top of sub-grade. Borrow material shall be tested and shall have a California Bearing Ratio (CBR) of 25 as a minimum.

E Rolling shall be carried out in the direction of the road axis until the fill reaches the required density. In crowned sections, rolling shall start from both edges of the road in the direction of the axis. If the road is supere-levated, rolling shall commence from the lower side and continue to the higher side. In order to compensate for the amount of water lost in evaporation in the course of compaction, additional quantities of water shall be added as required.

F The surface shall thereafter be levelled longitudinally and transversely by motor graders and finally rolled to achieve uniform compaction free from undulations, soft spots and depressions.

3.04 Sub-grade Preparation

A All sub-grade material within the upper 450 mm below the top of sub-grade elevation shall have a minimum California Bearing Ratio (CBR) of 25 when tested in accordance with BS 1377: Part 4, Method 7. When the upper 450 mm below the sub-grade elevation of earth cut is found to be incapable of compaction as specified such sub-grade material shall be removed and replaced.

B After the foregoing work has been accomplished, the entire sub-grade shall be shaped to a smooth uniform surface. Excess material, which cannot be disposed of by normal drifting to the low spots during blading and shaping operations, shall be removed and disposed of by placing it in sub-grade areas deficient in materials and shall be watered and compacted as necessary to yield a true finished sub-grade as described above.

C Once prepared, the sub-grade shall be maintained in the finished condition until the first succeeding course of sub-base or base material has been placed. The Contractor shall take all precautions necessary to protect the sub-grade from damage. Hauling over finished sub-grade shall be limited to that which is essential for construction purposes. The Contractor shall protect the prepared sub-grade from both his own and public traffic. The Contractor

shall maintain the sub-grade by blading and rolling as frequently as may be necessary to preserve the sub-grade in a completely satisfactory condition.

3.05 Geotextile Fabric Installation

A In areas where the Engineer considers and deems the use of geotextile fabric necessary, the Contractor shall furnish and place geotextile fabric as specified herein and as directed by the Engineer. Sub-grade surface to receive the geotextile fabric shall be prepared by spreading sand to a relatively smooth condition free of obstruction, depressions, and debris. Geotextile fabric shall not be laid in a stretched condition, but shall be laid loosely with the long dimension parallel to the centre line of the pavements. In the event the width of the proposed area for fabric requires more than one panel width of fabric, the panels shall be overlapped a minimum of 15 percent of the panel width. Longitudinal joints in the fabric shall have an overlap of 500 mm. To prevent slippage of the overlapping fabric, the areas of overlap shall be stabilized as approved by the Engineer with pins, anchor blocks, or aggregate piles. In the event construction machinery is used to place the fabric, the working platform for the machinery shall be the soil sub-grade and not the previously laid fabric. Prior to placement of the aggregate material the Contractor shall spread a layer of sand over the geotextile fabric as directed by the Engineer. Aggregate material shall not be dumped directly on the fabric, nor shall the haul trucks run on the fabric. Aggregate shall be spread by a bulldozer or front end loader. Blade or bucket shall be kept sufficiently high so that the aggregate is not being pulled over the fabric, but being dropped at a minimum height to the satisfaction of the Engineer. Fabric damaged or displaced before or during installation or during placement of overlying aggregate material shall be replaced or repaired at the Contractor's expense and to the satisfaction of the Engineer.

3.06 Installation of Precast Concrete Kerbs

A Kerbs shall be set to the lines and grades shown on the Drawings. Under no circumstances will it be permitted for levels to be set by direct measurement from pavement layers.

B Unless otherwise indicated, elements shall be laid either directly onto a wet concrete base or on to a cement, sand (1:3) mortar bedding, 25 mm thick on a previously laid concrete base on approved sub-grade. Dimensions of the base shall be as shown on the Drawings. Concrete base shall be constructed with Grade 20 Concrete.

C Unless otherwise indicated, after kerbs units have been laid a contiguous backing of Grade 20 Concrete shall be poured for the elements using steel forms.

D No pavement layers shall be laid against kerbing until such time as the backing is complete, back filled and approved by the Engineer.

E Joints between radius kerbs, shall have a clear width of 4 mm and be filled with a cement, sand (1:3) mortar with 1/5 part hydrated lime and sufficient water to make the mixture plastic and easily smoothed. A grooving tool shall be used to produce a smooth, circular section groove not more than 3 mm deep in all joints. Grouted joints shall be cured by an approved method to the Engineer’s satisfaction. Joints between straight kerbs shall not be filled.

F Immediately after any concrete is in place and for 7 days thereafter the kerbs, base backing and mortared joints shall be fully cured and protected from drying out and against the harmful effects of weather, including rain and rapid temperature changes. Method of protection shall be subject to the Engineer’s approval. Use of coloured curing membranes

will not be permitted. Concrete not properly cured and protected will be rejected and shall be removed from the works.

G At each 9 metres or as directed by the Engineer or shown on the Drawings, the joint between kerbs shall be filled with an approved joint filler 10 mm thick to form an expansion joint. Filler shall extend through the kerb, bed, backing and channel, and shall be trimmed to the finished shape of the kerb and channel.

H At the end of any kerb run, the end kerb section shall be sloped down to ground level, if applicable, angled away from the road at 30 degrees.

I Where specified, kerbs shall be painted.

J. Any excavated surface for the concrete bedding shall be watered and compacted to a minimum of 95 percent MDD.

3.07 Installation of Paving Blocks

A Paving blocks shall be laid on the sand laying course in such manner as not to disturb the blocks already laid. Each block shall be placed firmly against its neighbour so that they fit closely together. Joints between blocks shall not exceed 3 mm. Laying of the paving blocks shall commence at right angles to the main pavement axis starting at one end of the area. Shall be laid in a herringbone pattern unless otherwise shown on the Drawings or instructed by the Engineer at 45° to the main pavement axis.

B Where blocks do not fit the edge restraints or other obstructions such as manholes or upstands the gaps shall be filled using cut blocks.

C Blocks shall be cut using only a mechanical block splitter.

D Dimensional accuracy, uniformity of joint gaps, alignment and squareness shall be checked after laying the first three rows of blocks and thereafter at regular intervals. If joints begin to open the blocks shall be knocked together using a hide mallet.

E After each 20 sq.m or such area that has been agreed with the Engineer, laid blocks shall be compacted to the required levels using a plate vibrator. Plate vibrator shall have a plate area of 0.20 to 0.35 m^2, a compaction force of 12-24 kN and a frequency of approximately 75 to 100 Hz.

F A minimum of two passes of the plate vibrator shall be made in each direction, i.e. at 90 degrees to each other. Vibration shall continue until no further compaction of the sand layer is apparent. Laying course shall have a compacted thickness of 50 mm. Fine dry sand with a particle size of 0.3 mm shall then be brushed over the paving. Further passes of the plate vibrator made in each direction, until the sand is no longer absorbed into the joints. Plate vibrator shall not pass closer than 1 m to a temporarily unrestrained edge during laying. No paving shall be left uncompact overnight except for the 1 m strip at the temporarily unrestrained edge.

G On completion, the finished surface level, shall be within 5 mm of the design level. Maximum deviation within the compacted surface, measured by a 3 m straight edge shall not exceed 3 mm. Level of any two adjacent blocks shall not differ by more than 1 mm. Any areas of paving which do not comply with these tolerances shall be removed. Sand laying course adjusted and the paving blocks re-laid to the correct levels.

3.08 Road Construction

A Granular sub-base shall be:

1 delivered to the roadbed as uniform mixture
2 spread in layers or windrows.
3 segregation shall be avoided.
4 free from pockets of coarse or fine materials.
5 spread by finisher and or grader or their approved mechanical methods.
6 watered, shaped to a compacted thickness not exceeding 150 mm and compacted to the required grade and cross-section.
7 compacted with procedure and plant to the satisfaction of the Engineer. At the time of compaction the moisture content of the laid material shall not vary by more than $\pm$ 2 percent of the Optimum moisture content.
8 compacted to not less than 95 percent of the maximum density determined in accordance with BS 1377: Part 4: Method 3.6. Surface on completion of compaction shall be well closed, free from movement under compaction plant and free from ridges cracks or loose material. Finished surfaces of the road sub-base shall not vary at any point more than 10 mm above or below the grade established by the Engineer.
9 maintained in a condition satisfactory to receive any subsequent base or surfacing material.

Sub-base which does not conform to the above requirements shall be reshaped or re-worked, watered and thoroughly re-compacted to conform to the specified requirements.

B Granular road-base shall be constructed as follows:

1 it shall be spread on sub-grade or sub-base as shown on the Drawings and as approved by the Engineer. Layers shall not exceed 150 mm in compacted thickness. Material shall be handled in a manner which avoids segregation and any segregated materials shall be re-mixed until uniform. Suitable precautions shall be taken to prevent rutting of the sub-grade or sub-base during the spreading. No hauling or placement of material will be permitted when, in the judgment of the Engineer, the weather or road conditions are such that the hauling operations will cause cutting or rutting of the sub-grade or cause contamination of aggregate road-base material,
2 road-base which has been placed on a sub-grade or sub-base not approved by the Engineer shall be removed at the Contractor's expense,
3 moisture content of the aggregate road base material shall be adjusted prior to compaction, by watering with approved sprinkler trucks or by drying out, as directed by the Engineer, to that required to obtain the specified density for aggregate road-base,
4. it shall be compacted by means of approved compaction equipment progressing gradually from the outside of the road towards the centre with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until entire thickness of each layer is thoroughly and uniformly compacted to the specified density. Rolling shall be accompanied by sufficient blading in a manner approved by the Engineer, to ensure a smooth surface free from ruts or ridges and having the proper section and crown,
5. the surface of the material shall on completion of compaction be well closed, free from movement under the compaction plant and free from compaction planes, ridges, cracks, or loose material,
6 any areas inaccessible to normal compaction equipment shall be compacted by means of mechanical tampers until satisfactory compaction is obtained,
7 the Contractor shall program his operations to avoid the drying out of the sub-base during construction. If any layer of aggregate road-base material, or part thereof, is permitted to dry out after compaction, or does not conform to the required density or

finish, the Contractor shall, at his own expense, rework, water and recompact the material, as directed by the Engineer, to the density specified before the next layer of aggregate road-base or subsequent pavement layers are placed,

8 if directed by the Engineer, prior to the commencement of the aggregate road-base operations, the Contractor shall construct trial lengths not to exceed 250 metres. Materials used in the trials shall be those approved for use as aggregate road-base. Equipment used shall be that according to the Contractor's approved detailed program of work. Trial lengths may not form part of the permanent works but may be permitted in the construction of temporary detours of sufficient length. The Contractor may proceed with the aggregate road-base work only after the methods and procedures established in the compaction trials have been approved by the Engineer. The object of these trials is to determine:
   a adequacy of the Contractor's equipment,
   b loose depth measurements necessary to result in the specified compact layers depths,
   c field moisture content,
   d relationship between the number of compaction passes and the resulting density of the material.

9 immediately prior to the placing of the first layer of the next pavement course on to the aggregate road-base the final layer of aggregate road-base shall be at the specified density and to the required grade and section. In order to maintain these requirements while placing the next course it may be necessary to water and reshape the surface of the aggregate road-base. The work shall be at the Contractor's expense. The surface of the finished aggregate road-base will be tested with a 3 m straightedge by the Engineer at selected locations. Variations of the surface from the testing edge of the straight edge between any two contacts with the surface shall at no point exceed 12 mm when placed on or parallel or perpendicular to the centreline of the roadway. The cross section as shown on the Drawings shall not vary by more than 10 mm from the required elevation. All humps and depressions and thickness deficiencies exceeding the specified tolerance shall be corrected by removing the defective work or by adding new material as directed by the Engineer.

C Mix for bituminous paving courses shall be designed using Marshall tests and field trials with the following recommendations shall be taken into account:

1 for base course the Marshall shall be modified by substituting all aggregate sizes over 25 mm with an equal weight of sizes in the next lower grading size,

2 combined aggregate gradation should be adjusted within the allowable limits to achieve maximum stability whilst not going below the minimum requirement for void content,

3 minimum bitumen binder content according to the results of the Marshall Method of Mix Design should be used provided that it will still satisfy the durability, the stability and the void content requirements,

4 prior to final approval, the proposed job mix, but with a bituminous content at the upper percentage limits shall be compacted to refusal (400 to 600 blows). The resulting voids in the mix shall not be less than two percent for asphaltic concrete and three percent for DBM,

5 final job mix must display the Marshall characteristics as specified for asphaltic concrete and DBM,

6 fix formula must take into consideration the absorption of bitumen into the aggregates. For calculations for voids in the mix (VIM), the Rice Method as per ASTM D2041 and by using maximum theoretical specific gravity as prescribed by ASTM D2041 shall be used. For calculation of voids in the mineral aggregate (VMA) the equations

as mentioned in Asphalt Institute Manual MS-2 shall be used. Voids filled with bitumen (VFB) shall be calculated using the following equation:

$$VFB = \frac{(VMA - VIM)}{VMA} \times 100$$

7 at least thirty days prior to the date he intends to begin production of plant-mix "Bituminous Paving Course" Mixes, and after receiving approval of the aggregates and bitumen from the Engineer the Contractor shall make a written request for the approval of the job-mix formula from the Engineer. The formula will be prepared by the Contractor under the supervision of the Engineer in the laboratory. The laboratory job mix formula shall fix single definite values for:

a percentage of aggregate passing each required sieve size,
b percentage of bitumen binder to be added to the aggregate,
c temperature at which the mix is to be emptied from the mixer,
d temperature at which the mix is to be delivered to the works site.

8 laboratory job mix formula shall be used for the basis of approval of the job standard mixture.

9 trials areas having lengths of at least 30 m and to the specified layer thickness shall be laid outside the area of the permanent work by the Contractor for the Engineer's approval, before the start of the permanent work. At least two samples of non-compacted material from the trial area shall be taken in accordance with AASHTO T-168 and shall be analysed in the presence of the Engineer to determine:

a aggregate grading
b binder content
c stability
d flow
e Marshall density
f voids

results shall be submitted to the Engineer for approval before further mixing or laying is carried out.

10 should the laboratory job mix formula after passing the mixing plant and laid and compacted with approved plant, fail to produce a satisfactory trial area, the mix proportions may be modified by agreement with the Engineer, as necessary and within the requirements as applicable to produce a mix of satisfactory workability and acceptable surface finish. After approval of the trial area by the Engineer this mix shall be designated the 'Job Standard Mix' and shall thereafter be the approved mix.

11 all mixes produced shall conform to the Job Standard Mix approved by the Engineer, within the ranges of tolerance specified.

12 should a change in a material be encountered or should a change in a source of material be made, a new Job-Standard Mix shall be submitted by the Contractor and approved by the Engineer before the mix containing the new materials delivered. Job materials will be rejected if they are found not to have the characteristics required by the approved Job Standard Mix.

13 job mix tolerances shall be:

Aggregate retained on 4.75 mm sieve or larger	$\pm$ 5%
Aggregate passing 4.75 mm sieve and retained on 0.85 mm sieve	$\pm$ 4%
Aggregate passing 0.85 mm sieve and retained on 0.075 mm sieve	$\pm$ 2%
Aggregate passing 0.075 mm sieve	$\pm$ 1%
Bitumen Binder	$\pm$ 0.2%
Temperature of mixing and placing	$\pm$ 10° C

14 samples of bituminous paving course mixes shall be taken from the mixing plant and/or behind the paver prior to compaction, as decided by the Engineer, to check compliance with the approved job mix requirements.

15 density of the compacted mixes shall be related to the daily Marshall density which shall be determined by making four standard Marshall specimens from samples of the mix taken from the mixing plant or paver. The density of each sample shall be determined and compared with the mean value. Any individual result which varies from the mean by more than 0.015 g/cc shall be rejected. Marshall tests shall be repeated on a daily basis to establish the daily Marshal density for that particular day's production. Daily Marshall density shall not vary from the job mix design density by more than plus or minus one percent.

16 assistance of the Engineer in the preparation of the job standard mix in no way relieves the Contractor of the responsibility of producing a bituminous mix meeting the requirements of the Specifications.

D. Equipment for bituminous paving operations shall comply with the following:

1 method statement and equipment list shall be according to the type and number outlined in the Contractor's detailed programme of work, as approved by the Engineer,

2 trucks used for hauling bituminous mix shall have tight, clean, smooth metal beds which have been thinly coated with a minimal amount of paraffin oil, lime solution, or other approved material to prevent the mix from adhering to the beds,

3 when required by the Engineer, each vehicle shall be equipped with a canvas cover or other suitable material of such size as to protect the mix from the weather,

4 rolling equipment shall be self-propelled and wheels on the rollers shall be equipped with adjustable scrapers. Rollers shall have water tanks and sprinkling apparatus, which shall be used to keep the wheel wet and prevent the surface material from sticking. Rollers shall be of the steel-wheel and pneumatic tyre type; shall be in good condition; shall be capable of reversing without backlash and shall be operated at speeds slow enough to avoid displacement of the bituminous mix. The number and weight of rollers shall be sufficient to compact the mix to the required density while it is still in a workable condition. Use of equipment, which results in excessive crushing of the aggregate, will not be permitted. A minimum of three rollers, two steel-wheel and one pneumatic-tyre type, shall be used with each spreading operation for each lane.

5 the Contractor shall provide adequate back-up equipment for use in the event of mechanical failure, all to the satisfaction of the Engineer.

E Heating of the bitumen binder for mixing and compacting shall be in accordance with ASTM D1559.

F Preparation of Mineral Aggregate for Bituminous Mix

1. Coarse and fine aggregate shall be stored at the asphalt plant in such a manner that the separate stockpiles will not become intermixed. Stockpiles shall be of sufficient size to provide a minimum quantity of one week's continuous production of asphalt mix. Aggregates brought to the asphalt plant to supplement stocks should be tested and approved prior to placing in the existing approved stockpiles.
2. Cold bins shall be calibrated with the materials to be used and the settings shall be such as to produce a combined gradation in accordance with the job mix formula. Proportioning shall be such that surpluses and shortages in the hot bins will not cause breaks in the continuous operation. All the above shall be as approved by the Engineer.
3. Materials shall be thoroughly dried and heated so that their temperature is within 8°C of the temperature needed to satisfy the viscosity requirements of the asphalt cement. The moisture content of the heated and dried materials shall not exceed 0.5 percent.

The quantity of materials fed through the drier shall in all cases be held to an amount which can be thoroughly dried and heated within the limits specified.

4. Immediately after heating, the aggregates shall be screened into at least five sizes and conveyed into separate bins ready for batching and mixing with bituminous materials. When the aggregates supplied are of such size and grading that separating into five bins is impractical, the number of required separations may be reduced to four or to three with the approval of the Engineer.
5. Efficiency of the screening operations shall be sufficient to produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates which are reasonably uniform and result in the production of a mix complying with the limits specified for the aggregate gradation.

G. Preparation of Bituminous Mix

1. Dried aggregate as specified and prepared as prescribed above shall be combined in the plant conforming to ASTM D 995-88 in the approved proportions. Bitumen binder shall be introduced into the mix in the proportion specified by the job-mix formula.
2. Initial mixing time will be designated by the Engineer. Mixing time may be increased by the Engineer if additional time is necessary to obtain a homogeneous mix and satisfactory coating.
3. Batch plants, timing shall begin at the start of the introduction of the bitumen into the pugmill.
4. Length of mixing time for continuous plants will be determined by the following formula or other approved methods:

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead load capacity in Kg}}{\text{Pugmill output in Kg/second}}$$

5. Temperature of the aggregate immediately prior to mixing shall be within $\pm$ 8° C of the temperature of the bitumen binder. The temperature of the aggregate and asphalt prior to mixing shall be approximately that of the completed mix as defined in the job mix formula approved by the Engineer. Mix temperature shall be within the limits set out in the job mix formula when emptied from the mixer.

H. Surface preparation

1. When the Bituminous Mix is placed on a prepared road-base and whether or not a prime coat is designated on the Drawings, the Granular Road-base shall be even and firm and within the construction tolerances specified for the road-base to the satisfaction of the Engineer.
2. When the paving layer is constructed on an existing bituminous surface, the surface shall be cleaned of all foreign material and broomed free of dust. Any loose, broken or shattered bituminous material along the edges of the existing surface shall be removed. Exposed sub-grade and a sufficient width of the shoulder adjacent to the edge of the existing surface to receive the new bituminous mix shall be shaped, bladed, compacted and broomed and primed to provide a uniform firm sub-grade for the new surface course.
3. Existing bituminous surface, base, or sub-grade shall be removed if broken, shattered, or unstable. Areas shall be excavated to a depth as directed by the Engineer, and refilled with the bituminous mix according to the Specifications.
4. Prior to the placing of the mix, when designated on the Drawings or directed by the Engineer, a prime coat or tack coat shall be applied to the road-base or surface in accordance with the Specification for prime coat or tack coat.

I. Placing of the mix.

1 All bituminous mixes shall be introduced to the paver at a temperature not less than 135° C and not more than 163° C. Mixes outside this temperature range shall be discarded.

2 Bituminous mix shall be spread and finished to crown and grade by automatically controlled bituminous paver. Bituminous mix may be spread and finished by hand methods only where machine methods are impractical as determined by the Engineer. The paver shall lay the bituminous mix without tearing the surface and shall strike a finish that is smooth, true to cross section, uniform in density and texture, free from hollows, transverse corrugations and other irregularities. The paver shall be operated at a speed which will give the best results for the type of paver being used and which co-ordinates satisfactorily with the rate of delivery of the mix to the paver, to provide a uniform rate of placement without intermittent operations of the paver.

3 The mix shall be delivered to the paver in time to permit completion of spreading, finishing and compaction of the mix during daylight hours.

4 Longitudinal joints in successive layers shall be offset not less than 150 mm. Width of surface or top course placements shall conform to traffic lane edges as shown on the Drawings.

5 Leading half of half roadway paving shall not get ahead of the trailing half of the pavement by more than one average full-day of paving. In no case, shall the leading half be more than 0.5 km ahead of the trailing half without the written permission of the Engineer. If the Contractor fails to comply with this requirement, the Engineer may suspend paving on the leading half until such time, as the Contractor shall pave the trailing half to a point approximately even with the leading half.

6 Unless otherwise directed by the Engineer, where successive layers are to be placed, the surface of the existing layer shall be swept clean with a power broom, or by other means as approved by the Engineer, and a tack coat applied. Tack coat may not be required where delay between courses laying is less than 48 hours. The surface shall be fresh and clean at the discretion of the Engineer.

7 Asphaltic concrete mixes, except levelling courses shall be laid at an uncompacted thickness such that, after rolling the thickness of the compacted layer shall be:

	Minimum	**Maximum**
Base Course	60 mm	100 mm
Wearing Course	30 mm	60 mm

8 DBM thickness shall be as specified in Tables 9 & 10.

9 Maximum thickness for layers may be increased slightly when much increase is more adaptable to total pavement thickness and when in the opinion of the Engineer it is not detrimental to placement and rolling conditions.

10 The Contractor shall erect and maintain an approved reference string line and operate the paver to conform to the reference string line for the initial layer and/or any other layers as directed. Elevation control point stakes for the first layer of bituminous paving course shall be set at a maximum spacing of 20 m. For subsequent layers, control points shall be set at 10 m maximum spacing.

J. Compaction of Bituminous Layers

1. After spreading and strike off, and as soon as the mix conditions permit the rolling to be performed without excessive shoving or tearing. Mixture shall be thoroughly and uniformly compacted.
2. Rolling will not be prolonged to an extent that cracks appear.
3. Initial or breakdown rolling shall be done by means of either a tandem power steel roller or three-wheel roller followed by a pneumatic-type roller or as agreed by the

Engineer. Rolling shall begin as soon as the mix will bear the roller without undue displacement. Rolling shall be longitudinal, beginning at the low side of the spread of material and proceeding toward the high side, overlapping on successive passes by at least one half the width of the near wheels. Alternate passes of the roller shall be of slightly different lengths.

4. Motion of the roller shall at all times be slow enough to avoid displacement of the mix. To prevent adhesion of the mix to the rollers, the wheels of the rollers shall be kept properly moistened with water, but an excess of water will not be permitted. Under no circumstances shall the use of diesel fuel or any other asphalt stripping agent be used for preventing adhesion of the asphalt to the roller wheels.
5. Final compaction and finish rolling shall be done by means of a tandem power steel roller, unless otherwise directed. When the specified density is not obtained, changes in the size and/or number of rollers shall be made as corrective measures, to satisfy the density requirements.
6. Rollers shall be operated by competent and experienced roller men and shall be kept in operation continuously if necessary, so that all parts of the pavement will receive substantially equal compaction at the time desired. The Engineer will order the mixing plant to cease operation at any time proper rolling is not being performed.
7 Any mix that becomes loose, broken, mixed with foreign material, or which is in any way defective in finish or density, or which does not comply in other respects with the requirements of the Specification shall be removed. Replace with new materials, and finish in accordance with the Specifications.
8 Road density requirements:
   a base course - 97% of average Marshall density
   b wearing course - 98% of average Marshall density
   c densities in excess of 101.8% shall not be permitted.
9 Prior to the commencement of the bituminous paving operations, the Contractor shall construct trial lengths, of at least 30m. Materials used in the trials shall be those approved for use in the bituminous paving courses. Equipment used shall be that according to the Contractor's approved detailed Method Statement and equipment list and the programme of work. The Contractor may proceed with the bituminous paving operations only after the method and procedures established by the compaction trials have been approved by the Engineer. The object of these trials is to determine:
   a adequacy of the Contractor's equipment.
   b loose depth measurements necessary to result in the specified compacted layer depths.
   c field moisture content.
   d relationship between the number of compaction passes and the resulting density of the material.
10 Compaction sampling and testing of bituminous courses
   a Density of the mix as placed and compacted on the road shall be determined from cores cut from the compacted courses on the road at locations specified by the Engineer.
   b Samples shall be obtained in accordance with ASTM D979 in sets of two from the same location on the road.
   c Frequency of testing shall be one set of samples per traffic lane per 300 m per layer or minimum of one set per day for shorter lengths.
   d Additional tests to determine limits of area deficient in density, or for recheck.
   e Density of these samples will be referred to as "Road Density".
   f Contractor shall cut the samples with an approved core drill in the presence of the Engineer.
   g Equipment shall be capable of cutting the material without shattering the edges of the specimen.

h Diameter of samples shall be 150 mm for base courses and 100 mm for wearing courses

i All test holes shall be filled and made good with approved material by the Contractor at his expense.

K. Re-rolling of bituminous courses

Should any bituminous course fail to achieve the specified density, at the discretion of the Engineer re-rolling may be allowed subject to the following conditions:

1 densification to be achieved shall be one percent or less,
2 only PTR's to be used weighing no greater than 18 tons,
3 re-rolling to take place within 72 hours from the time of the initial rolling of the asphalt,
4 re-rolling to take place at the time of the day when the asphalt has attained its maximum natural temperature,
5 re-rolling to be applied for a maximum of two hours,
6 re-rolling to be carried out in the presence of the Engineer's representative,
7 section of the works in question shall be cored for density determination immediately after the completion of re-rolling,
8 if after re-testing, the density achieved is 0.5 percent below the specified density, the asphaltic material will be accepted in the works subject to a 20 percent reduction to the billed rates. If, the density is greater than 0.5 percent below the specified density, the asphaltic material shall be removed and new material to the specification laid at the Contractor's cost.

L Contact surfaces between the bituminous paving and of kerbing, gutters, manholes, and other appurtenances shall be painted with a thin uniform coating of tack coat as approved by the Engineer prior to paving.

M. Joints in bituminous paving

1 Joints between old and new pavement or between successive day's work shall be made, to ensure thorough and continuous bonding between the two.
2 All construction joints in previously laid material shall be constructed by cutting the material back vertically for its full depth to expose a fresh surface.
3 Before placing the fresh mix against a cut joint or against old pavement, the contact surface shall be sprayed or painted with a thin uniform coat of tack coat.
4 Where a finishing machine is used the longitudinal joint shall be made be overlapping the screed on the previously laid material for a width of at least 30 mm and depositing a sufficient amount of mix so that the joint formed will be smooth and tight.

N Protection of compacted layer

1 Contractor shall protect all sections of newly compacted pavement from traffic until they have hardened sufficiently to the approval of the Engineer.
2 On heavily trafficked roads a minimum period of 7 days must elapse before the newly compacted pavement is trafficked.

O. Surface tolerance for bituminous courses

.

1 At final compaction the finished surfaces of the individual layers shall fall within the following maximum tolerances, measured with a 3 m straight edge laid in any direction.

Base course	6 mm
Wearing course	4 mm

2 Rideability of the finished wearing course shall be checked with a portable laser road surface testing machine. The riding surface shall have an IRI (International Roughness Index) of less than 0.9 m/km.

3 All humps and depressions exceeding the specified tolerance shall be corrected by removing the defective work and shall be replaced with new material as directed by the Engineer at the Contractor's cost.

P Core samples

1 Depth of each bituminous paving course shall be measured by cored samples.

2 Contractor shall furnish and operate an approved core drill for cutting samples from the compacted mix on the road.

3 Equipment shall be capable of cutting the mix without shattering the edges of the specimen or otherwise disturbing the density of the specimen.

4 Cored sample diameters shall be 150mm for base course and 100mm for wearing course.

5 Cores extracted for thickness measurement may be used for density determination. Density samples may be used for thickness measurements.

Q Thickness of the bituminous paving courses shall be as shown on the drawings.

R Weather Limitations for Paving Operations

1 Hot bituminous mix shall be placed when:
   a Air temperature is 8°C or above.
   b Weather is not dusty, foggy or rainy.
   c Existing surface is free from moisture.

2 No paving operations shall be started if rain is imminent.

S Minimum test requirements for bituminous courses

1 Bitumen material: One sample shall be tested for penetration and Ring ball test for every 80 Mg or part thereof.

2 Aggregate:
   a One sample for each stockpile every 2,000 m^3 of part thereof.
   b Perform all the required tests.

3 Bituminous mix:
   a One sample of mix shall be obtained from at least every 300 Mg or part thereof.
   b

Tests	**Method**
Bitumen content	ASTM D2172
Grading	ASTM C117 & C136
Density	ASTM D1188/D2726
Stability	ASTM D1559

   c Loss of Marshall stability shall be tested for at least every 7,000 Mg.

T Prime coat shall be applied at a rate of not less than 0.7 l/m^2 and not more than 1.5 l/m^2. The exact rate of application, which may be varied to suit field conditions, will be determined by the Engineer following trials to be carried out by the Contractor. Surface to be prime coated shall be uniformly smooth and firm and true to the grades and cross sections shown on the Drawings within specified tolerances. Prime coat shall not be placed on a soft, uneven base. Any holes, depressions or irregularities shall be repaired by the removal of loose and unsuitable material. Replace with suitable material compacted to produce a dense, even surface of uniform texture. When required, the surface to be primed shall be lightly bladed and compacted. The Engineer may instruct a light application of water to facilitate penetration. Priming will not be permitted when the surface is wet. Prime coat shall not be applied when the ambient temperature is less than 13° C or during rain, fog, dust storms or other unsuitable weather. Application temperature for MC-70 liquid asphalt shall be between 50°C and 80°C as approved by the Engineer. It shall be applied to one lane of the carriageway width at a time. When applied in two or more lanes there shall be a slight overlap along adjoining edges. Overlapping will not be permitted at transverse joints. Thick paper shall be used to protect the previous application. Traffic shall be kept off the prime coat until it has penetrated the sub-grade or road-base and fully cured and it shall be left undistributed for a period of 48 hours or as otherwise directed by the Engineer. The Contractor shall furnish and spread at his cost sufficient clean fine sand, of an approved quality, to blot up areas which show an excess of prime coat. Primed surface shall be maintained in a good, clean condition at all times until the next course is placed. Any surface irregularities or holes in the primed surface, however caused, shall be repaired and corrected to the Engineer's satisfaction.

U The tack coat shall be applied in quantities of not less than 0.3 l/m^2 and not more than 0.6 l/m^2. Immediately before applying the tack coat, all loose material, dirt, clay or other objectionable material, shall be removed from the surface with a power broom or blower supplemented with hand brooms, as directed by the Engineer. After the cleaning operation, and prior to the application of the tack coat, an inspection of the area to be coated will be made by the Engineer. Application temperature for the tack shall be between 10° C and 60° C as directed by the Engineer. Tack coat shall not be applied when the ambient temperature is less than 13° C or during rain, fog or other unsuitable weather. After application, the surface shall be allowed to dry to the proper condition of tackiness to receive the following pavement course. The tack coat shall be applied only so far in advance to pavement courses to obtain the proper condition of tackiness. The Contractor shall protect the tack coat from damage during this period. If the completed tack coat is damaged by rain or dust, it shall be allowed to dry, cleaned by power broom or blower. If required by the Engineer, an additional light application of tack coat shall be applied. No additional payment shall be made for this work. Where, in the opinion of the Engineer, a tack coat is not necessary, the Contractor shall clear, at his expense the existing surface free of dust and other deleterious material.

V A self-powered pressure distributor should be used for applying asphalt mixture. The distributor shall have pneumatic tyres of such width and number that the load produced on the base surface shall not exceed 110 kg/cm of tyre width and shall be so designed and equipped as to distribute the bituminous material uniformly at even heat on variable width of surface at readily determined and controlled rates from 0.2 to 7.5 l/m^2 with a pressure range of 1.25 kg/m^2 to 5.2 kg/m^2. The allowable variation from any specified rate shall not exceed 5 percent. Distributors and booster tanks shall be so maintained at all times that no dripping of bituminous material will occur from any part of the equipment. Distribution equipment shall include:

1 independently operated bitumen pump,
2 tachometer pressure gauges,

3 volume measuring devices,
4 thermometer for reading the temperature of tank contents,
5 hose attachment for applying bituminous material to spots unavoidably missed by the distributor.

Distributor shall be equipped for circulation and agitation of the bituminous material during the heating process. Equipment for heating shall consist of steam coils and equipment for producing steam, so designed that steam will not be introduced into the material. In the event of storage tanks being used, an armoured thermometer with a range from 10° C to 150° C shall be fixed to the tank so that the temperature of the bituminous material may be determined at all times. Other heating facilities may be used subject to the approval of the Engineer.

W When bituminous materials are being applied, the surface of all structures, wheel guards, guard rail, kerbs and gutters, and other roadway appurtenances shall be protected in an approved manner to prevent them from being splattered with bituminous material or marred by equipment operation. In the event that any appurtenances become splattered or marred, the Contractor shall at his own expense, remove all traces of bituminous materials using approved solvents. Repair all damage, and leave the appurtenances in an approved condition.

3.09 Application of Traffic Markings

A The Contractor shall layout the work in accordance with the Drawings furnished or as directed by the Engineer. The layout shall include all necessary painting operations to place and/or replace the pavement marking in accordance with the Drawings or instructions of the Engineer.

B Longitudinal lines shall be reasonably straight and shall not deviate more than 50 mm in 100 metres. STOP, crosswalk. arrows and parking space lines shall not deviate from the plans more than 2 percent. Pavement markings outside the above tolerances shall be removed or painted out and reinstated at the expense of the Contractor.

C Application shall be by mobile sprayer, either hand propelled or self-propelled.

D Road surface shall be dry, and free of loose, detritus, mud, or other extraneous matter. Where old paint or thermoplastic material are present, the manufacturer shall be consulted as to whether or not the surface is suitable.

E A tack coat shall not be necessary when the thermoplastic is applied to carriageways. Where it is considered necessary to use a tack coat, this shall be rubberized type recommend by the manufacturers of the thermoplastic material.

F In addition to the Balloting included in the mix, an additional quantity of glass beads shall be sprayed on to the hot thermoplastic line at the time of application at a rate of application of about 0.5 kg/m^2.

G Thermoplastic material shall be applied in intermittent or continuous lines of thickness 1.2 $\pm$ 0.3 mm. For special lettering, arrows or symbols the material shall be applied by hand methods. Finished lines shall be free from raggedness at all edges and be true in place with the road surface. Upper surface shall be level, uniform and free from streaks, blisters, lumps and other defects. Application of thermoplastic material to new pavement construction shall be preceded by wire brushing to remove bitumen rich surface mortar. Sufficient compatible mineral oil plasticisers should be incorporated in the thermoplastic

material to reduce levels of early shrinkage in the material and subsequent cracking of the asphaltic pavement structure.

H Pavement marking shall be protected from marring by traffic as directed by the Engineer with rubber or plastic traffic cones. Traffic cones shall be placed on the line at the time the paint is applied and shall remain until the paint has dried, or in accordance with the directions of the Engineer. Traffic cones shall be collected by a follow-up vehicle and crew. During painting operation, one large working sign with the marking "TRAFFIC STRIPPING" shall be placed as the beginning of each operation. The Engineer may direct that other safety signs be placed at various locations to guide or warn traffic regarding the operation.

I The Engineer may direct that the strips be broken into segments, with unpainted gaps between. Broken lines shall be 150 mm wide and have painted segment length of 2 m, with 5 m gaps.

J The Engineer may specify transverse lines 200 mm or 300 mm wide for stop lines, crosswalk lines or parking staff lines. These lines must receive special attention in both application and protection from marring by traffic.

K Painted traffic arrows or symbols may be specified by the Engineer at designated locations. Details of these arrows or symbols are shown on the drawings. Total area for the painted arrow or symbol will not exceed 3 m^2.

L Painting of kerb stones shall be with alternating bands of black and reflectorized yellow paints. The length or each band and the portion of kerb to be painted are shown on the Drawings or as instructed by the Engineer.

3.10 Application of Road Marking Paint

A Paint shall be applied at a covering rate recommended by the manufacturer and approved by the Engineer.

B Where markings are to be reflectorized with ballotini it shall be sprayed uniformly on to the wet paint film at the rate of 400 to 500 g/m^2. Ballotini shall comply with the requirements of BS 3262: Clause 15.

C Marking materials shall only be applied to surfaces which are clean and dry. Markings shall be free from raggedness at their edges and shall be uniform and free from streaks. Carriageway lane and edge lines shall be laid by approved mechanical means to a regular alignment.

END OF SECTION 02520

Section 02700

Pipework

Part 1 General

1.01 Description

A The work included in this section comprises furnishing all plant, labour, equipment, pipe, fittings, adaptors, valves, appliances, appurtenances and materials and performing all operations in connection with the installation of pipework in accordance with these Specifications and Drawings.

1.02 Section Includes

A The manufacture, factory testing and supply of pipes and appurtenances of different materials for underground and internal pipework for water mains, sewer systems, pressure mains and stormwater drainage.

B Laying, jointing, testing, repairing and retesting where necessary, disinfection as necessary, and commissioning of pipework. The Contractor shall provide all labour, materials and equipment necessary for providing the pipes, fittings and jointing materials, transporting to sites, excavation, backfilling and compaction, laying, installing, jointing and testing, disposal of excess excavated materials, and removal of surplus pipes, fittings and jointing materials. The responsibility for the safety and soundness of all material shall rest with the Contractor. The Contractor shall carry out any tests, at his cost, needed to satisfy himself regarding the soundness of the pipes, fittings and jointing materials prior to acceptance testing by the Engineer.

1.03 Submittals

A Product data, samples and shop drawings shall be submitted to the Engineer in accordance with Section 01300 hereof, which shall be as follows:

1 manufacturer's printed brochures and catalogues with relevant information highlighted (or irrelevant information struck out), along with write up of selection criteria;

2 shop drawings including:

a general piping layout drawings to a scale not smaller than 1:500;

b detailed piping layout plans to a scale of 1:200 along with profiles;

c builders work plans to a scale of 1:100 / 1:50 as appropriate;

3 Shop drawings shall be a single set for each facility showing:

a each piping system,

b piping material, class, grade and joint type,

c anchors and supports, including hangers, saddles, straps, and other accessories,

d fittings, couplings, joints, and joint harnesses,

e centreline elevations,

f location, size, and type of anchor bolts,

g structure penetrations, including sleeves, sealant and other accessories,

h orientation of valves,

i critical clearances,

j insulation,

k pipe coatings,

l valve and control tag numbers,

m miscellaneous details required for complete installation.

4 installation details of:
   a manholes, chambers, valve chambers, interceptors, sleeves and penetrations etc. to a scale of 1:50, as required;
   b manhole covers, drains, and items of similar nature to a scale of 1:10, as required;
5 calculations / details to substantiate the shop drawings;
6 shop drawings for valves and fittings;
7 designs, including calculations; for piling, shoring of trenches, dewatering systems, cofferdams and similar auxiliary items required for the construction of piping and associated concrete works; where required;
8 samples of each type valve and/or manhole covers and step iron, frames, drains etc., for approval and carrying out the required tests;
9 samples of gaskets, insulation and sealant systems.

B The following detailed written procedures shall be provided to supplement the shop drawings:
1 Installation:
   a the preparation and making of each type of joint and coupling,
   b measures to ensure integrity of interior pipe lining and exterior protective coating at joints and couplings,
   c the installation and adjustment of pipe hangers and other supports,
   d the procedures to be used in setting, supporting, and anchoring valves,
   e the fitting of line pipe to valves for proper coupling.
2 Testing details shall include:
   a procedures for adjusting and testing valve assemblies,
   b a detailed procedure for the testing of systems including, as a minimum:
      i equipment to be used, including calibration information, range, and sensitivity,
      ii qualifications of the person performing the testing,
      iii details of bulkheads, flanges, caps and the like to isolate systems for testing,
      iv procedures to be followed,
      v a schedule of times when tests will be performed, including durations,
      vi procedures for obtaining and disposing of fluid used in testing.

C. Quality Control Submittals
1 certified copies of reports of required tests, including:
   a pipe pressure tests.
   b valve tests.
   c dielectric joint tests.
2 certificates:
   a approval certifications of welders qualifications certified by an approved testing agency including a statement that the welder is experienced and skilled in the materials and methods to be used.
   b qualifications shall be according to ASME Boiler Code, Section IX.
   c qualification shall have been within six months of employment on the Work.
   d after approval, the Engineer will return the certificates which will be retained by the Contractor at the Site.
   e welds by non-certified individuals will be rejected.
3 pipe support drawings signed and stamped by an engineer.

D. Operation and Maintenance Manuals
1 installation data shall include certified equipment drawings with bolt hole patterns and bolt sizing, access door swings and maintenance clearances.
2 operation data shall include starting requirements, cautions, and testing.

3 maintenance data shall include lubricating schedule, approved lubricants, maintenance and replacement schedules and supplier locations with phone and facsimile numbers.

1.04 Marking

Each length of pipe, fitting and each coupling shall be legibly and permanently marked with the following:

1 Name of Employer;
2 manufacturing standard;
3 serial number;
4 pressure rating in bars;
5 nominal diameter in mm;
6 name or trade mark of manufacturer;
7 date of manufacture;
8 inspection mark;
9 material (indicated i.e. "DI")
10 angle of bends in degrees;
11 socket penetration lines on spigot ends;
12 circular concrete pipes with elliptical reinforcement shall have the letter "T" clearly marked on the inside and outside to indicate the crown of the pipe when laid.

1.05 Infiltration

The Contractor's attention is brought to the stringent requirement for infiltration specified in paragraph 3.04C of this Section for non-pressure pipelines. The Contractor shall be responsible for providing a jointing system that enables the installation and use of the pipeline systems required by the Contract.

1.06 Service Conditions

A All water pipeline materials, fittings, valves and components shall be suitable for carrying potable water at temperatures up to $50^{O}C$ and suitable for storage, installation, use and operation in climatic and soil conditions encountered at the Site.

B All other pipes and fittings shall be suitable for carrying sewage at temperatures of up to $40^{O}C$ with sulphide concentrations up to 65 mg/l and all pipes shall be suitable for immersion in corrosive ground water.

1.07 Basis of Acceptance

Acceptability of the pipes and fittings will be based on the results of tests carried out by an approved independent laboratory at the Contractor's expense and the result of any independent testing carried out by the Employer or his agent. The frequency and type of test required for each pipe material are given in the following sections and certified copies of all records of inspections and test results shall be submitted to the Engineer. All pipeline materials and components, including the protective coatings and jointing materials that will come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth, shall not cause taste or odour, cloudiness or discoloration of the water and shall be approved as being suitable for use in water supply schemes. Material that fails to comply with these specifications will be rejected and the Contractor shall remove such materials from the Site at his expense.

1.08 Utilities

A "Utilities" mean services ranging from the water, gas and fuel networks and their respective individual metered connections, electrical and telephone networks, poles, pylons, lighting columns and traffic signals, storm water drainage and sewerage networks as well as roads and other public or private services. The Contractor shall notify all authorities whose services might be affected by the Works regarding his programme. The Contractor shall refer to, and comply with, the current regulations and specifications of the authorities before commencing any works adjacent to other utilities. This requirement will not relieve the Contractor of responsibility for taking every precaution to avoid damage to these utilities and he shall be held responsible for the cost of repair of all damage and other liability claims in accordance with the Conditions of Contract and the Specifications.

1.09 Quality Assurance

A All pipe, fittings, valves, appurtenances and accessories furnished shall be new and from a current manufacturer. A certificate from the manufacturer stating the materials furnished are new and of a recent manufacture shall be furnished to the Engineer. The Contractor shall also provided the Employer with an affidavit (four copies) from the manufacturer stating that the pipe, fittings, valves, appurtenances and accessories comply with the provisions of these specifications. Certificates that the items comply with the relevant ISO 9000 series for manufacturing processes are also required from the manufacturer.

B The Contractor shall also submit evidence that the manufacturer has a long and successful record of operation together with a representative list of overseas consignments where his pipe (of similar diameter) has been placed in operation.

1.10 Packing

A All pipes and fittings, valves and specials and all other products shall be packed in such a manner as to prevent damage in ordinary handling and transportation. Each box, bundle or crate shall be legibly marked identifying the contents, and giving the name and address of manufacturer, name of the project, name of employer, and date of dispatch.

B Bolts of the same length and size (and their accompanying nuts and washers) shall be packed together in boxes not exceeding 100 kg gross weight. Joint rings, lubricants, sleeving, paints and gaskets shall be packed in boxes and separate packages shall be provided for each size and description of ring or gasket. Each box and package therein shall be clearly labelled stating the manufacturer's name, date of manufacturer, number, size and description of the contents.

1.11 Transporting and Handling

A The Contractor shall provide protection, to the approval of the Engineer, for the ends of all pipes and fittings prior to the pipes and fittings leaving the place of manufacturer in order to guard effectively against damage during transit and storage and the ingress of foreign matter inside the pipes and fittings.

B In handling pipes and fittings every care shall be taken to avoid distortion, flattening, denting, scouring or other damage. Pipes and fittings shall not be allowed to drop or strike objects and shall be lifted or lowered from one level to another by means of approval equipment only.

C When required, pipe and fittings to be lifted by means of a mechanical forklift, or similar equipment, belt slings shall be applied at the correct lifting points along the length of the pipe section, with tackle suitably padded to prevent damage to the coating or lining.

D Pipes and fittings that are damaged during transportation, handling or stockpiling shall be satisfactorily repaired. If the damage to any pipe or fitting is serious or beyond the capability of repair in the field as determined by the Engineer, the Contractor shall replace it with new pipe or fitting.

1.12 Storage and Security

A All pipes, fittings, valves and appurtenances shall be stored at sites in or around project area approved by the Engineer in accordance with the manufacturer's recommendations until they are incorporated in pipe laying work. The Contractor shall be responsible for providing security including fencing, watching and lighting for the materials at his own cost.

B Pipe shall be stockpiled on timber cradles on level ground, in such a manner as will prevent damage to any part of the pipe. During stacking and removal operations, safe access to the top of the stack is essential. Stacking types and the maximum stacking height shall be in accordance with manufacturers' recommendation or comply to BS 8010 Section 2.

C Products shall be delivered to the Site, stored, and protected under provisions of Section 01600 hereof. Pipes and fittings shall be unloaded near the place of installation. Pipes shall be distributed to their point of installation only in such quantities as can be installed in one working day or as allowed by the Engineer.

D Vitrified clay pipes and fittings shall be transported in pallets and handled with suitable power driven equipment only.

E Jointing materials and operational gear shall be stored under cover. Pipes may be stored in the open, but shall be placed on adequate timber supports to prevent damage. Pipes shall be stored on elevated racks to prevent damage to the seals and shall be protected in a proper manner to prevent deterioration. Plastics and rubber products shall be stored out of direct sunlight. If any pipes or fittings show signs of corrosion or deterioration during storage, they shall immediately be treated by the Contractor to arrest deterioration, or to be removed from the Site as the Engineer directs, all at no extra charge to the Employer.

F The Contractor shall submit to the Engineer, and obtain approval before starting the works, (i) the manual for handling, storage, installation, maintenance and repair, (ii) test report on materials to be used for manufacture and (iii) shop drawings giving complete dimensions of all pipes and fittings.

1.13 Material Reconciliation Schedule

A Upon completion of the work, the Contractor shall submit to the Engineer a materials reconciliation schedule in respect of the materials supplied. The schedule shall give the following detailed for each item:

1 quantity ordered;
2 quantity delivered;
3 where used;
4 quantity surplus and in good condition;
5 quantity surplus but partially complete cut or damaged and in repairable condition;
6 quantity surplus but damaged beyond repair;

7 quantity missing or lost.

B The Contractor shall collect and transport the surplus materials in (4) and (5) to a central location near the job site for inspection by the Engineer's Representative. Materials in group (4) shall be stacked separately. All material shall be in a reasonably clean state and each piece shall be marked with its items number for easy identification.

C The Employer, may accept some or all of the surplus materials for maintenance purposes. The Contractor shall load the materials to be taken into stock and transport and off-load them at the Employer's storage yards within 10 km of the job site. The Contractor will be paid for all surplus materials in good condition taken into stock.

Part 2 Products

2.01 Ductile Iron Pipes and Fittings

A Pipes shall be as follows:
1 spigot and socket pipes shall be used, unless otherwise shown, for buried pipe and shall conform to ISO 2531 with thickness class of K9. The working pressure shall be 16 bar;
2 flanged pipes shall be used, unless otherwise shown, for exposed pipe and shall conform to ISO 2531 with thickness class of K12;
3 the Contractor shall supply additional materials for maintenance to the Employer as specified herein.

B Fitting Compatibility
1 The Contractor shall supply the fittings manufactured by the same manufacturer of pipes, using the same kind of material and compatible standards. The Contractor shall also ensure the dimension compatibility of pipes, fittings and couplings to valve flanges.

C Joint types shall be as shown on the drawings and meet the following requirements.
1 Flexible Joint (Push-In Joints)
(a) Except where flanged joints are required, standard pipes and fittings for pipelines of ductile iron shall be supplied with push-in socket and spigot joints similar to joint type A.1 illustrated in BS 8010: Part 2: Section 2. The material of the joint rings use shall be in accordance with the requirement of BS 2494 type W.
(b) Where pipes and fittings are not available with this type of joint, they shall be supplied with mechanical type flexible joints of the bolted gland type. Glands, bolts, and nuts for mechanical joint shall be of ductile iron having the same mechanical properties as the fittings.
2 Flange Joint
(a) PN 16 pressure rated flanges shall be flat faced and shall conform to the requirements of BS 4504 Part 1 (or to ISO 2531 or BS EN 1092 which are compatible with BS 4504 Part 1 for the same nominal diameters)
(b) The flanges of all fittings including Tees shall be integrally cast with the fitting. The flanges of flanged pipes may be screwed, welded or integrally cast with the pipe unless otherwise stated.
(c) "Welded" means the flanges should be welded to the pipes at the point of manufacture under factory conditions.
(d) All nuts, bolts and washers to be supplied with flanged joints shall be of galvanized mild steel to the approval of the Engineer. Flanged joints shall be complete with all nuts, bolts, gaskets and two washers per bolt. Protection of all buried bolts, nuts,

washers etc. and the joint as a whole shall be covered with Denso paste and primer, Denso mastic, Denso tape or equivalent and PVC or polyethylene outer wrapping.

(e) Gaskets for flanges shall be inside bolt circle type, with dimensions complying with BS 3063, and be manufactured from material complying with BS EN 1514, BS 2494: Type W listed in the Directory of the Water Research Centre, UK or equivalent.

(f) The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, specially where connections are required to pipe work and valves associated with pumping plant and inlet/outlet pipe work at service reservoirs or other structures. Isolation valves shall match pipe flanges.

3 Restrained Self Anchoring Joints

The design of restrained joints shall comply with ISO 10804-1 or equivalent.

4 Flexible Coupling and Flange Adapter

(a) Bolted sleeve type couplings, stepped couplings and flange adapters may be used for connecting plain ended steel, ductile iron, grey iron, uPVC and other rigid or semi-rigid pipe materials, subject to approval of each type by the Engineer. Couplings, etc. shall be designed and manufactured in accordance with AWWA C219 "Bolted, Sleeve-type Couplings for Plain-end Pipe" except that elastomeric gaskets shall comply with BS 2494 Type W and or BS EN 681-1.

(b) Couplings included in this section will effect a connection between two pipes of either the same pipe materials, or of two different pipe materials, at the same nominal bore. Couplings and flange adapters shall be manufactured from one of the following materials:

Carbon Steel	:	BS EN 10025 Grade Fe 430A, or JIS G3101 SS400, or ASTM A283 grade C
Malleable Cast Iron	:	BSEN 1562: Grade B35-12, or JIS G5702 FCMB340 or 360, or ASTM A47 grade 32510 or 35018
Ductile Iron	:	BS 2789 Grade 420/12, or JIS G5502 FCD400, or ASTM A536 65-45-12

(c) Gaskets shall be of elastomeric conforming with the requirements of BS 2494 Type W. Gasket shall have a hardness rating of 80IRHD to prevent gasket extrusion at the bottom tolerance of the fitting. All gaskets shall have identification to detail size range, mould number compound and year and quarter of manufacture.

(d) Nuts, bolts and tee bolts fasteners shall be manufactured from alloy or carbon steel conforming to BS 970 Part 1 grade 070 M20 or JIS G4051 S20C.

(e) Bolts shall be restrained against rotation by means of "D" shaped necks which will locate in similar "D" shaped holes in the end rings to facilitate single spanner operation. Washers shall be provided to prevent damage to the coating of the fittings.

(f) Centre sleeves, end rings and flange adapters bodies shall be coated with Rilsan Nylon 11 coating, to a uniform minimum thickness of 250-300 microns, having been shot blasted and suitably primed prior to application of coating, maintaining the minimum thickness throughout the fitting. Holding points shall be touched in with the appropriate Rilsan repair coating.

(g) Fasteners shall be electroplated to BS 1706 grade Zn10 or equivalent followed by a suitable primer and then with a coating of Rilsan Nylon 11 to a uniform thickness of 60-120 microns.

(h) Flange adapters for jointing flanged specials to plain-ended pipes shall conform to the foregoing contents of this clause. Prior to the commencement of the manufacture the Contractor shall submit to the Engineer for approval detailed drawings of all couplings and flange adapters.

(i) When harness is specified with coupling or flange adapter, the harnessing shall be provided as recommended by the manufacturer of couplings or flange adapters.

Harness joints shall be designed and manufactured to withstand for the pull-out force caused by the internal pressure of 16 bar at the joint.

D Length of straight pipes shall conform to the requirements in ISO, BS, JIS or AWWA to be applied. It shall be the sole responsibility of the Contractor to examine the difficulties he is likely to face in transporting, storing, handling and installing long lengths of pipe. In ordering pipe, the Contractor shall consider the possibility of negotiating (pulling) the horizontal and vertical bends. The Contractor shall purchase a sufficient number of straight pipes for his operations, having applicable external diameter to the joints for full length of barrel and be suitable for usage by cutting at sites. Such pipes shall be clearly marked.

E Coating and Lining

1 External Coating

Pipes and fittings shall have a factory applied external coating of metallic zinc and bitumen paint conforming to BS EN 545 or ISO 8179, which shall not contain any constituent soluble in water or any ingredient liable to leach in water after drying. The coating shall have good adherence to the pipe and fittings and not scale off. Thickness of the bitumen coating shall not be less than 70 microns and the zinc coating shall have a minimum mass of 200 g/m^2 of pipe surfaces area and a minimum thickness of 30 microns.

2 Internal Lining

Internal surface protection shall be either:

Cement mortar lining, or
Fusion-bonded epoxy coating

(a) Cement Mortar Lining

Pipes and fittings shall be internally lined with cement mortar using ordinary Portland cement conforming to BS 12 or Sulphate resisting cement confirming to BS 4027. The thickness of lining shall be as follows:

Pipe Nominal Diameter (mm)	Thickness of Lining (mm)	
	Nominal	Minimum
80 to 250	4	3
300 to 600	6	5
700 to 900	8	6
1000 to 1200	10	7

Inside of socket shall be free of cement mortar lining and shall be coated with the material used for external coating. Internal lining shall be done in accordance with BS EN 545, ISO 4179, JIS 5314, AWWA C104, or equivalent.

(b) Fusion-bonded Epoxy Coating

Fusion-bonded epoxy coating for ductile iron pipe and fittings shall conform to JIS G5528, AWWA C213 or equivalent. Material shall consist of a one-component powdered fusion-bonded material composing of epoxy resin, hardener, and fillers. Composition of epoxy resin hardener shall not be less than 55 percent in weight. The standard film thickness shall not be less than 300 microns except for the socket portion where the minimum film thickness shall be 100 microns. The physical properties of coating shall satisfy requirements of JIS 5528, ANSI/AWWA C213 or equivalent. ANSI/AWWA requirements are shown below:

	Item	Requirement	Test Method
i	Impact	Min.1.1 kg-m	AWWA C213
ii	Bendability	Pass	AWWA C213
iii	Appearance	Pass	AWWA C213
iv	Shear adhesion	Min. 210 kgf/sq.cm	ASTM D1002
v	Penetration	Less than 10%	ASTM G 17

vi	Abrasion resistance (5000 cycles-gm loos)	Max. 0.3	ASTM D1044
vii	Cathodic disbondment area	Max. 9.7 sq.cm	ASTM G8
viii	Hot water resistance	Pass	AWWA C213
ix	Water extractable	Max. 0.078 mg/sq.cm	AWWA C213
x	Taste and odour	Pass	AWWA C213

Should the coating fail to satisfy the requirements of the tests or the coating be damaged, the defective or damaged area shall be repaired by using a two-component liquid type epoxy paint.

Pipe components, including the linings and joint materials that will be or may be in contact with potable water shall not constitute a toxic hazard, shall not support microbial growth, shall not cause taste or odour, cloudiness or discoloration of the water and shall be approved by a recognized certifying authority are being suitable for use in potable water supply systems.

F Special Protections

1 All pipe and fittings are to be encased in polyethylene sleeving. The polyethylene sleeving supplied shall be heavy duty polyethylene sleeving with a thickness of 250 microns, suitable for use in underground locations and shall conform to BS EN 545 6067 or ISO 8180. Sleeves over successive pipes and at joints between separate sleeves shall be carefully overlapped. The overlap shall be a minimum of 250 mm. The junction shall be carefully taped along the edge of the outer sleeve with an adhesive tape recommended for the purpose by the manufacturer. The Contractor shall furnish all the relevant technical specifications of the sleeving he intends to use in the works to the Engineer for approval, before the sleeves are used. The sleeves supplied shall include necessary adhesive tapes and any other material that may be required for the purpose. Sleeving for a minimum additional 5 percent of the normal pipe length shall be supplied to cover wastage, overlapping and slack.

2 Tape wrapping shall be provided as additional protection in aggressive soil conditions where the soil resistivity is less than 75 ohm.n or where the occurrence of stray currents is observed or occurrence of corrosion shells due to external metallic structures. Tape wrapping shall be self adhesive bituminous rubber compound providing self sealing joints at over laps and shall be high resistance to cathodic disbondment. Site application shall be conforming to the recommendations of the manufacturer. The Contractor shall furnish all the relevant technical specifications of the tape wrap he intends to use in the works to the Engineer for approval, before use.

G Glass lining shall meet the following requirements:

1 thickness shall be from 0.2 mm to 0.3 mm;
2 hardness shall be from 5 to 6 on the Mohs scale;
3 density shall be from 2.5 to 3.0 grams per cubic centimetre, measured in accordance with ASTM D 792;
4 the glass shall be capable of withstanding thermal shock of 180°C, from 220°C to 0°C, without crazing, blistering, or spalling;
5 there shall be no visible loss of surface gloss in the lining after immersion of a normal projection run sample in an 8 percent sulphuric acid solution at 65°C for a period of 10 minutes;
6 when tested in accordance with ASTM C 283, the lining material shall show a weight loss of not more than 4.7 mg per 1000 mm^2;
7 the thickness class of the selected piping item shall be such that after application of the glass lining material the metal wall of the piping item shall have a thickness of not less than thickness Class 53;

8 interior surfaces of the ductile iron piping items shall be machined smooth and grit blasted to white metal before application of the glass lining material. Factory assembled flanges on piping items shall be screwed on, unless otherwise specified, and bolt holes and flange faces shall be aligned before application of the glass lining;
9 the lining materials shall be factory applied. After application of the coating, the parts shall be placed in a specially designed furnace for this purpose and brought up to a temperature that shall melt the glass and fuse the material to the base metal. Firing of the piece shall continue until fusion has completely taken place and the coating has and integral molecular bond with the metal;
10 pinholes, crazing or fishscales which expose the metal substrate shall be cause for rejection of the item. Interior surfaces of glass lined items shall be glass smooth.

H Coatings for the outside wall of glass lined pipe and fittings shall:
1 for exposed pipe, comply with shop primer specified in Section 09870;
2 for buried pipe, comply with zinc and bitumen coating as per ISO 8179, and with polyethylene encasement, as per ISO 8180;
3 provide an outside pipe coating as per ISO 8179 except for exposed pipe scheduled to be painted. Ensure that the final coating is continuous and smooth, neither brittle when cold, nor sticky when exposed to sunlight, and strongly adherent to pipe at all temperatures. Repair outside abrasion marks with adequate and suitable coatings.

2.02 uPVC Pipes and Fittings

A Pipes shall be installed in accordance with the manufacturer's guidelines. All jointing shall be by socket and spigots with sealing rings which shall conform to BS 2494. Solvent welded joints are not permitted. Pipes shall be capable of withstanding ultraviolet degradation and shall incorporate a rodent inhibitor. Pipes shall be furnished in standard laying lengths of 6 m and shall be grey in colour.

B Fittings made of uPVC shall conform to BS 4346 and shall be manufactured by heat injection moulding or extrusion machine only. Fittings shall have the same strength as the connecting pipe.

C All joints shall be designed to have the same characteristics and strength as the connecting pipe. Unless otherwise specified;

1 joints for underground pipes and fittings 90 mm and larger shall be push in type using rubber gaskets;
2 joints for underground pipes and bends of 63 mm shall be welded using solvent cement;
3 joints for other underground fittings of 63 mm shall be push in type using rubber gaskets;
4 joints for all exposed pipes, and pipes smaller than 63 mm, shall be welded using solvent cement.

D For push in joints, the pipes shall have an integral socket end and spigot end. The socket shall be designed by the manufacturer. One neoprene ring shall be furnished for each joint. The neoprene ring shall conform to JIS K6353, BS 2494, ASTM F477, or equivalent.

E For welded joints, the pipes shall have an integral socket end designed by the manufacturer. Solvent cement shall conform to BS 4346 and shall be mixed in strict accord with the manufacturer's instructions. Any impurities in the cement shall be cause for rejection. Data on the pot life of the cement shall be for the approval of the Engineer.

F Flanged joints shall be made using flange adapters.

G Testing of pipes and fittings shall be carried out in accordance with JIS K6741, JIS K6742 or equivalent. Each pipe and fitting shall be tested under an internal hydrostatic pressure of not less than 118 Pa for the duration of 60 seconds. The Contractor shall furnish test certificates of tests carried out for quality control during the manufacture of the pipes in accordance with Section 7.2 of SLS 147:1983 and Appendices A to E of BS 3505:1986 and shall, if required by the Engineer, undertake such additional tests as the Engineer considers necessary.

2.03 HDPE Sewer Pipes and Fittings

2.03 (a) General

A Pipes shall be installed in accordance with the manufacturer's guidelines and specified herein.

B. Fittings made of HDPE shall conform to the relevant standards specified herein or equivalent. Fittings shall have the same strength as the connecting pipes.

C. Joints shall be designed to have the same characteristics and strength as the connecting pipe. Pipes and coupling shall be connected by push-in method.

D. For push-in joints, the coupler and sealing rings shall be designed by the manufacturer to meet the requirements specified herein.

E. Testing of pipes and fittings shall be carried out in accordance with DIN 16961 Part 2, or prEN 13476-1, or equivalent. The Contractor shall furnish test certificates of tests carried out for quality control during the manufacture of the pipes in accordance with prEN13476-1. Test carried out shall include melt flow rate (test method ISO 1133), pipe ring stiffness (test method EN ISO9969), fitting stiffness (test method ISO13967), pipe impact strength (test method EN744), and fitting impact strength (test method EN12061). Each pipe and fitting shall be tested for leakage and sealing tightness under test method EN1277. The Contractor shall, if required by the Engineer, undertake such additional tests as the Engineer deems fit at the Contractor's expenses.

2.03 (a) HDPE Non Pressure Pipe

A. High density polyethylene (HDPE) pipe shall be manufactured to conform to the requirements of CP 312 Part 1 and 3, and BS EN 123244- 1,2,5:2002. Where pipes are used for renovation work, pipes shall be of short lengths conforming to the requirements of the method selected and the available working space in the manholes or drive shafts. Longer lengths may be used for new installation where conventional open trench methods of construction are employed.

B. The base polymer shall be polyethylene with a derived density greater than 930 kg/m^3 when determined in accordance with the method required by BS 3412. The base polymer shall be blended with additives that are necessary for the manufacture, storage and use of HDPE pipes for sewer lines, including antioxidants, carbon black and UV stabilizers.

C. The material in pipe form shall have a thermal stability of at least 15 minutes when tested in accordance with the isothermal method for differential thermal analysis. The ends of the pipe shall be cut, cleanly and squarely.

D. The jointing system for polyethylene pipes and fittings shall be in accordance with the pipe

manufacturer's recommendations subject to approval by the Engineer.

E. The polyethylene pipe shall be Type 50, and. shall be designed to sustain a maximum working stress of 50 bar at 20°C. The wall thickness shall be based on a nominal pressure rating (PN) of l0 bar.

F. HDPE non-pressure pipes are used for gravity sewers having internal diameter larger than 250 mm. uPVC pipes are used for gravity sewers having diameter 250 mm or less.
The list of main standards to refer to is as follows, for undated references the latest edition of the published referred to applies:

1. CEN (Draft prEN 13476-1): "Thermoplastics piping systems for non-pressure underground drainage and sewerage – Structured-wall piping systems of Polyethylene".
2. DIN 16961: "Thermoplastic pipes and fittings with profiled outer and smooth inner surfaces".
3. ISO 9969: "Determination of Ring Stiffness of Plastic pipe by parallel plate loading".
4. DVS 2209 Part 1: "Welding of polyethylene pipes by extrusion welding technique".
5. RIL – 77: 190: "Plastic pipes laid in ground and water – Laying instruction".
6. ASTM D 2321: "Underground Installation of Flexible Thermoplastic Sewer Pipe".

Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply. Compliance with other equivalent, pertinent or comparable standards (e.g., ISO, DIN, BS, EN) may be acceptable; provided that the Contactor submits certification and complete documentation (including English-language versions of such other standards), to the satisfaction of the Engineer, proving that such other standards meet or exceed the specific requirements of the comparable standards.
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G. The raw material shall consist of black PE-HD with properties listed in Table A given hereunder. The raw material may only be added such additives that are needed to facilitate the manufacture of sound, durable pipe of good surface finish and mechanical strength conforming to these specifications, for intended end use, including weldability. A raw material with unknown properties must not be used. As fittings are fabricated from pipes, the same material properties and requirements apply to fittings.

Table A

Physical Properties	Value	Unit	Test method
Density: Base Resin Compound	938 948	Kg/m^3 Kg/m^3	ISO 1183D/ISO1872/2
Melt index: 2.16 kg	0.2	g/10 min	ISO 1133
Melt index: 5 kg	0.6	g/10 min	ISO 1133
Carbon black content	> 2	%	ASTM D 1603
Tensile strength at yield point	18	N/mm^2	ISO 6259
Elongation at yield point	9	%	ISO 6259
Ultimate elongation	>600	%	ISO 6259
E-modulus, tangent	550	N/mm^2	ISO 6259
Hardness	58	ShoreD	ISO 868
Charpy impact strength	No failure	Kj/m^2	ISO 179 (unnotched)
Vicat softening temperature	118	^oC	ISO 306 A-50
Brittleness temperature	<-70	^oC	ASTM D 746
Linear Expansion Coeff. (Average value over temp. range 20-90°C)	0.25	mm/m ^oC	ASTM D 696

Physical Properties	Value	Unit	Test method
Specific heat, Cp	2.0	Kj/kg.K	at 20°C, DSC
Specific heat, Cp	2.7	Kj/kg.K	at 200°C, DSC
Thermal conductivity	0.33	W/m.K	DIN 52612 (20°C)
Thermal stability Induction time	> 30	min	Al can, isothermal in oxygen, 210°C
Crystalline melting range	123-127	^oC	DSC
ESCR, F50	>10,000	h	ASTM D 1693

H. The raw material shall be pre-pigmented, UV-stabilized and anti-oxidanted. The on-line addition of pigment and/or stabilizer during pipe extrusion is strictly prohibited. All HDPE resins shall be pipe grade, single compound. Mixing of different resin compounds is not permitted. Different batches of the same compound can be used. The use of recycled resin permitted if the origins and grade are approved by the Engineer. The material used for extrusion welding shall be the same grade as the pipe material. Each consignment of raw material shall be accompanied by the manufacturer's/ suppliers test certificate.

I. Pipes used in the works shall be manufactured at plants that meet the requirements of and are accredited to ISO 9001 or 9002. The twin wall construction of the pipe shall be structurally designed to withstand external loads i.e. combination of dead load & imposed live load. The pipes are categorized in stiffness class 2, 4 & 8 kN/m^2. The stiffness class of the pipe shall be dependent on the load and installation condition of the pipe. The physical properties of the raw material shall be in accordance with those listed below.

J. The HDPE material manufacturer shall demonstrate to the Engineer, that he has the capability of manufacturing the required HDPE pipes of the sizes in accordance with the contract. The manufacturer shall have an internationally recognized quality management system in place and shall be accredited to ISO 9002 or equivalent.

K. The following markings shall be printed on the pipe:
   a) Name or trademark of the pipe manufacturer
   b) Nominal pipe size, in mm

c) Pipe stiffness class in KN/M².
d) Manufacturing standard.
e) A production code from which the date and place of manufacture can be determined

L. Handling of pipe & fittings shall be in accordance with the manufacturer's instruction and as specified below:
1. Care shall be taken in loading, transporting and unloading of pipes, to prevent any cuts/gauges/scratches, Nylon Belts/ropes or rubber-protected slings/straps shall only be used for handling the pipes. Use of steel chains, steel wire ropes and steel hooks inserted into pipe ends shall not be permitted.
2. Pipes shall be stored on clean, dry, level ground, free of sharp protrusions. Stacking of pipes shall be limited to a height that will not cause excessive deformation of the bottom layer of pipes. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitably, as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.
3. Pipes and fittings shall be examined before installation and any damage to pipes/fittings shall be repaired as directed by the Engineer. Pipes/fittings, discovered after installation to be damaged, shall be removed and replaced by new and undamaged pipes/fittings at the Contractor's expense.

2.03 (b) High Density Polyethylene (HDPE) Pressure Pipe and Fittings

A. Product manufacture, testing and installation shall comply with the latest edition of the following references, unless otherwise stated in the specification or unless otherwise approved by the Engineer:

1.	ISO 161/1:	Thermoplastics pipes for the transport of fluids – Nominal outside diameters and nominal pressures – Part 1 : Metric Series.
2.	ISO 1167:	Plastic pipes for the transport of fluid – Determination of resistant to internal pressure
3.	ISO 1133:	Plastics Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics
4.	ISO 1167:	Plastic pipes for the transport of fluids – Determination of the resistance to internal pressure
5.	ISO 2505-1:	Thermoplastics pipes – Longitudinal reversion – Part 1 Determination methods
6.	ISO 2505-2:	Thermoplastics pipes – Longitudinal reversion – Part 2 Determination parameters
7.	ISO 3126:	Plastic Pipes – Measurement of dimensions
8.	ISO 3607:	PE-HD Pipe Tolerances
9.	ISO 4065:	Thermoplastic pipes – Universal wall thickness table
10.	ISO 4427:	Polyethylene (PE) pipes for Water Supply
11.	ISO 4437:	Buried Polyethylene (PE) pipes for the supply of gaseous fuels
12.	ISO 4607:	Plastics – Methods of exposure to natural weathering
13.	ISO 6964:	Polyolefin pipes and fittings – Determination of carbon black content by calcinations and pyrolysis – Test method and basic specification
14.	ISO 12162:	Thermoplastics materials for pipes and fittings for pressure applications pipes – Classification and designation – overall service (design coefficient).
15.	ISO Data 8:	Chemical Resistance of PE pipe
16.	ISO/TR 9080:	Thermoplastics pipes for the transport of fluids – Standard extrapolation method for the long term resistance to constant internal pressure

17. ISO/TR 10837: Determination of the thermal stability of polyethylene (PE) for use in gas pipes and fittings
18. ISO/DIS 6259-1: Thermoplastics pipes – Tensile properties – Determination and basic specifications – Part 1: General test method
19. ISO/DIS 6259-3: Thermoplastics pipes – Tensile properties – Determination and basic specifications – Part 3: Polyolefin pipes
20. ISO/DIS 11420: Method of test for carbon black dispersion in polyethylene pipes and fittings
21. ISO/DIS 11922: Thermoplastics pipes for the transport of fluids – Dimensions and tolerances. Metric series.
22. ISO/DIS 13761: Plastics pipes and fittings – Pressure reduction factors for polyethylene pipeline systems for use at temperatures above 200C
23. ISO/DIS 13949: Methods for the assessment of the degree of pigment dispersion in polyolefin pipes, fittings and compounds
24. WRC WIS 4-32-08: Specification for site fusion jointing of PE 80 and PE 100 pipe and fittings
25. WRC WIS 4-32-14: Specification for PE 80 and PE 100 Electro- Fusion fittings
26. WRC WIS 4-32-15: Specification for PE 80 and PE 100 spigot fittings
27. DVS 2207: Welding of Thermoplastic HDPE pipe & pipeline components. The following definitions shall pertain to words or phrases as utilized in this section

B. Pipe and standard joints shall be submitted for all proposed sizes and pressure classes for the Engineer's approval. The submittal shall clearly indicate or include the following:
   a. Pipe manufacturer's name.
   b. Proposed pipe diameters.
   c. Proposed standard dimensional ratio (SDR).
   d. Proposed pressure class or rating.
   e. Maximum internal operating pressure at 400C.
   f. Proposed manufactured lengths.
   g. Proposed joint type.
   h. Proposed Electro-Fusion fittings (if applicable).
   i. Proposed sub-contractor for joint welding.
   j. Maximum depth of cover (depending on soil)
   k. Minimum depth of cover.
   l. Maximum internal test pressure.
   m. Maximum allowable external pressure.
   n. Recent type test results according to the relevant standard of manufacture to prove the adequacy of the pipe.

C. Fittings, bends and special couplings for all proposed sizes and pressure classes shall also be submitted for the Engineer's approval. Samples shall be supplied according to the Engineer's request.

D. All joint welding equipment, materials and procedures shall be submitted for the Engineer's approval.

E. The HDPE material manufacturer shall demonstrate to the Engineer, that he has the capability of manufacturing the required HDPE pressure pipelines of the sizes in accordance with the contract. The manufacturer shall have an internationally recognized quality management system in place and shall be accredited to ISO 9002 or equivalent.

F. Handling of pipe & fittings shall be in accordance with the manufacturer's instruction and as specified below:
   1. Care shall be taken in loading, transporting and unloading of pipes, to prevent any cuts/gauges/scratches, Nylon Belts/ropes or rubber-protected slings/straps shall only be used for handling the pipes. Use of steel chains, steel wire ropes and steel hooks inserted into pipe ends shall not be permitted.
   2. Pipes shall be stored on clean, dry, level ground, free of sharp protrusions. Stacking of pipes shall be limited to a height that will not cause excessive deformation of the bottom layer of pipes. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitably, as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.
   3. Pipes and fittings shall be examined before installation and any damage to pipes/fittings shall be repaired as directed by the Engineer. Pipes/fittings, discovered after installation to be damaged, shall be removed and replaced by new and undamaged pipes/fittings at the Contractor's expense.

G. PE Pipes & Fittings shall comply with the following general requirements, unless otherwise approved by the Engineer:
   a. All pressure pipe and fittings 75mm OD & larger shall be manufactured with PE-100 material and a minimum SDR of 11.
   b. Pressure pipes & fittings 63mm OD & smaller may be made with PE80 or PE100 material.
   c. All pipes and fittings shall be suitable for sustained operating temperatures `of up to 40°C for a service life of 50 years. Contractor must provide suitable calculations to confirm the above performance for approval of the Engineer.
   d. All PE pipes shall be manufactured in standard metric sizes according to relevant ISO Standards. The designated sizes on the drawings refer to nominal internal diameters.
   e. All pipes shall be black in colour.

H. Raw PE material shall have properties listed in Table B given hereunder and shall comply with the following requirements , unless otherwise approved by the Engineer.
   a. All PE pipes and fittings shall be manufactured from virgin material. Recycled PE shall not be used.
   b. All PE material shall be pre-pigmented and stabilized. The on-line addition of pigment and/or stabilizer during pipe extrusion or fitting manufacture is prohibited.
   c. All PE material shall be a single compound. There shall be no mixing of different pipe compounds, however different batches of the same compound may be used.
   d. The Contractor shall use PE resins that have outstanding SCG resistance. The resins used shall exhibit no "knee" in stress rupture curves at 800C for up to 1 year.
   e. PE pipes made from the very high molecular weight resins shall not be used.
   f. PE material shall conform to the following properties:

Table B.

Physical Properties	Unit	PE100	PE80
Density	Kg/m^3	>950	>940
Melt flow index: 2.16 kg (190^oC@2.16kg)	g/10 min	0.4 – 0.7	0.4 – 0.7
Mechanical Properties			
Tensile Strength	N/mm^2	>20	>18
Elongation at break	%	>600	>500

Flexural creep modulus	N/mm^2	>1,000	>700
Shore hardness	-	60 - 65	58 - 62
Environmental stress crack resistance	H	>200	>200
Notched impact strength	mJ/mm^2	15	15
Thermal Properties			
Vicat softening point	^oC	124	116
Average coefficient of thermal expansion ($20^oC – 90^oC$)	$mm/m\,^oC$	0.15 - 0.20	0.15 - 0.20
Thermal conductivity	W/m^oK	0.3 - 0.4	0.3 - 0.4
Normal operating temperatures	^oC	-30 to +50	-30 to +50
Oxidation Induction Time	Minutes	>20	>20

I. Joints for PE pressure pipes shall comply with the following requirements, unless otherwise approved by the Engineer.
   1. All joints between PE pipes and/or fittings for sizes 75mm OD & larger shall be welded by butt fusion or Electro Fusion methods.
   2. Any pipes delivered in coils shall be fusion welded with special electro-fusion fittings and fully/semi-automated equipment.
   3. Pipes delivered in straight lengths may be welded with electro-fusion couplers or butt-welded with fully/semi-automated equipment.
   4. The Contractor must employ an approved sub-contractor with certified staff to perform all welding operations. All sub-contractors and staff must be approved by the pipe manufacturer and the Engineer.
   5. PE pipes 63mm OD & smaller may be joined with butt fusion welding or approved compression fittings.
   6. PE pipes may be jointed to other piping systems by the following methods
      a. Special flanged fittings.
      b. Special compression fittings suitable for PE pipe.
      c. Other methods as approved by the Engineer.

J. Bends and Special Fittings shall comply with the following requirements, unless otherwise approved by the Engineer:
   1. All bends and special fittings, even if manufactured elsewhere, shall be obtained from the pipe manufacturer.
   2. All bends shall be “long-radius”, unless noted otherwise.
   3. Additional testing for bends and special fittings may be directed by the Engineer at the Contractor’s expense.

K. Each pipe, fitting or coupling shall be clearly marked at the place of manufacture with the following information, or as per ISO 4427:
   a. The name or distinctive mark of the manufacturer.
   b. The date of manufacture.
   c. The standard dimensional ratio (SDR).
   d. The pressure rating (if applicable).
   e. The nominal diameter (O.D.).
   f. The manufacturing standard to which the product has been produced.
   g. The angle of bends or branches.

h. Where appropriate, the name of the Client and contract number.
i. Where appropriate, individual reference number.
j. Number and mark of independent testing agency (if applicable).

L. Elastomeric sealing rings for flanged fittings shall be manufactured with the following material in compliance with the following standards, unless otherwise approved by the Engineer.
1. EPDM material conforming to BS 2494 Type "D" requirements.
2. Routine sampling and testing shall be according to the schedule given as Table C, D, and E hereunder, unless otherwise approved by the Engineer.

Table C

1	Density	Once per row material batch	ISO 1183
2	Melt flow index (190 °C@2.16kg)	Once per row material batch	ISO 1133
3	Oxidation Induction Time	Once per row material batch	ISO 10837

Table D

1	Outside diameter	Every hour/Pipe	ISO	ISO4427
2	Wall Thickness	Every hour/Pipe	ISO	ISO4427
3	Length	Every hour/Pipe	ISO	12 Mtr. Or as agreed
4	Ovality	Every hour/Pipe	ISO	ISO4427
5	Marking	Every hour/Pipe	ISO	As per tender requirements of
6	Visual Inspection	Every hour/Pipe	ISO	ISO4427
7	End Finishing	Every hour/Pipe	ISO	ISO4427

Table 4.5

1	Heat Reversion Test	3 Samples per run/batch	ISO2505-1	<3%
2	Hydrostatic Pressure Test @ 20 degree 100hrs	1 Sample / project	ISO1167	ISO4427 @12.4 MPa Wall Stress
3	Hydrostatic Pressure Test @ 80 degree 165hrs	1 Sample / project	ISO1167	ISO4427 @5.0 MPa Wall Stress
4	Hydrostatic Pressure Test @ 20 degree 1000hrs	1 Sample / project	ISO1167	ISO4427 @5.5 MPa Wall Stress
5	Tensile Strength at yield	Every run/batch	ISO6259/ ASTM D638	See Table 1

(Note)
(1) Hydrostatic testing shall be carried out in accordance with the procedures in ISO 1167 and the pipes shall not fail in brittle mode.
(2) Tensile samples taken from the wall of PE pipes shall exhibit only a ductile mode of failure. These tests shall be undertaken at 23°C 1 using a sample shape defined in ASTM D638 and testing according to ISO 6259. Pipes shall

be sampled and tested under the Engineer's supervision.

K. For pipes with a nominal wall thickness of 20mm and above, a sample of polymer shall be taken from the pipe, using a sliver of material 0.5mm thick. The oxidation induction time of this material must meet the requirements listed in Table 1. This test should be on all pipes with a wall thickness at or above 20mm.

L. Jointing

Polyethylene pipe or fittings are joined to each other by heat fusion or with mechanical fittings. Polyethylene may be joined to other materials by means of compression fittings, flanges, or other qualified types of fittings.

(a) Butt Fusion

The most widely used method for joining individual lengths of polyethylene pipe and pipe to polyethylene fittings is by heat fusion of the pipe butt ends. This technique produces a permanent, economical and flow-efficient connection. Quality butt fusion joints are produced by using trained operators and quality butt fusion machines in good condition.

The steps involved in making a butt fusion joint are:

(1) Clamp and align the pipes to be joined
(2) Face the pipe ends to establish clean, parallel surfaces
(3) Align the pipe profile
(4) Melt the pipe interfaces
(5) Join the two profiles together by applying the proper fusion force
(6) Hold under pressure until the joint is cool

(b) Electrofusion

The main difference between conventional heat fusion and electro-fusion is the method by which the heat is applied. In conventional heat fusion joining, a heating tool is used to heat the pipe and fitting surfaces. The electro-fusion joint is heated internally, either by a conductor at the interface of the joint or, as in one design, by a conductive polymer. Heat is created as an electric current is applied to the conductive material.

The steps to be followed when performing electro-fusion joining are:

(1) Prepare the pipe (scrape, clean)
(2) Mark the pipe
(3) Align and restrain pipe and fitting per manufacturer's recommendations
(4) Apply the electric current
(5) Cool and remove the clamps
(6) Document the fusion procedures

2.04 Glass Reinforced Plastic Pipe

A GRP pipes shall have a service life of 60 years.

B GRP pipes shall be fabricated in compliance with BS 5480. Resins shall comply with BS 3532, BS 3534 or ASTM D1763. Approved isophthalic, bisphenol, epoxy or vinyl ester resins may be used, lass reinforcement shall be E-glass fibres complying with BS 3396, BS 3496, BS 3691, or BS 3749 or the type known as ECR. If filler aggregates are used, they shall be graded silica sands complying with ASTM C33 of sizes between 0.5 and 3 mm. All pipes shall have a suitably reinforced resin rich layer to give high corrosion, impact and abrasion resistance. The inside of pipes shall have a vinyl ester resin rich layer at least 1.5 mm

thick. No reinforcing fibres or extraneous material shall protrude from the inner surface of the pipe wall. The outside of the pipe walls shall have a resin rich layer at least 1 mm thick. Sand may be incorporated into the outside layer. Resins shall be cured to a hardness of not less than 90 percent of the Barcol hardness recommended by the resin manufacturer when measured according to BS 2782: Part IV, method 1001 or ASTM D1583

C Dimensions and Tolerances

1 The finished dimensions of all pipes, fittings, couplings, specials or other items shall enable their assembly into a complete system required by the Contract, particularly in respect of joint flexibility and water tightness. Incompatible components shall be replaced at no extra cost to the Employer. The dimensions of every pipe will be measured.
2 The manufacturing tolerances for pipe diameter shall be $\pm$ 1 percent for pipes up to and including 600mm diameter and $\pm$0.5 percent for larger sizes. Deviations shall be such that joints are not affected.
3 The standard lengths of pipes shall be in accordance with BS 5480 Part 1 unless otherwise specified. The tolerance for special pipes of specified lengths shall be $\pm$25 mm.
4 The maximum permissible deviation of the pipe bore from the true straightness when measured at the factory or at site, shall be 0.3 percent of the effective pipe length or 15mm, whichever is smaller.

D Mechanical Properties

1 The stiffness of the pipe when defined as EI/D^3, where E is the circumferential bending modulus of the pipe wall (N/m^2), I the moment of inertia of the pipe wall per unit length (m^2/m) and D the nominal pipe diameter, shall be 10kN/m. One pipe in every twenty five of each class and diameter manufactured shall be tested to determine the initial specific stiffness in BS 5480, Part 2 Appendix J.
2 The composition of the wall shall be such that a minimum hoop flexural modulus of 12 GN/sq.m and 15 GN/sq.m shall be achieved over the whole thickness for pipes up to and including 350mm diameter and pipes above 350 mm diameter respectively.
3 Beam strength. The following shall be the minimum values of the initial ultimate resistance to longitudinal tensile force per unit of circumference:

Nominal Diameter (mm)	**Initial Ultimate Resistance (N/mm)**
above 600 through 1200	200
above 1200 through 2400	250
above 2400 through 4000	300

Longitudinal tensile strengths shall be determined in accordance with ASTM D638 or DIN 53 - 455 and shall be carried out on one pipe in every 100 pipes of each class and diameter manufactured.
4 When subjected to a parallel plate load test in accordance with ASTM D2412 the pipe shall reveal no evidence of crazing, cracking at deflection of 10 percent, and no evidence of structural failure at a deflection of 20 percent. Evidence of compliance with the foregoing requirements shall be provided by carrying out the tests in the presence of the Engineer or his representative.
5 All non-pressure pipes shall be tested to an internal pressure of 1.5 bar for a period of 5 minutes. Any appearance of water on the outside of the pipe shall be deemed to represent failure. All pressure pipes shall be tested to the specified internal pressure.
6 Samples of pipe representative of those to be supplied shall be subjected to the corrosion test detailed in ASTM D3681 in the Engineer's presence if necessary, and evidence of conformance shall be furnished prior to commencement of manufacture. Further regular tests shall be made by the Contractor and the results furnished as a feature of his quality

control procedure. Notwithstanding the requirements of Section 5.1.1 of ASTM D3681, any appearance of blisters, delaminations, wicking or other structural blemishes shall be taken to mean that the pipe has failed and the end point reached.

7 The Barcol hardness test to check resin cure shall be done on every pipe or fitting.

8 One pipe in every twenty five of each size shall be tested for loss on ignition in accordance with ASTM D2584.

E Checks of dimensional accuracy will be carried out by the Engineer or his representative, as required, both at the place of manufacture and at site. Any units found at any time failing to meet specified dimensional criteria or quality criteria or any quality criteria set out hereinafter, shall be destroyed forthwith or indelibly marked as rejected and removed from site. Any pipe which when resting freely on the ground and not subjected to any loads other then its self weight exhibits a deflection, measured along the diameter, of more than 2 percent shall be condemned and treated as described above.

F The visual inspection criteria for GRP pipes shall be:

1 scratches - not deeper than 0.3 mm and no reinforcing fibres are exposed. Acceptable after repair if greater than 0.3 mm but less than 1 mm.

2 cracks - no cracks permitted on inside of pipe. Hair cracks on the outside may be permitted with repair if not longer than 200 mm circumferentially or 6mm longitudinally. Impact cracks shall not affect more than 3 percent of surface area.

3 delaminations - not permitted.

4 impact or other damage to pipe ends - the end surface of pipe of other unit shall be completely covered with resin and free from cracks, porosity, bubbles, voids, exposed reinforcement or extraneous matter.

5 protruding fibres - no protruding fibres permitted on internal or jointing surfaces. In any pipe or unit, not more than three areas, each not more than 100 sq. mm in area, will be permitted on the outside.

6 other protuberances - small globules or resin projections permissible if not more than 25 percent of area is affected. Internal and jointing surfaces shall be completely free of any such flaws. Ridges formed by resin shall not exceed 1.5 mm in depth.

7 air voids, blisters, bubbles. - not acceptable if greater than 5mm diameter or 1 mm depth. If less than 0.5 percent of internal areas are affected, grinding out and repairing may be permitted.

8 pitting - not more than 5 percent of the internal or 10 percent of the external surface shall be affected. No individual pit shall be more than 1 mm diameter or 0.5 mm depth.

9 wrinkles and indentations - not more than 2 mm deep and not more than 3 percent of surface area affected. If not more than 5mm deep and 0.5 percent of surface area is affected, repairing may be permitted.

G GRP pipes are made of delicate elastic materials, and require special care in loading, unloading, handing and storing. Nylon lifting straps shall be used for loading and unloading of pipes. Pipes shall not overhang trucks or trailers while being transported and shall be securely tied. Avoid sudden drops or motion while loading and unloading.

2.05 Vitrified Clay (VC) Pipe and Fittings

A All pipes, fittings, and related accessories used shall conform to EN-295 including its latest amendments, additions, and revisions, or any approved equal standard, and shall be procured from an approved manufacturer.

B The value of the crushing strength shall not be less than as specified under:

Pipe Dia.(mm)	Crushing Strength (kN/m)

200	24
250	28
300	36
375	45
400	48
500	60
600	72
700	84
800	96

C The physical properties of the pipe material shall not be inferior to:

specific weight	22 kN/cu. m.
bending tensile strength	15 N/sq. m.
compressive strength	100 N/sq. m.
tensile strength	10 N/sq. m.
Mohs hardness	7

1 the outer and inner surface on the barrel of pipes and fittings shall be ceramic glazed. The outer surface of the spigot end may remain unglazed for a length equal to the socket depth. The body of pipes and fittings shall be hard and solid and differences in colour, if any, shall not affect the quality.

2 joints shall be watertight and resistant to acids, chemicals, and root penetration, and will last for the full lifetime of pipe. It should be easy to assemble and shall not unduly stress the pipe barrel. All the joints in vitrified clay pipes shall be designed to withstand a pressure of at least 8 m head of water. Such joints shall be constructed by introducing sealing elements between socket and spigot pipe barrel gaps. Pipes having size ND 200 and above will have sealing element fixed on both spigot and socket ends. These joints are called K-type joints. The sealing element on the socket shall consist of a rigid compensating material and an elastic sealing and compensating material on the spigot end. Joint material shall be suitable for the environmental conditions in the sewers as defined in these Specifications.

3 testing of materials shall be carried out in the following stages:

a manufacturer shall furnish an understanding that all the pipes and jointing material is manufactured to satisfy all the requirements of BS EN-295 specifications,
b all the materials shall be tested by an approved international testing agency before actual shipping of material to site is effected. Frequency of testing shall be as specified in BS EN-295. All test results shall be supplied to Engineer,
c the Employer may elect (at Contractor's cost) to send an engineer to supervise the manufacturing, testing and forwarding processes to ensure strict compliance to these specifications. All the costs of testing of materials and boarding, lodging and air-ticket of the Employer's representative shall be borne by the Contractor. If any material fails in any of the tests stated above or if the Contractor fails to fulfil these requirements, the whole lot of that batch of materials shall be rejected
d after arrival of material at site and before acceptance all pipes and fittings shall be inspected for any visible defects, damage and cracks. Fine cracks can be detected by dusting with talcum powder,

4 dimensions of the pipes and fittings shall be measured as follows:

a internal diameter inside the barrel at a distance of about 50 mm from the socket level,
b external diameter of socket outside pipe at the middle of socket,
c external diameter of spigot outside pipe at spigot end,
d the wall thickness shall be measured at several points of the barrel and an average taken,
e deviation of the pipe barrel from straightness shall be determined using a straight gauge rod having a length of 0.8 of the pipe length. The rod shall be kept outside or inside the pipe barrel approximately equidistant from spigot end and socket shoulder. Distance at the centre of the rod, between the rod and pipe barrel, shall be measured and related to the length of gauge length,
f deviation of pipe barrel from straightness when measured in accordance with Clause 3 of BS EN-295 shall not exceed the values as mentioned below:-

DN(mm)	Deviation (mm/m)
100 & 125	6
150 & 250	5
300 & above	4

g average internal diameter of pipe shall be such that cross-sectional area of pipe is not reduced more than 3 percent from that considered for design calculations
h length variation shall usually not exceed +4 percent or -1 percent of specified pipe lengths. For length of fittings the same limits shall apply,

5 the following markings shall be stamped on the product before fixing:

a BS EN-295
b manufacturer's symbol
c date of manufacture
d nominal size, DN
e type (standard strength/extra strength)
f minimum crushing force (for pipes only)
g the angle in degrees (for bends only)
h inspected by (Name and Mark of Testing Agency)

2.06 Concrete Pipes and Fittings

A All reinforced concrete pipe and fittings, except where otherwise specified, shall conform to BS5911 except as modified hereunder. All pipes shall be hydrostatically tested.

B Pipe materials shall be as follows:

1 cement used for manufacturing pipes and fittings shall be Ordinary Portland Cement, conforming to the requirements of BS 12. The minimum cement content shall not be less than 335 kg/m^3,

2 aggregates shall conform to the requirements of BS 882. No modification to the grading may be made without the written approval of the Engineer. The Engineer may require proof of satisfactory performance of the concrete manufactured with aggregates with the modified grading. The nominal maximum aggregate size shall be less than 20 mm, the concrete cover to reinforcement or one quarter of the pipe wall thickness.

3 reinforcement shall conform to BS 4449 or BS 4483 as appropriate. Transverse reinforcement shall be located in a circular, or helical arrangement, and shall be fixed in such a manner as to prevent displacement during concreting. Reinforcement steel shall be accurately placed in the concrete wall. The placement of all steel shall not vary from the

position in the pipe wall shown on the drawings by more than plus or minus 6mm from the nominal position. In no case shall the cover to the reinforcement be less than 25mm. Other permissible variations shall be in accordance with BS5911.

4 admixture shall be used only with the written permission of the Engineer. The methods of use and the quantities of admixtures used shall be subject to the approval of the Engineer. Admixtures containing calcium chloride will not be permitted. The chloride ion content of admixtures used in reinforced pipes using sulphate resisting cement, shall not exceed 2 percent by mass of the admixture, or 0.03 percent by mass of the cement,

5 water shall be clean and free from harmful matter. The water/cement ratio shall not exceed 0.49.

C Unless stated otherwise, concrete shall be placed in the form by means of vertical casting. Storage of concrete materials, mixing, curing and testing of concrete shall be in accordance with the appropriate clauses of Section 03300. Any deviation from these clauses shall be made only with the written approval of the Engineer.

D Unless stated otherwise crushing strengths of pipes shall not be less than those specified in BS5911 for the respective classes of pipes shown on the drawings.

E Reinforced concrete pipes shall have a minimum nominal length of 2.5 m except as otherwise specified, or required for special purposes such as curves, closures or built in pipes. Unless otherwise detailed the maximum nominal length shall be 6m.

F The pipe joints shall be supplied with flexible joints of the spigot and socket type. Joints shall comply with BS5911 and be tested to a hydrostatic pressure equivalent to 10 m head of water to the soffit of the pipe. Acceptance of concrete pipes is dependent upon the Contractor demonstrating that the joints are capable of withstanding an external pressure equivalent to 10 m head of water without leaking in both the straight and deflected positions. The demonstration shall be repeated at agreed intervals during the supply of the pipes. The sealing ring shall be confined in a contained groove on the spigot face of each pipe section to properly position and confine the rubber gaskets in the annular space. Each joint shall contain a neoprene ring gasket which shall be the sole element depended upon for watertightness of the joint. The gasket shall be of circular cross sections unless otherwise approved by the Engineer. The length and cross-sectional diameter of the gasket, the annular space provided for the gasket, and all other joint details shall be such as to produce a watertight joint which shall not leak when pulled 13mm over and above the initial jointing allowance. The initial jointing allowance is the gap between the spigot and the shoulder of the socket measured parallel to the centre of the pipeline and shall not be less than 6mm or greater than 12mm. The joints shall be capable of unsymmetrical closure in any direction with not more than 25mm opening at the joint and shall maintain watertightness at any deflected position within this specified range.

G Gasket stock shall comply with BS5911 and shall be a synthetic rubber compound in which the elastomer is neoprene, exclusively. Solid compound shall contain not less than 50 percent by volume of neoprene and shall contain no reclaimed rubber or any deleterious substances. The stock shall be extruded or moulded and cured in such a manner that any cross-section shall be dense, homogeneous and free from porosity, blisters, pitting and other imperfections. The stock shall be extruded or moulded with smooth surfaces to the specified size within a tolerance of $\pm$6 percent on any dimension, measured at any cross-section.

H Concrete pipes shall be substantially free from fracture, large or deep cracks, and surface roughness. The planes of the ends of the pipe shall be perpendicular to their longitudinal axis.

J Inspection procedures and test shall be carried out in accordance with BS 5911. All pipes will be hydrostatically tested in accordance with BS5911. Pipes shall be subject to rejection on account of failure to conform to any of the specification requirements or on account of any of the following:

1 failure to pass hydrostatic test,

2 failure of the longitudinal concrete surfaces of joints to meet the dimensional tolerances indicated on the shop drawings,

3 fractures or cracks passing through the shell, except that a single end crack that does not exceed the depth of the joint shall not be cause for rejection. If a single end crack that does not exceed the depth of the joint exist in more than 10 percent of the pipe inspected, however, the defective pipes shall be rejected,

4 defects that indicate defective mixing and moulding,

5 surface defects indicating honeycomb or open texture,

6 spalls deeper than one half the depth of the joint or extending more than 100 mm around the circumference or spalls smaller than one half the depth of the joint or less than 100mm around the circumference exist in more than ten percent of the pipe,

7 exposed reinforcement which indicates that the reinforcement is misplaced.

K All exterior surfaces that will be exposed after joining of the reinforced concrete pipe shall be coated by the pipe manufacturer with a minimum 650 microns dry thickness of a heavy duty, 100 percent solid coal-tar epoxy durable abrasion resistant and especially designed for production line application on moist concrete as specified in Division 9.

2.07 Steel Pipe

A Steel pipe and fittings shall conform to AWWA C200, subject to the exceptions and supplemental requirements set out below

B Steel Cylinder shall be as follows:

1 For pipes and fittings, the cylinder shall be fabricated from hot rolled carbon steel sheets or plates conforming to either ASTM A283 Grade D, or ASTM A570 Grade 33, or JIS G3101 Class 2 SS 400. The minimum yield point of steel used for fabrication of steel pipes and fittings shall not be less than 230 N/mm2.

2 Fabrication of steel pipes and fittings shall be in accordance with AWWA C200 or BS 534. The weld shall be of uniform width and height for the entire length of the pipe and shall be made by automatic means.

3 All longitudinal seams or spiral seams and shop girth seams shall be butt welded. The maximum allowable number of shop seams shall be one longitudinal seam and five girth seams per length of pipe. The longitudinal shall be staggered on opposite ends for adjacent sections. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of the pipe.

4 All steel fittings except bends having a deflection angle less than five degrees shall be shop fabricated. Bends having a deflection angle of less than five degrees may be fabricated from shop fabricated steel by means of field cutting and welding.

C Fitting Dimensions

1 All fittings shall be of the same steel grade, outside diameter and wall thickness as that of the pipes, and shall be provided with reinforcing rings and saddles when required in accordance with AWWA Manual M11.

D Joints and Pipe Ends

1 Unless specified otherwise, pipes, fittings, and sleeve pipes shall be bevel ended for jointing by means of single butt welded joints.

2 Pipes and fittings to be jointed by flexible coupling shall have the plain end.

3 Where shown on the drawings, flanged joints shall be provided. Flanges shall be made as seamless forgings or cut and fabricated from steel plates and shall conform to BS4504. Class of flange shall be PN10 unless otherwise specified on the drawings.

4 Material for flanges, bolts and nuts shall be the same steel used for fabrication of steel pipes and fittings. Flanges shall be steel welding neck flanges, and shall be attached to pipes or fittings by means of single butt-weld. All flanges shall be flat faced with bolt holes straddling the vertical axis of the pipes or fittings, and all gaskets shall be of at least 3.0 mm thick asbestos or neoprene, full face with bolt holes correctly sized and spaced. Flanges shall be supplied complete with the required size, quantity and quality bolts, nuts and gaskets. Unless otherwise particularly indicated on the drawings, all plate and neck flanges shall, in mating dimensions and drilling, conform to BS4504.

Nominal Pipe Dia.	Outside Diameter	Wall Thickness (as minimum)	Cement Mortar Lining Thickness
150	168.3 ± 1.6	3.5	6 (+3.2,-1.6)
200	219.1 ± 1.6	4.0	6 (+3.2,-1.6)
250	273.0 ± 1.6	4.8	6 (+3.2,-1.6)
300	323.9 ± 1.6	4.8	8 (+3.2,-1.6)
400	406.4 ± 1.6	5.2	8 (+3.2,-1.6)
500	508.0 ± 1.6	6.4	8 (+3.2,-1.6)
600	610.0 ± 1.6	7.1	10 (+3.2,-1.6)
700	711.0 ± 1.6	7.1	10 (+3.2,-1.6)
800	813.0 ± 1.6	7.1	10 (+3.2,-1.6)
900	914.0 ± 1.6	7.1	10 (+3.2,-1.6)
1000	1016.0 ± 1.6	8.7	13 (+3.2,-1.6)
1100	1118.0 ± 1.6	9.5	13 (+3.2,-1.6)
1200	1219.0 ± 1.6	9.5	13 (+3.2,-1.6)
1300	1321.0 ± 1.6	10.3	13 (+3.2,-1.6)
1400	1422.0 ± 1.6	10.3	13 (+3.2,-1.6)
1500	1524.0 ± 1.6	12.7	13 (+3.2,-1.6)
2000	2030.0 ± 1.6	15.0	13 (+3.2,-1.6)

E Lining

1. Cement used for lining shall be sulphate resisting cement conforming to BS4027.

2. Steel pipes and fittings shall have cement mortar lining with the thickness as specified in Table 4.1.

3 When cement mortar lining is applied at shop, it shall be in accordance with AWWA C205 or JWWA A109.

4 When cement mortar lining is applied at site, it shall be in accordance with AWWA C602. The equipment, materials and details for constructing method to be used for lining work at site shall be subject to the approval of the Engineer. The Contractor may be required to submit the evidence to this effect together with a representative list of installation by the same method.

5 Fittings larger than 600 mm in diameter shall be wire-fabric reinforced. The wire-fabric shall be 2 x 4 steel wire mesh, 13 gauge each way, and shall conform to the requirements of ASTM A185.

F Coating

1 The outside coating for all pipes and fittings, excluding sleeve pipes, to be placed underground, shall be shop-coated and conforming to the followings:

a AWWA C203: "Coal Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot-applied" which shall consist of, but not limited to, the followings:
1 Coal-tar primer
2 Coal-tar enamel 2.40 ± 0.8 mm. thick
3 Bonded asbestos-felt wrap or fibrous glass mat
4 Coal-tar enamel 0.8 mm. thick
5 Bonded asbestos-felt wrap
6 Water-resistance white wash or kraft-paper finished coat

or

b BS534: "Specification for Steel Pipes, Fittings and Specials for Water, Gas and Sewage" which shall consist of, but not limited to, the followings:
1 Coal-tar primer
2 Coal-tar enamel 2.40 ± 0.8 mm. thick
3 Glass tissue inner wrap
4 Coal-tar enamel 0.8 mm. thick
5 Coal-tar impregnated reinforced glass tissue outer wrap
6 Water-resistance white wash or kraft-paper finished coat.

2 The above-ground pipe and fittings shall be shop-coated with one or more coats of non-breeding type coal tar epoxy followed by additional two or more coats of epoxy-resins Micacous Iron Oxide (MIO) paint. The total uniform dry film thickness of non-breeding type coal tar epoxy coating shall not be less than 0.15 mm. while that of the MIO point shall be at least 0.06 mm. The method of surface preparation and coating shall conform to the manufacturer's standards and recommendations.

3 The exterior of sleeve pipe shall be coated with non-breeding type coal tar epoxy at the total uniform dry film thickness of at least 200 microns.

G Lining and Coating at Pipe Ends

1 Bevelled Ends

a Where shop lining is applied, at bevelled ends of pipe and fittings 600 mm and larger in diameter, both shop lining and coating shall have a cutback of 20 cm. to facilitate field welding.

b At bevelled ends of pipe and fittings smaller than 600 mm in diameter, only coating shall have a cutback of 20 cm, and lining shall be extended to the pipe ends.

c All interior surface left as cutback at the bevelled ends shall be given Cement-Mortar lining conforming to AWWA C205 or JWWA A109 after jointing the pipe. All exterior surface left as cutback at bevelled ends shall be given:

1 one shop coat of Type B coal tar primer conforming to AWWA C205 for underground buried pipe and fittings, or

2 one shop coat of epoxy primer conforming to the paint manufacturer's standards for above-ground exposed pipe and fittings.

2 Plain Ends

a At all plain ends, only coating shall have a cutback of 20 cm, and lining shall be extended to the pipe ends. The exterior surface left as cutback shall be given one shop coat of Type B coal tar primer conforming to AWWA C203.

3 Flanged Ends

a At all flanged ends, no cutback of lining and coating shall be provided.

4 For underground buried pipe and fittings including those installed in concrete valve chambers, coal tar epoxy lining shall be extended to the entire flange surface.

5 For above-ground exposed pipe and fittings, coating system consisting of non-bleeding type coal tar epoxy and MIO paint as specified for above-ground exposed pipe and fittings shall be extended to the entire flange surface.

H Manufacturer's Mark

1 Each pipe and fitting shall bear the mark of the manufacturer; the nominal diameter; wall thickness; year of manufacture; the wordings "Steel Pipe" or "SP", and the owner's name. The marking shall be conspicuously painted in non-toxic paint on the inside of each section of pipe and each fitting.

I Shop Testing

1 Pipe

a Shop testing and inspection of the pipe shall be conducted in accordance with AWWA C200 in the presence of the representative of the Engineer. The minimum hydrostatic test pressure for straight pipe shall be determined in accordance with Section 3.4 of AWWA C200 using the design stress equal to 75 percent of the minimum yield point of the steel used. When approved by the Engineer, the hydrostatic test may be replaced by other appropriate non-destructive testing methods such as ultrasonic and/or radiographic testing methods.

b During pressure test, all welds shall be thoroughly inspected and all parts showing leakage shall be marked. Pipes that show any leakage under test shall be rewelded at the points of leakage and subjected to further hydrostatic tests until satisfactory results are obtained.

2 Fittings

a Upon completion of welding, but before lining and coating, each fitting shall be bulk headed and tested under the same hydrostatic pressure as for the pipe. Provided, however, that if fittings are fabricated from previously tested straight pipe, only those welding seams that were not previously tested in the straight pipe may be tested by

means of ultrasonic or radiography method or other methods as approved by the Engineer, with no further hydrostatic test.

b Any leakage and porous welds which may be revealed by the test shall be chipped out and rewelded and the fitting be retested until satisfactory results are obtained.

3 Flexible Coupling

a Flexible couplings to join the plain ended pipes shall conform to the requirements as specified for couplings and flange adapters for Ductile Iron Pipes in this specification.

4 Harness Joint

a The harness joint shall be provided where shown on the drawing. Steel plate for lugs shall have the same properties as the pipe. Tie rods shall be made of steel conforming to ASTM A307 "Carbon Steel Externally and Internally Threaded Standard Fasteners, Grade B" and shall be hot-dipped galvanised.

b The dimensions of nut shall conform to BS4140 "British Standard Specification for ISO Metric Black Hexagon Bolts, Screws, and Nuts Normal thickness Nut Type".

2.08 Blue Epoxy Protective Coating

A The non toxic, high build, solvent free, chemical and corrosion resistant epoxy resin based coating shall be approved for contact with drinking water by NWC/WRC (UK) or similar authority. The necessary certificate is to be provided. The coating shall be smooth and glossy, colour code RAL 5015 and shall be suitable for application to valves, water pipes etc.

2.09 Low Density Polyethylene Pipe for House Service Connections

A Outside diameters and pressure class shall be in accordance with ISO 161/1 - 1978 (E) and minimum wall thicknesses (e) are calculated using the ISO formula with a working stress (p) of 32 kgf/ cm^2:

$$e = \frac{P.d}{2 + P}$$

B Pipe supplied shall be Class 10 and maximum sustained working pressure is based on water at a service temperature of 30^{o} C.

C Pipes shall conform to the outside diameters and wall thickness given in below:

Nominal Diameter ND	Outside Diameter		Wall Thickness Class 10		Coil Length	Minimum Coil Weight
	Min	Max	Min	Max		
mm	mm	mm	mm	mm	m	Kg/coil
25	25.0	25.3	3.4	3.7	200	43
32	32.0	32.3	4.4	4.8	150	53
50	50.0	50.4	6.8	7.5	150	129
63	63.0	63.3	8.6	9.4	100	137

D Visual Requirements. Pipes shall be free from gouges, voids and other defects that would, in the judgment of the Engineer, impair the serviceability of the pipe.

E Material composition shall be in accordance with BS 1972:1967.

F Mechanical properties shall be in accordance with BS 1972:1967.

G Sampling and testing shall be in accordance with BS 1972:1967. Copies of factory test reports shall be made available to the Engineer upon request. Witnessing by the Engineer of factory testing shall be required prior to delivery of any consignment.

H All pipe coils shall be indelibly marked in blue colour at intervals of not more than three metres with the manufacturer's name, specification number and nominal size and class as shown in the table above.

I Pipes shall be supplied in coils and lengths and minimum weight per coil shall be in accordance with the table above.

J Each delivery of polyethylene pipe to the site shall be accompanied by a certificate from the manufacturer certifying compliance with these specifications. Any deviations found in random checks by the Engineer on coil lengths, coil weights, pipe dimensions and any failure in hydrostatic pressure tests shall be considered a cause for rejection of the entire consignment.

K Fittings for low-density polyethylene pipe shall be manufactured from Acetal or Gunmetal and shall have bodies with internal taper, grip ring for end loading resistance, and "O" ring for water tight seal. All components shall be manufactured from UK WFBS listed materials. Seal of the push-fit joint is obtained using water pressure as a thrust medium and hence no tool is used to obtain a watertight joint. Supplier to be approved to BS 5750: Part 1:1987; ISO 9001-1987 for supplier quality management systems. Materials shall conform to the following:

1 gunmetal fittings -BS1400:LG2 cast gunmetal

2 plastic fittings -threaded generally Dupont Derlin 107 black 601, Acetal Homopolymer;
all other fittings Hoechst T 1020 black R2 Acetal Terpolymer.

3 components -grip ring; Acetal polymer "O" ring;
EDPM elastomer to BS 2492 type W, such as Millflex M28, Victaulic EP52, Exxon 584/111 EDPM or Wooduolle Polymer 09-333.

Fittings shall be designed for use underground and to handle potable water at temperatures up to 60^{o}C. They shall be capable of test operation at a pressure of 25 bars without leaking and shall be manufactured in Japan, Western Europe or North America. Adapters for connecting polyethylene and G.I. pipe shall be designed with an inlet for metric size PE pipe and a female threaded outlet to BS 21:1975 or ISO 7/1 for galvanized iron pipe to BS 1387.

2.10 Ferrules and Saddles

A Ferrules shall be supplied with a push-fit outlet for PE. All ferrules shall be designed as a main stem with a 360^{o} swivel outlet at 90^{o}, with control of water flow via a threaded inner plug. The inlet shall be a male taper threaded to BS21: 1975 or to ISO 7/1. Ferrules shall be designed for use underground and to handle potable water at temperatures of up to 50°C and shall be capable of working at a pressure of 21-bar without leaking. Ferrules shall be easily "shut off" by means of spindle extending from the top cap. Design of the ferrule shall further

permit use with conventional drilling machines, which mount on to the ferrule/saddle assembly to drill the main via the ferrule stem waterway, dry or under pressure. Ferrule stem, inner plug and top cap shall be manufactured of Gunmetal/Bronze to BS 1400:1986 LG2. The ferrule banjo may be manufactured of gunmetal/bronze or acetyl. Banjo washer and the top cap washer shall be manufactured in nitrile rubber to BS2494 and shall provide the sealing between the outer body and ferrule stem.

B Saddles for installation on asbestos cement pipes shall be of cast gun-metal to BS 1400 LG2 and shall be supplied with aluminium bronze or stainless steel bolts and nuts and synthetic nitrile rubber gaskets. They shall have an untapped boss on the top surface suitable for installation of the approved ferrule. All saddles shall accept ferrules up to 50 mm diameter. All strap bolts shall be fully threaded.

2.11 Galvanized Steel Pipes and Fittings

A Galvanized steel pipes and fittings shall conform to BS 1387 or ISO R49. Fittings shall be galvanized malleable cast iron complying with BS 1256.

B Where indicated on the Drawings, or otherwise required, "Denso" tape, or equal, shall be used for corrosion protection of buried galvanized pipe and fittings. Tape shall be applied in accordance with the manufacturer's recommendations.

2.12 Stopcocks

A Unless otherwise specified or directed, stopcocks shall be gunmetal 12mm BS1010.

B Stop valves supplied with female thread inlet and 12mm female thread outlet.

C Valves shall be provided with a detachable key operator with the spindle shielded so as to prevent unauthorized operation with a wrench.

D Jumpers shall be fixed.

2.13 Consumer Meters

Consumer meters shall be volumetric rotary piston type meters complying with the requirements of BS 5728/1 or ISO 4064/1, Class C suitable for water temperatures up to 50^{o}C, a working pressure of 10 bar and exposed outdoor location. Meters shall indicate water consumption by means of a counter resetting to zero at 10 000 cu m consumption for 15 mm size meters and 100 000 cu m for larger size meters. Meters shall indicate to 0.1 litre consumption for 15 mm size meters and 1 litre for larger size meters. Counters shall have black numerals on white to denote cubic metres and white numbers on red to denote litres. Meters shall be supplied with bodies having B.S. male threads. Meters shall be Kent PSM meters or approved equal. Where directed by the Engineer, meters of 50 mm and above shall be of the helical vane combination type having a PSM by-pass and metric registration.

2.14 Mechanical Couplings

A Grooved end couplings shall engage and lock the grooved or shouldered pipe ends allowing some degree of contracting, extension, and angular defections. Coupling housing shall be of ductile iron or malleable iron and consist of two or more segments held securely together by at least two steel bolts. Sealing gaskets shall be of such design that internal pressure in the pipe increases the tightness of the seal and shall be of materials suitable for the intended service. Couplings shall have a rated working pressure not less that the pressure rating of the pipe.

B Flexible couplings shall be provided with all necessary nuts, washers and gaskets plus an extra 10 percent to cover wastage. All nuts, bolts and washers shall be of alloy or carbon steel conforming to BS 970 Part 1, Grade 070 M20 0r JIS G4051 320C or approved equal. Bolts and nuts shall be supplied with two washers per bolt. Bolt length shall be such that after the joints are made up, the bolts protrude through the nut, but not more than 12 mm. Flexible (sleeve) couplings shall be of the full sleeve long type, split sleeve type or flanged adapter type, as shown on the Drawings, specified herein, or as otherwise permitted by the Engineer.

C Full sleeve couplings shall be the long type, properly gasketed and shall be of a diameter to fit the pipe. Each coupling shall consist of a steel middle ring, 2 steel followers, 2 gaskets, and the necessary stainless steel bolts and nuts to compress the gaskets. Stepped Couplings of the general type shall be used when stepping from one pipe material to another of the same nominal diameter.

D Split sleeve type couplings shall consist of one gasket, 2 housing clamps, and 2 stainless steel bolts, nuts and washers to obtain the flexibility for connecting the piping. Steel shoulders shall be provided and welded to the pipe ends to accommodate the couplings.

E Flexible flanged coupling adapters shall be of the sleeve type, consisting of steel middle ring, steel followers, gaskets, and stainless steel bolts, nuts and washers to compress the gaskets. Couplings shall contain stainless steel anchor studs of strength adequate to hold the pipe together under a pull equal to the longitudinal strength of the pipe at a tensile stress of 140 MPa. They shall provide the requisite pipe flexibility without jeopardizing pipe joint integrity due to hydraulic thrust and shall have the same pressure-rating as the pipe. All flexible couplings and flanged adapters shall be restrained unless the Engineer has given his approval to omit this feature for specific cases. Couplings shall have all metal bearing surfaces and shall be internally and externally fusion bond epoxy coated as specified paragraph 2.01 F.

2.15 Wall, Floor, Slab, and Roof Penetrations

A Wall pipes shall comprise:
1 ductile iron wall pipes with paddle flange. If standard castings with integral paddle flange are not available provide special castings that will provide a watertight installation,
2 wall thickness of the pipe shall be equal to, or greater than, that of adjacent piping, and in compliance with the requirements for fittings,
3 rubber-gasketed compression collars are not acceptable. The welding or brazing of paddle flange to ductile iron wall pipes at site is not acceptable,
4 coat wall pipes as specified in Section 09870.

B Pipe Sleeves shall comprise:
1 galvanized steel pipe or 18 gage galvanized steel sleeve with centre flange for water stoppage,
2 caulk shall be rubber sealant,
3 mechanical closures shall include:
a interlocking synthetic rubber sealing links shaped to continuously fill the annular space between the pipe and the sleeve,
b stainless steel bolts and nuts and steel pressure plates under each bolt head,
c closures sized according to the manufacturer's instructions for the size of pipe shown on the Drawings,
d closures rated to withstand a hydrostatic head of 12m of water,
e coating to pipe sleeves as specified in Section 09870.

2.16 Marker Posts

Marker posts, as detailed on the drawings, shall be installed at the locations of all valves, air/vacuum valves, washouts and access manholes. The type, depth, location and diameter of the main shall be indicated on the post. The Contractor shall obtain the approval of the Engineer on the location of marker posts and the permission of the RDA or municipality in the location within road property limits.

Part 3 Execution

3.01 Pipe Installation

A General

1 the Contractor shall supply all necessary tools for cuttings, chamfering, jointing, testing and for any other requirement for satisfactory installing the pipelines.

2 pipes and fittings including any sheathing, sleeving, lining or protective coating, shall be inspected by the Contractor immediately before and after installation. Any damage shall be repaired by the Contractor, as directed by the Engineer, before the pipe, or fitting, is installed or jointed. Any specified material required for the repair of pipe, sheathing, sleeving, lining or coating shall be obtained by the Contractor and shall be used in accordance with the Manufacturer's recommendations. The Engineer may, and without relieving the Contractor of any of his obligations, inspect and test the pipe and appurtenances by any means he considers appropriate. Any damage discovered by such inspection shall be repaired by the Contractor. The Contractor shall remove from the Site any pipe or appurtenance, which, in the opinion of the Engineer, is so damaged as to be unfit for incorporation in the Works. Replacements for damaged pipes or fittings shall be obtained by the Contractor at his cost.

3 the Contractor shall furnish, install and operate all necessary machinery, appliances, and equipment to keep the excavation sufficiently free from water during construction of the work to permit proper laying and jointing all as described in Section 02220.

4 for the purpose of reducing the angular deflections at pipe joints, and for closure sections, the Contractor shall be permitted to install pipe sections of less than standard length. Closing courses and short sections of pipe shall be fabricated and installed by the Contractor as found necessary in the field. Where closing pieces are required, the Contractor shall make all necessary measurements and shall be responsible for the correctness thereof.

B Joints

1 requirements of this clause shall be read in conjunction with the particular requirements specified elsewhere for joints of particular kinds. Joints shall be made in accordance with the manufacturer's instruction and as specified herein. Before making any joints the Contractor shall ensure that the interior of each pipe or valve is clean and that it remains clean. Immediately before starting a joint, the Contractor shall clean the end of each pipe to be joined and shall otherwise specially prepare the ends for jointing as may be necessary for the particular kind of joint. All mechanical joints shall be cleaned and have their paintwork or coating made good before assembly. Contractor shall use only the proper jointing materials (gaskets, nuts, bolts, washers, lubricants) as specified and obtained through the respective suppliers of pipes, couplings or valves. All joints shall be

accurately made and shall be capable of passing tests for individual joints and for the completed pipeline as may be specified. Graphite grease shall be applied to the threads of bolts before mechanical or flanged joints are made. After completing a joint, any protective paint or coating shall be made good, and any metal joint, which is not already coated, shall be cleaned and painted with two coats of polyurethane paint. Additional external protection of joints where ordered by the Engineer shall be carried out as specified.

2 for rubber ring joints, the hardness of the rubber shall be such that the joint, when made on the installed pipes, will be watertight, as specified, under any combination of working or test loads. Immediately before assembling, each joint incorporating a rubber ring seal shall be inspected for cracks. Each part of the ring shall be arched by hand into a radius of approximately 150mm. If, under this deformation, any cracks are either revealed or initiated the ring shall be rejected and shall be cut through completely to prevent inadvertent use, and the matter reported forthwith to the Engineer. If more than three successive rings, inspected in this way, are rejected, the Contractor, shall on the instruction of the Engineer, stop all pipe jointing until the cause of the defect has been proved and remedied to his satisfaction. Rubber rings shall be placed in the groove on the socket or spigot ring, and the spigot end of the pipe then entered into the socket of the adjoining pipe and forced into position. Care shall be taken to avoid twisting or cutting the ring when jointing the pipe. The inside surface of the socket shall be lubricated with a compound, recommended by the manufacturer, and which will facilitate the telescoping of the joint.

3 where mechanical joints are approved, installation shall be in accordance with the manufacturer's recommendations. The Contractor shall render the end of each pipe perfectly smooth so as to allow the joint sleeve to slide freely and, where necessary, shall coat the pipe ends with two coats of an approved quick drying sealing and protective compound. Where specified and/or directed by the Engineer, end movement of pipes jointed by the coupling shall be restrained by a steel work harness, which shall be cleaned and painted with two coats of polyurethane paint or painting system compatible with that of the pipe. Joints shall be moulded with a suitable material as recommended by the manufacturer or directed by the Engineer. Installation of couplings and flanges shall be strictly in accordance with the manufacturer's instructions and the tightening of bolts shall be done progressively drawing up bolts on opposite sides a little as a time. Bolts shall be tightened with a torque wrench to the torque recommended by the manufacturer so as to ensure even pressure all round the joint. The appropriate lubricants, as recommended by the manufacturer, shall be used when installing gaskets, in the absence of which soapy water may be used as directed by the Engineer. As the greatest gasket pressure loss occurs throughout the first 24 hours after pressuring the main, the Contractor shall re-torque the bolts again to that recommended by the manufacturer after 24 hours and ensure that the pipe is supported adequately all round.

4 flanged joints for ductile iron pipe and specials shall be made with gaskets and steel bolts and nuts which shall include two washers per bolt. The use of jointing paste or grease will not be permitted. Gaskets may be fastened to the bolts with cotton thread. The bores of abutting pipes or fittings shall be concentric and no jointing material is to be left protruding into the bore. All nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then first be alternately and progressively tightened with a torque wrench to the toque recommended by the manufacturer so as to ensure even pressure all around the joint. Joint shall be moulded with suitable material as recommended by the manufacturer or directed by the Engineer.

5 GRP pipe joints shall be assembled strictly in accordance with the manufacturer's instructions for the type of flexible joint provided and cutting of pipes will not be permitted.

6 screwed joints on galvanized steel piping and elsewhere shall be made using PTFE tape.

7 for the purpose of reducing the angular deflections at pipe joints of polyethylene pipes, and for closure sections, the Contractor shall be permitted to install pipe sections of less than standard length. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. Butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 205^{o}C, alignment, and 517 kN/m^2 interfacial fusion pressure. Butt fusion joining shall be 100 percent efficient offering a joint weld strength equal to or greater than the tensile strength of the pipe. Socket fusion shall not be used for pressure pipe applications nor in fabrications where shear or structural strength is important. Flanges, unions, grooved-couplers, transition fittings and some mechanical couplers may be used to mechanically connect HDPE pipe without butt fusion, in accordance with the manufacturer's recommendations.

8 anchorage lugs shall be provided for socket and spigot fittings, and socket clamps and tie rods used, where there is a possibility of pulling the joint under pressure. Where specified, restrained joints or concrete thrust blocks will be used in lieu of the above where socket and spigot pipe is used below ground.

9 unless otherwise specified, metallic mechanical joints, flanged joints and ferrule and saddle straps shall be protected by the cold application of Densyl tape or equivalent. Application of Densyl tape with Denso Primer, Densyl Mastic and Outerwraps or equivalent shall be strictly in accordance with the manufacturer's recommendations.

C Pipe Installation

1 The Contractor shall, after excavating the trench and preparing the proper bedding for the pipe in accordance with Section 02221, furnish all necessary facilities for properly lowering and placing sections of the pipe in the trench, without damage and properly install the pipe. The section of pipe shall be fitted together correctly and laid true to line and grade in accordance with the benchmarks established by the Contractor. The full length of the barrel of the pipe shall have a uniform bearing upon the bedding material and if the pipe has a projecting socket, suitable excavation shall be made to receive the socket, which shall not bear on the subgrade.

2 No pipe shall be rolled into place for lowering into the trench except over suitable timber planking, high enough for the socket to clear the ground and free from roughness likely to damage any coatings. Before laying, each pipe shall be cleaned out and inspected for defects. Any defective, damaged or unsound pipe shall be rejected. Piping shall be placed when trench and weather conditions are suitable and no pipe shall be laid in water or mud.

3 Any damage to the protective coating of the pipe or fittings shall be carefully repaired before installation. All sheathed pipes shall be checked for continuity of the applied protection by a "Holiday" detection unit. Discontinuities and pinholes indicated by the test shall be made good. Pipes shall be inspected for damage to any internal lining. All damages shall be repaired before installation.

4 Pipes shall be laid with any class identification marks uppermost. Pipe sections shall be so laid and fitted together that the pipeline will have a smooth and uniform interior. The pipeline shall be clean and unobstructed at the time of its completion and acceptance and shall be true to the line and grade as shown on the plans and profile. Spigot and socket pipes shall be laid upgrade without break from structure to structure and with the socket end upgrade. Whenever work ceases on any pipeline, the unfinished end of the pipeline shall be securely closed with tight fitting plug or cover.

5 Before any pipe is lowered into place, the bedding shall be prepared so that each length of pipe shall have a firm and uniform bearing over the entire length of the barrel. Pipes shall be laid in straight lines, both in the horizontal and vertical planes, between structures or, where directed in the case of pressure pipes and larger diameter pipelines, to regular curves. Each pipe shall be plumbed to its correct line and directed and accurately sighted by means of a laser positioning system. Alternative methods of locating and levelling pipelines may be allowed subject to the approval of the Engineer. Each pipe shall be carefully lowered onto its prepared bed by means of necessary slings and tackle. A recess shall be left in the prepared bed to permit the sling to be withdrawn. If the prepared bed is damaged the pipe shall be raised and the bed made good before pipe laying is continued. Any pipe which is not in true alignment, both vertically and horizontally, or shows any undue settlement after laying, shall be taken up and relaid correctly by the Contractor at his own expense. All adjustments in line and grade shall be made by scraping away or filling and tamping in under the barrel of the pipe and not by wedging or blocking. Sub-soil water shall be kept below the joint when jointing. In no case shall pipes be jointed before being lowered into position. If any damage should occur to any pipes through failure of the Contractor to comply with these conditions, the damage shall be made good at the Contractor's expense. All pipelines adjoining structures shall have a flexible joint near the face of structure as detailed.

6 The formation level of the excavated trench surface shall be firm and true to grade and compacted to a minimum of 95 percent maximum dry density before placing of pipe bedding. If soft, spongy, unstable, or similar, other material is encountered upon which the bedding material or pipe is to be placed, and the specified compaction cannot be achieved, this unsuitable material shall be removed to a depth ordered by the Engineer and replaced with compacted bedding material, or as instructed by the Engineer. Pipe bedding and concrete barriers shall be in accordance with Section 02221.

7 Concrete protection of pipe shall be in accordance with Section 02221.

8 Where a change of direction to deflect pipelines from a straight line, either in the vertical or horizontal planes, to avoid obstruction, or where long radius curves are permitted or specified, the amount of deflection allowed shall not exceed that required for satisfactory connection of the joint, and shall be approved by the Engineer. The maximum deflection shall not exceed 75 percent of that recommended by the manufacturer unless otherwise approved by the Engineer. Where a change of direction cannot be made by deflection at the joints of ordinary straight pipes, bends shall be used. The locations of such bends and other special are indicated on the Drawings and their exact positions will be determined by the Engineer on site. All pressure pipelines shall be secured at all changes in direction by concrete anchor blocks or by restrained joints.

9 All flexible pipelines except 100 mm diameter, or smaller, pipes will be subjected to deflection measurements at site by passing a suitable ball through the pipeline. The ball should be sized so that its external diameter equals the calculated installation deformation plus the recommended two percent allowable tolerance for isolated extremes. Any

sections of pipe failing to meet the specified deflection criteria shall be removed from the trench and relaid if the pipe is not damaged. This procedure shall be repeated until the pipeline is found to be satisfactory. Removal from the trench and relaying shall be at the Contractor's expense. If the permanent set or deflection, after removal, exceeds the limits set out below, the pipes shall be deemed to be damaged and will therefore be condemned. The pipes so condemned shall be indelibly marked, removed from the site and replaced at the Contractor's expense.

10 The maximum deflections for flexible pipes with granular bedding (measured-in-situ) shall be:

a after completion of surround: 0 percent
b one month after reinstatement of trench: 2 percent
c immediately prior to issue of Final Certificate: 4 percent
d immediately prior to commissioning: 4 percent
e deflection of pipes installed with concrete surround shall be measured when the concrete has set and the deflection shall not exceed 2 percent.

Any pipe exhibiting a greater deflection shall be broken out. Deflections shall be considered as the maximum difference between the measured in-situ diameter and the stated non-deflected diameter on any axis divided by the non-deflected diameter and shall be measured by an approved mechanical device at any points determined by the Engineer.

11 Back-filling should be carried out in accordance with Section 02221 and where concrete surround is provided shall not be placed before the compressive strength of the concrete has reached 15 N/mm^2.

12 The Contractor shall be responsible for taking the measurements required to determine the lengths of cut portions of pipes for insertion as closing lengths in pipelines. The pipe and methods of jointing shall be such that the locations of fittings and lengths of pipe can be adjusted in the field to suit field conditions and variations in stationing. No extra payment will be made for such adjustments nor for any welding, couplings, fittings, or special lengths required to meet this requirement. A reasonable tolerance in the location of lines, fittings, and appurtenances will be permitted by the Engineer to enable the minimum use of special lengths. Cutting of reinforced concrete and GRP pipes will not be allowed. Special lengths of pipes shall be manufactured for closure as required. The cutting of vitrified clay pipes, uPVC, DI and asbestos cement pipes for inserting specials, fittings or closure pieces shall be carried out in a neat and workmanlike manner and without damage to the pipe and so as to leave a smooth end at right angles to the axis of the pipe by an approved cutting machine as under:

(a) cutting ring for 100 to 150 mm
(b) cutting chain for 100 to 450 mm
(c) disc cutter for all diameters

Only experienced men shall be employed by the Contractor on this work. The Contractor shall take every precaution to ensure that both the measurements and the cutting of pipes are to the accuracy required. Should any errors occur, the Contractor shall remedy them at his own expense and as the Engineer directs.

13 Work at any crossing of a watercourse shall be carried out as expeditiously as possible to the satisfaction of the Engineer and any responsible Authority with the minimum interference to the free flow of water in the watercourse. Details of any temporary works

which may affect the watercourse shall be submitted to the Engineer at least 14 days before starting work. Where the pipeline passes underneath a river, stream or ditch, unless otherwise detailed on the Drawings it shall be encased in concrete and the minimum thickness shall be 150 mm. Unless otherwise shown, the depth of cover shall be not less than 600 mm from the bed of the river, stream or ditch to the top of the concrete. The Contractor shall fill the trench in both banks with rock fill or concrete up to levels as shown on the Drawings or as directed by the Engineer. The extent of this work may be varied to suit each individual crossing. Unless otherwise ordered, the concrete encasement of the pipe shall extend at least to a section vertically below the tops of the banks. Protection against erosion to the banks shall be provided by means of stone pitching or riprap or gabions where shown on the Drawings.

14 Pipe hangers and supports shall be of standard manufacture and provided in compliance with the following general requirements. Piping shall be supported independently from equipment or structures to which it is affixed. All weight of piping and contained fluids shall be transferred to a structural or foundation system through the individual or combined use of bedding, pipe saddle supports, or overhead hanger systems. A support shall be provided for each pipe at or near the point where it is connected to machinery, valves or structures. A support shall be provided for each valve and special fitting.

15 All pipes built into a concrete wall or structure shall be provided with two flexible joints adjacent to the structure as shown on the drawings. Flexible pipes constructed into a concrete wall or structure shall be protected with a concrete surround integral with the external face of the structure as shown on the Drawings. All internal and external protection membranes to the concrete shall be sealed around the pipe openings as recommended by the membrane manufacturer. Any over-excavation adjacent to a structure and/or beneath the formation level of a pipeline, either to be constructed under the contract or in a future contract, shall be backfilled with Grade 20 concrete. Alternatively, the Contractor may propose a different method for supporting the pipeline for the approval of the Engineer. Approval to the use of compacted backfill alone will not normally be given.

16 The pipeline, chamber, vaults and manholes shall at all times be kept free of all silt, mortar, debris and other obstructions. When work is not in progress, the open ends of the pipeline shall be securely plugged with an approved watertight plug or stopper firmly fixed to resist unauthorized removal. Claw type plugs or any type liable to damage the pipe will not be approved. All such stoppers, plugs or caps shall be provided with a vent incorporating a valve for the purpose of testing whether the pipeline is under pressure or vacuum and to enable pressures to be equalized prior to its removal. The Contractor shall clear the inside of each fitting and pipe length immediately prior to jointing and shall swab all fittings and pipe lengths to remove all dirt, sand or other matter that may clog the line or contaminate the fluid to be transported in the pipeline. After jointing, the interior of the pipes shall be freed from any dirt, stones or other matter that may have entered them. For this purpose, a rubber disc, brush or other suitable implement that will not harm the internal lining of the pipe shall be pulled through the pipe after jointing. The Contractor shall enter the pipeline at access manholes to remove large sediment deposits or other items.

D Installation of Exposed Galvanised Steel Piping

All galvanized steel piping shall be fixed to walls and ceiling with galvanized malleable iron brackets conforming with BS 1494 Tables 6(a) and 7(a), with screwed backplates or tails. Where required extended brackets shall be used which shall consist of galvanized malleable

iron pipe rings as Table 13(a) with screwed galvanized mild steel rods split for building in or with screwed backplates as Table 10(a). Brackets shall be fixed in accordance with the following table on straight runs and, in addition, at all bends and fittings.

	Centres (m)	
Diameter of tube (mm)	Vertical	Horizontal
12	1.80	1.20
15 & 25	2.40	1.80
32	3.00	2.40
38 & 50	3.60	3.00
65 & 75	4.50	3.60
100	4.50	3.90

3.02 Pipeline Identification

All exposed and/or non-buried pipe, including tubing, galvanized pipe, polyvinyl chloride pipe, GRP and stainless steel pipe, shall be identified by colour to show its use function. Identification of piping systems shall conform to the requirements of Section 09870. Colour bands of an approved tape type may be used on PVC, and all other pipe not readily susceptible to painted finish. Markers shall be adhesive type with extra strength and suitable for continuous duty at 120°C. All markers shall have a protective silicone film. The colours shall be in accordance with Section 09870. Both the direction of fluid flow, and the name of the fluid in the pipe shall be stencilled on all pipe at least once every six metres and at every change of direction. Colour bands shall be spaced at four metre intervals and every change in direction. The size of the letters and colour bands shall be as specified in the table below:

Outside diameter of pipe or covering (mm)	Width of colour band (mm)	Height of legend or letters (mm)
10 to 30	25	5
40 to 50	25	15
60 to 150	150	50
200 to 250	150	60
Over 250	150	90

3.03 Pipeline Structures and Appurtenances

A Manholes. A concrete manhole shall be constructed at each change of gradient or direction, at each intersection with other sewers, at such other points as shown on the Drawings and as directed by the Engineer. Channel inverts shall be accurately laid to meet pipe invert elevations at the same time as the sewer pipes are laid. Channel bends in the benching are to be as "slow" as possible by setting the manholes "off-centre" at changes in direction. Short lengths of pipe with flexible joints shall be provided at entry and exit to manholes. Manhole bases shall be constructed with concrete formed to the required shapes with GRP formers. Manholes shall have protective linings and coatings as described in the Specification. Manhole covers generally shall be set to the paved area profile and be flush with the paved area surface. Manhole covers located in unimproved areas shall be set at an elevation to prevent the entry of surface water as directed by the Engineer. Where drop manholes are indicated, they shall be as shown on the Drawings and shall be formed where the upstream length of sewer enters a manhole at a higher level than the manhole invert level. All manholes shall be watertight on completion. Where leakage is discovered the Contractor shall perform such work and provide all materials as are necessary to render such faulty work watertight. The Contractor is warned that he should expect rubbish and debris to be deposited in

manholes, chambers or vaults during the course of construction and should take necessary measures to ensure that such are not used as rubbish and waste dumps.

B Chambers for valves, air valves, washouts, etc. shall be constructed with the details shown on the Drawings, or as directed by the Engineer. Each air valve shall be fixed with isolating valve, whether or not indicated on the Drawings.

C At the locations shown on the Drawing or directed by the Engineer at site, the Contractor shall connect new pipelines to the existing pipelines or structures but not until the new works have passed final tests. Existing mains and service pipes shall only be cut using special equipment approved by the Engineer. The cut shall be perpendicular to the centre line of the pipe and special care shall be taken with respect to the location of the cut to ensure that the new pipework shown on the Drawings may be installed. The Contractor shall agree with the Engineer the length of existing pipework to be removed. The Contractor shall take every care to avoid any dirt or extraneous material entering the existing main or service pipe. The Contractor shall have available at the site of the connection efficient dewatering pumps before commencing any cut into existing mains or service pipe in order that the excavation remains dry at all times. Work shall be carried out in a clean and efficient manner. The Employer may put the interconnection into use as soon as possible after its installation and will carry out an inspection to detect any evidence of leakage. Any remedial work, necessary to eliminate leakage, shall be carried out by the Contractor. No pipework shall be covered or backfilled until the Engineer is totally satisfied that the interconnection is free of all leakage.

D The Contractor shall construct all anchors and thrust blocks as required and where specified in the Particular Specifications. Generally, thrust blocks will be placed at all changes in pipe direction greater than seven degrees. Thrust blocks shall be constructed to the dimensions shown. Unless otherwise specified or directed anchor/thrust blocks shall be provided on pipelines laid to gradients steeper than 1:20 as follows:

a up to 1:15 every third pipe,
b up to 1:10 every second pipe,
c at 1:5 every pipe shall be anchored.

Concrete shall extend to undisturbed ground on thrust faces of thrust blocks and on both faces of anchor blocks. Each thrust block shall be designed to have a sufficient bearing area and shall be placed to safely transmit to the surrounding point. Thrust devices shall be cast-in-place concrete, placed between fitting and trench wall or trench bottom, as the case may be. Bearing faces of the block shall be placed against freshly cut and undisturbed trench wall or bottom of sound material. If the thrust exceeds the bearing value of the surrounding soil, the soil shall be pre-compacted before placing concrete. All concrete shall be kept behind the sockets and flanges of fittings. Formwork may be constructed with the approval of the Engineer wherever necessary to confine the concrete to the prescribed dimensions for the block. All form lumber shall be removed before testing. Blocks shall, unless otherwise shown or directed by the Engineer, be so placed that the pipe and fittings joints will be accessible for repair. Thrust blocks for GRP fittings shall completely encase the fittings, except for the joint area. For fittings larger than 300 mm diameter, a 10 mm thick, 150 mm wide rubber wrap shall be provided on the ends of the GRP fitting such that the rubber protrudes slightly from the encasing.

3.04 Testing

A The Contractor shall submit, for the Engineer's approval, details of his proposed methods and program for testing (including details of test equipment) and shall arrange for all tests to be witnessed by the Engineer, or other person appointed by the Engineer. The Contractor shall provide all things necessary for carrying out testing and cleaning including water, pumps,

compressors, gauges, piped connections, stop ends, and all other temporary works. Pipelines shall be properly completed and supported before being put under test except as hereinafter detailed. No testing will be permitted until ten days after thrust blocks and other holding down works have been completed. Trenches shall not be left open at joints prior to testing pipelines except in exceptional circumstances and as permitted by the Engineer who may lay down certain restricting conditions. In addition to any tests of individual joints or other interim tests, which may be specified elsewhere, the Contractor shall submit all parts of the pipelines to a final test. Notwithstanding the foregoing, the Contractor may at any stage of construction, carry out such other tests as he considers desirable to check materials and workmanship on the pipeline but this shall not relieve the Contractor of his obligations to achieve successful tests under the Contract. All water required for testing and cleaning the pipelines shall be treated or raw water, depending on the final product to be carried by the pipeline, and shall be provided by the Contractor at his cost. Potable water shall be used for potable water lines. All flexible pipelines shall be tested for deflection as described in paragraph 3.01C of this Section. The Contractor should note that neither the satisfactory testing of pipeline, section of a pipeline or any other pipework, nor the acceptance of such testing by the Engineer or his representative shall in any way relieve the Contractor of any of his responsibilities and obligations under the Contract. The Contractor shall notify the Engineer at least 24 hours before hand of his intention to test a section of pipeline having been satisfied, in the first instance, that the section of pipeline to be tested in the presence of the Engineer is satisfactory in all aspects.

B Each pipe line 600 mm or less in diameter shall be tested by air test. Should any pipe fail the air test, the Engineer may order the Contractor to perform a water test. Acceptance of the pipeline will then be based on the results of the water test. All pipelines 800 mm or greater in diameter shall be tested by water and shall be physically inspected internally by the Contractor in presence of the Engineer. Pipelines 600 mm to 800 mm may be tested by either air or water as directed by the Engineer.

C All gravity flow pipelines shall be tested by the following tests, to be selected by the Engineer. The Contractor shall, at his own expense, furnish all equipment and materials for making the test. Test (a) shall be performed before backfilling is commenced. Tests (1) or (2) and (3) shall be performed after backfill and compaction is complete, dewatering system removed and after all utilities are in the ground including sewer laterals, but prior to placing of permanent resurfacing. Tests shall be performed in the presence of the Engineer, and shall include the main and laterals as a unit. All pipes are to be clean and empty at the time of testing. When leakage or infiltration exceeds the amount allowed by the specifications, the Contractor shall, at his own expense, overhaul the pipe and make the necessary repairs or replacements in accordance with the specifications to reduce the leakage or infiltration to the specified limits. Any individual detectable leaks shall be repaired, regardless of the results of the test. Leakage tests shall be made on completion of gravity sewer lines as described hereinafter.

1 leakage due to internal pressure (air pressure method). The Contractor shall plug all pipe outlets with suitable plugs, and brace each plug securely where needed. The air test equipment is to be approved by the Engineer prior to testing. Air shall be pumped in slowly to the pipe until a pressure of 100 mm water gauge is indicated on a manometer connected to the system. After the internal pressure of 100 mm water gauge is obtained, two minutes shall be allowed for the air temperature to stabilize within the pipe. Air may be added to restore the pressure to 100 mm water gauge. During a further period of five minutes, the pressure should not fall below 75 mm water gauge without further pumping.

2 leakage due to internal pressure (water-test). All the joints of the pipeline shall be able to

withstand a pressure of a minimum 5m head of water, above the crown of pipe at the highest point of pipeline without leakage. Testing shall be carried out before backfilling of the trench. A layer of embedding soil equal to the diameter of pipe shall be laid over the pipe to prevent the lifting of pipe while applying test pressure. However all the joints shall be left open for the purpose of inspection for leakage if any. All branches and open ends shall be closed with stoppers, secured with longitudinal braces/thrust block, before testing commences. Water shall be filled from the lowest point and air allowed to escape through an air vent fixed for the purpose at the highest point of the pipe line section under test. The diameter of air vent shall be about one and half times the diameter of water inlet pipe to allow easy escape of air. No entrapped air shall remain in the pipeline while testing. A pressure of 5 m head of water shall be maintained for one hour to allow initial absorption of water. After that test pressure shall be maintained for 15 minutes and water added shall be measured. If water consumption in 15 minutes does not exceed 0.1 litres/m^2 of wetted inner pipe surface and if there are no visible leakage through joints the pipeline shall be treated as passed.

3 leakage due to infiltration. The upper ends of the sewer and laterals shall be closed sufficiently to prevent the entrance of water and the pumping of groundwater shall be discontinued for at least three days prior to the test for infiltration. The infiltration shall not exceed one litre per mm diameter per kilometre per day of that portion of sewer being tested, and includes the length of house laterals entering this section. The total length tested in one section shall not exceed 1000 m in length. This length is dependent upon the type of deflection measuring equipment proposed by the Contractor if flexible pipes are used.

D Pressure pipelines carrying liquids shall be pressure tested as specified herein.

1 Gauges used for testing pressure pipelines shall be either of conventional circular type, not less that 300 mm diameter, calibrated in metres head of water or shall have a digital indicator capable of reading increments of 0.1 metre head. Before any gauge is used, the Contractor shall arrange for it to be checked independently and a dated certificate of its accuracy shall be provided to the Engineer. One additional gauge as above shall be handed over to the Engineer's representative for purposes of verification during testing. Calibration of pressure gauges shall be carried out by the Contractor, at regular intervals, as required by the Engineer.

2 The Contractor should note that since valves cannot be guaranteed to be perfectly drop-tight, testing against closed valves shall not be permitted unless with the written approval of the Engineer. The "open" ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges, or cap ends, additionally secured where necessary by temporary struts and wedges. No claims whatsoever will be entertained on account of leaking valves, or any other difficulties in closing of lengths of pipework for testing, which shall be entirely at the Contractor's expense.

3 The Contractor shall remain responsible for the care of the works during testing of the pipework. For purpose of interim testing, the pipeline shall be divided into sections. Each section shall be separately tested to the Engineer's satisfaction for deflection and pressure when each section is completed. The Contractor shall submit to the Engineer detailed procedures for performing hydrostatic pressure tests of installed piping, fittings, valves, meters and appurtenances for approval. Procedures for performing hydrostatic pressure tests for each section of pipeline shall indicate:

- location and capacity of the test pump,

- test pressure at the pump and at the high and low points in the pipeline,
- procedures for venting the air from the pipeline,
- disposing the water after satisfactory testing.

4 The length of the section of pipeline to be tested shall not normally exceed 1000 m or as directed by the Engineer. A simple stop end consists of a section of steel pipe about 0.5-1.0 m long onto which a closing plate has been welded, containing the necessary opening for accommodating ongoing water and out-coming air. Stop ends may also include an opening through which the test water may be pumped from the line, if necessary, and shall be jointed to the pipe to be tested by means of a standard coupling or other method approved by the Engineer. Thrust blocks or temporary anchorages shall be provided to hold the stop end in place against the test pressure. The Contractor may also use proprietary restrained joints in lieu of thrust blocks. Interim test shall be carried out after the pipeline section to be tested has been laid, jointed and backfilled to a depth of at least 300 mm above the crown of the pipe but leaving the joints exposed. Sections to be tested shall be approved by the Engineer. Joints between each tested section shall then be left exposed until the pipeline has passed the Final Test on Completion.

5 Each pipeline or section thereof shall be filled with water and all air removed as far as possible. If permanent air vents are not located at all high points, the Contractor shall install suitable cocks at such points so that the air can be expelled as the line is filled with water. The line shall be filled slowly to prevent possible water hammer. The test pump and gauge shall be connected to the pipeline at a location other than the highest point in the line to facilitate the release of air from the highest point. Pressure in the pipeline shall then be raised steadily up to, and maintained at, the working pressure for a period of not less than 24 hours, to allow for absorption and achieve conditions as stable as possible for testing. The standing period will commence from the time at which the working pressure was reached successfully, after which all exposed joints shall be carefully inspected for evidence of leakage. If neither appreciable movement of the pipeline, nor any leakage, has been observed during the visual inspection, the section shall be subjected to the pressure test proper. Pumping shall then be resumed and the pressure slowly raised to the specified test pressure, at the highest point of the section of pipeline under test, subject to that at the lowest point of the section of pipeline under test shall not exceeding the works test pressure, or as directed by the Engineer. Test pressure shall be continuously maintained by the use of the pump for a period of at least four hours and the amount of make up water required to maintain the pressure shall be accurately measured (to the nearest $^{1}/_{8}$ litre) regularly every 30 minutes throughout the test. Pipelines with flexible joints shall be deemed to have passed the test if: no water is visible coming out of the pipe or joints at any point; the amount of make-up water required does not exceed the rate of 0.1 litre per millimetre of pipe diameter per kilometre of pipeline per 24 hours for each 30 m head of pressure applied; and the maximum drop in pressure (during the last half hour of the test period, when no further make-up water may be pumped in) shall not exceed 10 percent of the maximum test pressure.

6 For PVC, steel, cast iron, ductile iron or other pipe material, with solvent welded, welded, threaded or flanged joints, no leakage shall be permitted.

7 During all testing, the trench shall be kept clear of water. Should the trench become unstable due to work or leaking on testing or re-testing it shall be excavated to solid ground and made up with lean mix concrete or such other material as the Engineer may direct, all at the Contractor's expense.

8 Should a test fail, the Contractor shall at his own expense replace defective pipes or

fittings or make good leaking joints or otherwise rectify defective work. Cleaning, inspection and testing shall then be repeated until the work is to the Engineer's satisfaction and at no extra cost to the Employer.

9 Final acceptance test shall be carried out after all lengths have been joined together on completion of construction and interim tests have been carried out satisfactorily on the entire length of the pipeline, or such other length as may be determined by the Engineer. Final pipeline acceptance test pressures and procedures shall be as described in under pipeline testing.

E All pipelines carrying air or other gasses under pressure shall be given a pressure test as specified herein. No leakage is permitted. Low pressure air piping shall be tested pneumatically. Air pressure of 140 kPa shall be applied to piping and fittings. High pressure air piping shall be tested to 1400 kPa. There shall be no drop in pressure in a 24-hour period. Leaks shall be located and repaired to the satisfaction of the Engineer. Pressure drops due to thermal contraction are acceptable if the pressure returns to the original test pressure after 24 hours.

F Valves and all pipeline appurtenances shall be hydraulically tested together with the pipeline in which they are installed. Valves shall be tested for operation under working pressure and shall be adjusted so that they operate smoothly, seat properly and are installed to tolerances recommended by the manufacturer.

G All chambers and manholes shall be constructed so as to prevent leakage of water therefrom. Testing for leakage of water from manholes, chambers or vaults shall be conducted, unless it is deemed unnecessary in the opinion of the Engineer. The chambers and manholes shall be hydrostatically tested prior to backfill around manholes and damages revealed as a result of such tests, shall be made good to the satisfaction of the Engineer.

3.05 Disinfection of Pipelines

A All potable water pipes, fittings, valves, meters and appurtenances shall be disinfected by the Contractor, as specified herein, unless otherwise directed by the Engineer. All water and chlorine required for disinfection of pipelines shall be provided by the Contractor at his own expense. Bacteriological testing will be performed by an approved laboratory. The attention of the Contractor is directed to the requirements of these specifications whereby he is responsible for preventing the entry of foreign material of any kind into the pipework. The Contractor shall take extreme care to keep the interior of the pipework free of direct and other foreign material. If in the opinion of the Engineer, dirt or other foreign material, which will not be removed by flushing, enters the pipework then the Contractor shall clean and swab the interior of the pipework with a five percent sodium hypochlorite disinfecting solution to the satisfaction of the Engineer.

B After testing, and immediately before commissioning, all pipelines shall be washed out and disinfected as follows:

1 All mains shall be flushed out with clean water until there is no evidence of foreign matter or colour in the waste flushing water;

2 A stock disinfecting solution shall be prepared by mixing, for about 5 minutes, in a clean container, sodium hypochlorite solution (15 percent available chlorine) and distilled water in the proportion of 0.8 litres to 1000 litres water by volume. Stock solutions shall be made up fresh daily;

3 The main, to be disinfected, shall be filled with potable water at the same time as the stock solution is added through a convenient air valve in such quantities (to be determined by the Contractor and approved by the Engineer) as will result in a final solution containing 50 mg/l free chlorine. Care shall be taken to ensure that the stock solution is added at a constant rate, commencing when water is fed into the main and ending as soon as the main is full;

4 Every main charged with disinfecting solution shall stand for 24 hours, after which a sample shall be taken at a washout valve by the Contractor in the presence of the Engineer, from whom the sampling bottle shall be obtained. If the sample does not show at least 2 mg/l free chlorine, disinfection shall be repeated. If the sample is satisfactory the main shall be emptied, flushed out and filled with treated water and allowed to stand for 1 hour;

5 Two further samples shall then be taken as before, one for a further determination of free chlorine and the other, in a sterilized bottle, for bacteriological analysis. If the free chlorine determination shows more than 4 mg/l free chlorine the main shall be flushed out again. If the bacteriological analysis is unsatisfactory disinfection and sampling shall be repeated until satisfactory results are obtained before the main is commissioned;

6 The Contractor shall provide all equipment, materials and testing apparatus, etc., as may be necessary for the effective disinfection of all pipelines;

7 Water used for disinfection may be re-used in an adjacent section if the level of free chlorine is again brought to the level specified.

3.06 Cleaning of Pipework

A It is the responsibility of the Contractor to prevent all dirt and foreign matter from entering the pipework and for cleaning each length of pipe and all fittings, valves, meters and appurtenances, of sand, dirt and foreign matter during the installation.

B The interior of all liquid carrying pipework shall be cleaned by the Contractor using clean, potable water after, before and after all pressure tests and disinfection operations have been performed and accepted by the Engineer. Cleaning of chlorinated lines shall conform to the recommendations of the Chlorine Institute. All water required for flushing and disinfection of pipelines shall be provided by the Contractor at his own expense.

C Air and gas piping shall be purged with air or inert gas as directed by the Engineer.

3.07 Disposal of Water Used for Testing, Disinfection and Cleaning

The Contractor shall provide suitable means for disposal of water used for testing, disinfection and flushing such that no damage results to facilities; structures or property. These means shall be subject to the approval of the Engineer and local Authorities. Details shall be submitted to the Engineer upon request. The Contractor shall be responsible for any damage caused by his filling, testing, disinfecting, flushing and disposal operations.

END OF SECTION 02700

SECTION 02712

Sewerage

Part 1 General

1.01

A The work included in this Section comprises furnishing all plant, labour, equipment, pipe fittings, appliances, appurtenances and materials and performing all operations in connection with the installation of sewer systems in accordance with the Specification and Drawings.

B Method of Construction

1. The Contractor shall note that the sewers/pumping mains shall be constructed by the methods of open trench excavation and pipe-jacking.

2. In all cases the Contractor shall provide for all necessary working shafts, the design of which shall be to the approval of the Engineer, and maintain same for the whole duration for which the shafts are left open. Where a working shaft is used for the construction of a manhole/chamber, the Contractor shall allow for this in his rates for the construction of the manhole/chamber. Additional working shafts may be sunk with the approval of the Engineer, but will not be paid for.

3. The Contractor shall allow for any difficulty and inconvenience to be encountered during construction and is held to have visited the site to ascertain the existing condition.

1.02 Section Includes

A The manufacture, factory testing and supply of pipes and appurtenances of different materials for the sewer system.

B Laying, jointing, testing, repairing and retesting where necessary and commissioning.

C The Contractor shall provide all labour, materials and equipment necessary for providing the pipes, fittings and jointing materials, transporting to sites, excavation, backfilling and compaction, laying, jointing and testing, disposal of excess excavated materials, and removal of surplus pipes, fittings and jointing materials.

D Responsibility for the safety and soundness of all material shall rest with the Contractor.

E The Contractor shall carry out any tests, at his cost, needed to satisfy himself regarding the soundness of the pipes, fittings and jointing materials prior to acceptance testing by the Engineer.

1.03 Submittals

A All submissions shall be in accordance with submittals as described in Section 02700 – Pipework.

B Plans and details of the equipment, materials and the method of construction to perform and complete the work shall be submitted by the Contractor and must be approved by the Engineer before commencing these operations. Approval by the Engineer shall not relieve the Contractor of his sole responsibility for the efficiency, reliability and soundness of the method employed in completing the work in a satisfactory manner.

1.04 Marking

A Marking shall be in accordance with marking as described in Section 02700 – Pipework. Full records are to be maintained of each pipe test and for each individual pipe, the date of manufactured, cleared after testing and supplied.

B Pipe manufacture shall be arranged to permit the full completion of batching of pipe before testing. After the satisfactory completion of testing and approval of the pipes by the Engineer the pipes shall be stored during the period awaiting delivery.

1.05 Supply and Laying of Pipes and Fittings

A The Contractor shall note that there is no separate contract awarded for the supply of pipes and fittings in this Contract. The Contractor is required to schedule his own requisition and he shall ensure consistent delivery of pipes and fittings.

B All arrangements for the timely delivery of pipes and fittings to meet the progress of the work shall be solely the responsibility of the Contractor.

C The Contractor is required to plan and arrange the Works to ensure that standard pipe lengths are used between manholes including the short length pipes used next to the manholes. Where a pipe of odd length is, in the opinion of the Engineer, required, the Contractor shall arrange for the casting of such odd, make-up length of pipe or cutting of pipe when necessary. The Contractor shall allow in his rates for all such casting, cutting and waste.

Part 2 Material

2.01 Rubber Ring Joints

A The joints supplied shall be of the Cornelius rubber ring type or similar approved and shall be capable of accommodating 2° deflection at each joint. Joint rings shall comply with the current B.S. 2494 Part 2 1967 and shall be to the Engineer's approval. The properties of the joint ring shall be between those specified in B.S. 2494:1967 for Grade D and Grade B inclusive of Grade D and Grade B.

B The Contractor shall indicate the grade of rubber rings he intends to use and submit samples for approval and test prior to incorporation in the works. The grade, type of source of supply of rubber rings may not be changed without the written approval of the Engineer.

2.02 Manhole Frames and Covers

A The Contractor shall submit the following details of manufacture:-

1 Process of manufacture
2 Details of manufacture, country or place of manufacture
3 Details of materials to be used

B The manhole frames and covers to be installed under this Contract shall be sound and of the best quality. They shall comply with the specification or standards set out by the sewerage service entity (hereinafter called "SSE") or regulatory authority of the Project country. Where such specifications or standards contradict the specifications given in EN124, the former specifications or standards shall take precedence.

C The manhole frames and covers shall be manufactured in accordance with the type and size specified in the Drawings and shall be manufactured by manufacturer approved by either SSE of the Project country or the Employer.

D Load Class

Manhole covers and frames shall be capable of bearing wheel loads of up to 400 kN and, as such, shall meet the test load requirements for Class D400 manhole covers and frames given in EN124. The testing shall be conducted by an approved independent testing agency.

E Manhole covers and frames shall be certified as complying with the requirement and this specification before they can be accepted. The product testing for certification purposes shall be undertaken by an approved third party certification body. The approval of the product shall be from SSE of the Project country. Materials not accompanied by a Test Certificate (s) shall not be used in the Contract.

F Material

1 The materials for manhole covers and frames shall be either

a ductile iron complying with the requirements specified in BS EN1563 for Grade 500/7.

b flake graphite iron (otherwise known as grey iron or cast iron) complying with the requirements specified in BS 1452 for Grade 350.

2 The production, quality and testing of ductile iron shall comply with ISO 1083.

G Dimensions, Marking and Surface Finish

1 The manhole covers shall be free of defects which might impair their fitness for use.

2 The dimensions, marking and surface finish of manhole covers and frames shall comply with the requirements of SSE of the Project country.

3 Tolerance on dimensions shall be ± 1mm. The casting of markings shall be clearly legible.

4 The serial number imprinted on the manhole cover must tally with that shown in the test certificate accompanying it.

H Seating

1 When a random cover is placed in a random frame, the adjacent top surfaces of the cover and frame shall have flushness of level within ± 1mm.

2 The manhole covers shall be compatible with the existing seating. The new seating shall be manufactured in such a way to ensure stability and quietness in use.

I Casting

All cast units shall be cleanly cast and free from air holes, sand holes, cold shuts and chill. They shall be neatly dressed and carefully fettled. All castings shall be free from voids, whether due to shrinkage, gas inclusions or other causes.

J Protective Coating

1 All surfaces of manholes covers and frames shall be coated with either one of the following:

A hot applied bituminous material complying with BS 4147 Type I Grade C

B cold applied bituminous material complying with BS 3416 Type II

2 Immediately prior to coating, surfaces shall be clean, dry and free of rust. The coating shall be free of bare patches or lack of adhesion. The mean thickness shall be no less than 70μm and the local thickness shall be no less than 50μm.

K Water-tightness

No visible leakage shall occur between the manhole cover and its seating in the frame when tested in accordance with Appendix E of AS 3996.

L Safety Features

Manhole covers shall be provided with locking device and hinge to prevent rocking due to traffic and to provide a theft proof design.

M Locking Devices

Locking devices shall be either bolts and nuts or a mechanism with a special key design. The mechanism shall be able to be integrated with the covers and can also be used as a lifting device. All the mechanism for locking device shall be of stainless steel in accordance with ISO 3506 or BS 6105. Bolts and nuts for locking devices shall be hexagonally headed complying with BS 3692.

N Hinge

All manhole covers shall be hinged. The hinge shall be designed such that, when in the open position, they shall be secured by a positive mechanical retainer to prevent accidental closure of the covers. The opening angle of hinged covers shall be at least 100º to the horizontal. If hinge bolt is used for coupling separate sections of covers and frames, it shall be of stainless steel in accordance with ISO 3506 or BS 6105.

O The quality control of the certified manhole covers and frames shall meet the requirements given in Clause 10 of EN 124. However, the final inspection and tests and the frequency of tests/inspection shall not be as shown in Table A3 of EN124. Instead, the specifications as shown in Table.1 below must be followed. All final inspection and test documents shall be retained for at least 6 years.

Table.1. Final Inspection and Testing

Final Test/Inspection	**Frequency**
Markings legibility inspection	Every unit
Casting defects inspection	Every unit
Protective coating inspection	Every unit
Locking devise inspection	Every unit
Seating flushness of cover in frame	1 per 20
Measurements of all dimensions	1 per 100
Load Class Test	1 per 100
Water-tightness Test (only applicable for covers required to be watertight)	1 per 100
Protective coating thickness measurement	1 per 200

P The Engineer reserves the right, notwithstanding the aforesaid, to instruct the Contractor in writing to submit samples for load testing, if in his sole opinion, the quality of the materials supplied do not meet with our requirement. Upon receipt of written instruction from the Engineer, the Contractor shall within seven (7) days from that date arrange for the load test to be carried out.

Q In the event that the sample selected fails the load test, the entire batch from which the sample is selected shall be rejected and the cost incurred in carrying out such test shall be borne by the Contractor. However the Engineer may consider permitting a 100% test to be carried out on the whole batch from which the selected sample had failed the load test. Material from the batch which passes the load test shall be accepted and those that fail shall be rejected, provided a written request for such test be made to the Engineer. All additional costs incurred for carrying out such test shall be borne by the Contractor.

R Notwithstanding the aforesaid, the materials to be supplied under this Contract shall be sound and free from physical defects. All materials delivered shall be subjected to physical examinations; and any material which in the sole opinion of the Engineer or his representative is considered unsound or contains physical defects shall be rejected.

2.03 Precast Reinforced Concrete Chamber Rings

A The precast reinforced concrete chamber rings shall be manufactured in accordance with MS 881 or BS 5911.

B The materials and workmanship shall be of the best quality. The chamber rings shall meet the testing requirements hereinafter specified.

C The units shall be of reinforced Portland Cement Concrete. Each shaft ring shall be of uniform diameter and thickness of wall throughout its entire length and all the units shall be to the thickness, rebate length and dimensions given on the drawing.

D The rings shall be manufactured by an approved centrifugal process.

E The reinforcement shall consist of hoops or spiral and longitudinal firmly secured together and the steel grid or grids so forming the reinforcement shall be centrally and accurately located as shown in the Drawing by some positive method to maintain position during manufacture.

F The units shall be designed to withstand the specified tests and any unit which in the sole opinion of the Engineer, does not comply with the requirements of such tests, shall be rejected. The moulds and method of manufacture shall be such that the form and dimensions of the finished work are accurate within the limits specified, the surface and edges clean and true, the ends square with the longitudinal axis, and the concrete dense and homogeneous.

G Variation in Thickness of Walls

Subject to the mean thickness of the wall of the rings being not less than that specified in the standard, the radial thickness of the wall shall nowhere vary more than three (3) millimetres for the chamber rings. The mean thickness of the wall shall be ascertained by adding the measured least thickness to the measured greatest thickness and dividing the sum by two.

H Straightness

The barrels of all rings shall be truly straight when tested on the inside with a rigid straight edge for their full length and on a line parallel to the longitudinal axis of the pipe.

I Joints

All the units are to be formed with ogee joints in accordance with the drawing and all the joints are to be accurately and neatly formed so that all units fit neatly together. The ogee ends of each unit shall be parallel and square with the longitudinal axis.

J Lifting Holes

Each unit shall have two lifting holes 40mm diameter formed through the concrete to facilitate handling and positioning of the units. The holes shall be carefully positioned clear of reinforcement and should be left rough internally.

K Testing of Materials

Testing of materials shall be conducted by an approved independent testing agency.

L Testing Requirements

1 Reinforced concrete ring sections shall in addition comply with the following clauses in BS 5911. Test loads shall be to Clauses 18.3 and 18.4 for Class 'L' pipe.

2 Absorption test shall be to Clause 18.2 of BS 5911

3 The selection of samples for testing shall be as follows:-

Absorption Test	-	1 per batch of 100 or part thereof
Cracking Load	-	1 per batch of 50 or part thereof
Ultimate Load	-	1 per batch of 100 or part thereof

4 Should the section selected for Absorption Test fail, two further samples from the same batch may be selected for testing and if both comply with the test the batch represented shall be accepted, but if either fails the whole of the batch represented may be rejected.

5 Should the sections selected for the External Loading Test pass the test the whole of the pipes comprising the batch shall be deemed to comply with this test. If the sample fails two further number from the same batch may be selected for testing and if both samples comply with the test the whole of the pipes comprising the batch shall be deemed to comply with this test. If any of the samples for retest fail, then the whole of the batch represented may be rejected.

M The Contractor must produce a Test Certificate to the Engineer to certify that the precast concrete chamber rings he intends to use in the Contract have been tested by and that the products comply with the relevant Standard before they can be accepted. Where the products are obtained from different batches, they must be accompanied by a Test Certificates for the respective batches. Materials not accompanied by a Test Certificate(s) shall not be used in the Contract. Each and every chamber ring must be stencilled with a serial number which must tally with that shown in the Test Certificate accompanying it.

N Marking of Rings

The following information shall be clearly stencilled on the exterior surface of each section at the time of manufacture:-

1 The internal diameters of the ring and on each ring the word TOP at the upper end
2 The letters representing an abbreviation of SSE to be the owner and operator
3 Date of Manufacture
4 The serial number in the order of manufacture
5 Manufacturer's name and registered trade mark

O Maturing

Unless supplied under this Specification, they must have been allowed to mature under suitable condition for a period of not less than 5 weeks.

P Physical Inspection

The materials to be supplied under this Contract shall be sound and free from physical defects. All materials delivered shall be subject to physical examination; and any material which in the opinion of the Engineer or his representative is considered unsound or contain physical defects shall be rejected.

Q Rejected Materials

1 All materials that are not acceptable shall be removed from the site by the Contractor within seven (7) days after notification in writing by the Engineer.

2 Should the Contractor fail to remove the rejected material within seven (7) days, the Engineer shall have the right to remove the materials and the cost incurred shall be a debt owing to the Board by the Contractor and this shall be deducted from any monies due or to become due to the Contractor.

2.04 Manhole/Chamber Protective Lining

A High Alumina Cement Lining

Unless shown in the drawing, internal surface of the manhole shall be internally lined during the manufacturing process with 20mm thick 1:3 high alumina cement. The surface shall also be painted with two coats of coal tar epoxy and the application of the liner shall be as specified in Section 03350 hereof.

B PVC or HDPE Lining

1 The underside of all intermediate platforms and roof slabs of manholes/chambers shall be lined with PVC or HDPE lining or equivalent as indicated in the drawings.

2 The PVC or HDPE lining shall be of "Plastiline" or similar approved material. Ends of the lining shall be embedded 50mm inside the concrete or sealed by approved PVC or HDPE angle fillets and welded in accordance with the manufacturer's instructions.

3 The Contractor shall take all necessary measures to protect the PVC or HDPE lining or equivalent from being damaged during installation and shall make good any damage arising thereof. The Engineer may order a test be carried out to detect any holes in the PVC or HDPE lining.

4 Other types of lining proposed shall be accompanied by details of materials and tests, etc. and shall be to the approval of the Engineer who on approving will specify additional requirements, if necessary.

5 Specification for PVC Linings

Table 2A – Physical Properties

Property	Allowable Standard	Method
Tensile Strength	Longitudinal : 17.25 Mpa Transverse : 17.25 Mpa	ASTM
Elongation at break	Longitudinal : 225% Transverse : 225%	D 412
Hardness	54-62	Shore Purometer at 20C
Plasticizer Permanence	0.4%	ASTM D 1203
Water Absorption	0.1%	ASTM
Water soluble matter	0.05%	D 570
Porosity	No pin holes	Spark Tester 7 KV

Table 2B – Chemical Properties

Chemical Agents		Test Method	Change in Weight Not more than
Sodium Hypo-Chloride	1%		0.20%
Ferric Chloride	1%		0.60%
Sodium Chloride	5%		0.15%
Sulphuric Acid	20%	ASTM	0.12%
Nitric Acid	1%	D 543	0.20%
Sodium Hydroxide	5%	(7 days at	0.10%
Ammonium Hydroxide	5%	20C)	0.40%
Soap & Detergent Solution	2%		0.40%

6 Specification for HDPE Linings

a Approved HDPE linings of not less than 1.5mm thick is to be used. The linings must be designed and formed with mechanical keys for keying into the concrete.

Table 3A – Physical Properties

Property	Allowable Standard	Method
Density	0.94 g/cm^3	ASTM D 792 ASTM1 D1238
Melt Flow Rate	Condition E 0.5g/10 min Condition P 1.6 g/10 min	
Ball Indentation	31 N/mm^2	Shore Purometer at 20C DIN 53495
Elongation at yield	Longitudinal : 15% Transverse : 15%	ASTM D638 Speed D (50mm/min)
Elongation at break	Longitudinal : 800% Transverse : 15%	
Tensile strength at yield	18 N/mm^2	
Tensile strength at break	24 N/mm^2	
Water Absorption	0.085%	ASTM D 570
Water soluble matter	Zero	
Porosity	No pin holes	Spark Tester 7 KV
Coefficient of Linear Expansion	1.2 x 10-4 C-1	ASTM D 696
Plasticiser	Nil	

Table 3B – Chemical Properties

Chemical Agents		Test Method	Change in Weight Not more than
Sodium Hypo-Chloride	1%		0.09%
Ferric Chloride	1%		0.09%
Sodium Chloride	5%		0.09%
Sulphuric Acid	20%	ASTM	0.09%
Nitric Acid	1%	D 543	0.09%
Sodium Hydroxide	5%	(7 days at	0.09%
Ammonium Hydroxide	5%	20C)	0.09%
Soap & Detergent Solution	2%		0.09%

2.05 Preformed Cover Fillets

The Contractor shall include the supply and welding of pre-formed cover fillets or angles to seal the end of the PVC or HDPE lining at the manholes. The fillet or angle shall be of the same material and thickness as the PVC or HDPE lining of the pipes. The details of finishing, welding and fixing to the concrete walls adjoining the pipe end, spigot or socket will be supplied by the Supply Contractor. The Contractor will be required to form any chase, rebate, fillet or recess required for the proper fixing and sealing of the cover fillets.

2.06 Sacrificial Lined Reinforced Concrete Pipes

A The reinforced concrete pipes shall be designed, manufactured and tested in accordance with the following specification:

1 It shall be designed and manufactured with an internal sacrificial layer of 38mm in addition to the normal cover to reinforcement as provided for in the design of reinforced concrete pipes and in compliance with BS 5911 or accepted Equivalent Standard.

2 It shall be subject to test loads in accordance with Clause 18.3 and 18.4 of BS 5911.

3 It shall be designed such that in the absence of the sacrificial layer, the pipe shall withstand the test loads in accordance with Clause 18.3 and 18.4 of BS 5911. During the course of manufacture, the Contractor shall manufacture a pipe less the sacrificial layer from the same concrete batch mix for the purpose of this load test. The permissible crack width shall not be more than 0.25mm when subject to Load Test Requirements under Clause 18.4 of BS 5911.

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4 The Contractor may elect to manufacture an additional two (2) no. similar pipes without the sacrificial layer (of thickness 38mm) at his own expense and from the same concrete batch mix provided his intention is made known to the Engineer who initiated the instruction under Sub-Clause (3) above.

5 In the event that the pipe fails the load test under Sub-Clause (3) above, the Contractor may present two further pipes manufactured under Sub-Clause (4) above for testing. If either fails the Test Requirements, the consignment of the

thickwall reinforced concrete pipes manufactured from the same concrete batch mix shall be rejected.

6 The Contractor, in his prices for the supply of pipes shall take into consideration the cost of the tested pipes and the testing, and no claim shall be entertained by the Engineer in respect of this.

2.07 PVC or HDPE Lined RC Pipes

A The PVC or HDPE lined reinforced concrete pipes shall comply with the specifications/standards of SSE in the Project country, if any, as specified in Clauses 2.04 hereof.

B The PVC or HDPE lining shall have a minimum thickness of 1.5mm. The lining shall be fixed to concrete surface by mechanical keys and cover not less than 330° of the internal circumference of the pipes.

C Notwithstanding the physical and chemical properties of PVC linings as in the requirement of the Sewerage Department Standard Specifications, the supply of PVC or HDPE linings shall comply with the specifications as listed respectively in Clauses 2.09 and 2.10 hereof.

D In the event of the PVC or HDPE lining being damaged during the construction of the sewer, the whole pipe shall be replaced entirely at the Contractor's expense.

E When pipes are laid, care shall be taken to keep the cover flaps clear of the adjoining pipe socket and to place the pipe in the correct position so that the PVC or HDPE sheeting is evenly divided by the vertical pipe centre line.

F PVC or HDPE Jointing

1 At regular intervals the Contractor shall arrange for his pipe supplier to visit the site and weld up and test the PVC or HDPE joint flaps and end cover fillets. Not more than three (3) pipes shall be laid before the joints are welded up.

2 The Contractor will be required to afford all necessary assistance in keeping the pipes clear of mud and water during the jointing of the PVC or HDPE flaps.

3 The Contractor will be required to make arrangements for the supply of water and power and for the proper ventilation of the pipeline during cleaning, tacking and welding and testing of the PVC or HDPE joints.

4 On completion of the laying, jointing and welding, the Contractor will be required to carry out a detailed inspection and test of the PVC or HDPE lining and joint welding in the presence and to the satisfaction of the Engineer.

Part 3 Execution

3.01 Installing Pipelines, Pipeline Structures and Appurtenances

Requirement of this Clause shall be read in conjunction with the specifications specified elsewhere in the Specifications for satisfactory installing the sewer system.

3.02 Steel Trench Sheeting

A Wherever the sub-soil conditions are expected to be of a soft and unstable character, the normal methods of timbering will probably prove insufficient to avoid subsidence of the adjoining road surfaces, concrete drains and canal and other services.

B In such circumstances the Contractor shall use steel trench sheeting or steel sheet piling adequately supported by timber struts, wailings, etc.

C Steel sheet piles shall conform to the provision of B.S. 4360 and shall be driven where required and approved or directed by the Engineer.

D The Contractor will be required to design the layout of the piling and the overall dimensions of the excavation to suit the sheets and corners available and to give sufficient working space for the proper construction of the work.

E The Contractor will be expected to supply, pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Specification and the terms "timber" or "timbering" shall also apply to steel trench sheeting or steel sheet piling throughout.

3.03 Verifying Invert Levels of Existing Sewers

A The proposed sewers/pumping mains shall be laid as far as practicable to lines and levels as indicated in the Drawings.

B To ensure that the new sewers/pumping mains will be able to connect level-wise to the existing sewers, the Contractor shall, prior to the commencement of excavation work, set out the proposed lines and verify the invert levels of existing sewers.

C The Contractor shall establish all levels to be taken for the work site, in cross check with Survey Department's Precise Bench Mark (PBM) as datum. Adequate temporary bench marks shall be transferred from the PBM to the work site. In general, the invert level of an existing downstream manhole shall be adopted as the Master Bench Mark for the Contract. Where the invert of the downstream manhole, based on PBM, differs from the Department's record the Registered Surveyor employed by the Contractor shall notify the Engineer, and the Engineer shall decide on the value of the bench mark to be adopted. The adopted bench mark shall then be the Master Bench Mark for the Contract.

3.04 Connection to Existing Manholes

A The Contractor shall note that in connecting pipelines to existing manholes, every care shall be taken to ensure that the connections are watertight and the existing sewers and manholes are not damaged. Special precautionary measure shall be taken to ensure the stability of the existing manholes, vortex drop chamber and sewers connected to them.

B In connecting the pipeline to the existing manhole, the Contractor shall do necessary measures to ensure a compatible fit between the pipes and the existing manholes, such that a circular hole large enough to accommodate the pipeline shall be made in the wall and the cut end of the pipe neatly rendered to form a smooth bore. If the Contractor identifies any existing manholes that require remodelling for compatible fit, the Contractor shall immediately report it to the Engineer, design and carry out such remodelling work with the Engineer's approval and at no extra charge to the Employer, unless substantial remodelling are needed. Should substantial remodelling be needed, the Engineer will give an instruction for appropriate measures to be taken by the Contractor, and it will be deemed to be a Variation.

C The Contractor shall ensure that there is no interruption to existing flows during the connection works. No debris shall be allowed to fall or be discharged into the existing sewers. Any debris which falls into the existing sewer and any obstructions thereby caused shall be removed at the Contractor's expense.

D The Contractor shall not allow sewage to flow into the newly constructed pipeline or seal off the existing pipelines until and unless the part of the pipeline concerned and the downstream pipelines have been completed, inspected and certified fit for use. Before doing so, the Contractor shall wait for direction from the Engineer in writing.

E The Contractor shall allow for all the above in his rates, except the costs for substantial remodelling of the existing manholes to be carried out under the Engineer's instruction for a Variation as set out in Paragraph B above..

3.05 Abandoned Sewers/Pumping Mains and Manholes/Chambers

A Certain lengths of existing sewers/pumping mains as indicated in the Drawings will be abandoned on completion of the works. The sewers/pumping mains of 300mm diameter and above shall be filled with concrete grade 15 with retarder mixture or cement grout by an approved method. Ends of the abandoned sewers/pumping mains including those of 150mm and 225mm in diameter, shall be seated water-tight with 225mm thick brick plugs and rendered with cement mortar. All abandoned manholes/chambers are to be demolished and manhole frames and covers removed. All manhole frames and covers so removed shall be salvaged and the Contractor shall reimburse the Employer or SSE the cost recovered in salvaging the manhole frames and covers. An item has been included in the Bills of Quantities for the Contractor to price for the salvaging of manhole frames and covers. For manholes/chambers which are on the roads, the Contractor shall include in his rates the reinstatement of carriageways.

3.06 Connections to Existing Pipes

A Where connections are to be made to existing pipes, the Contractor shall ensure a compatible fit between the new and the existing pipes.

B Where such a fit is not possible, the Contractor shall be required to obtain the Engineer's approval for the use of a specially cast/manufactured piece for the transition. The cost of such special pieces is deemed to have been included in the Contractor's priced rates.

3.07 Diversion of Existing Sewers

A The Contractor shall note that some manholes are to be constructed onto existing sewer. He shall take all precautionary measures to ensure no interruption to the flow in the existing sewer. Care shall also be taken to prevent any debris falling into the sewer and being carried downstream. Any debris that has fallen into the sewer must be removed immediately at the Contractor's expense. The Contractor shall not seal off the existing sewer until the new line has been completely inspected and certified fit for use. For such cases, the Contractor shall plug up the ends of the newly constructed pipes until diversion of flow can be implemented. The breaking up of the existing sewer, blocking of flow etc., shall be done during night hours.

B The Contractor shall ensure that no drainlines affected by the work are sealed off without prior and proper diversion of the affected drainlines to the satisfaction of the Engineer. Diversion and/or sealing off works shall not be carried out until notice has been given by the Engineer. The Contractor shall allow for all the above in his rates.

3.08 Over-pumping and Flow Diversion

The Contractor shall maintain sewage flow arising from whatsoever source, and shall prevent any flow from entering the sewer being worked on during any phase of the execution of the works. The Contractor shall submit his proposed method of over-pumping or flow diversion to the Engineer for approval prior to the start of construction. The proposed method shall include proposed alignments and design requirements of the discharge pressure pipe to the terminal point. The Contractor shall furnish, install, and operate pumps, plugs, conduits and other equipment required to divert flow around the pipe segment upon which work is to be performed. Sewage shall not be allowed to flow into gutters, streets, or over sidewalks. After the work on the sewers has been completed, tested and accepted by the Engineer, flow shall be restored to normal.

3.09 Pipe Stoppers

Flow shall be plugged off using an approved type of mechanical pipe stopper having a circumferential compressible rubber ring. The stopper shall be fully inserted inside the pipe before tightening up. Suitable inflatable stoppers may be approved for small diameter sewers. Stoppers shall be sophisticated and reliable as approved by Engineer. For work on any length of sewer, the Contractor shall plug off any number of inlets to the upstream manholes as required. The next manhole upstream shall be used as a pumping sump with the outlet to that manhole also being plugged. When there is a possibility of sewage backup from downstream, the outlet to the downstream manhole shall also be plugged. Additional stoppers shall be used as necessary to ensure safe working conditions. All house connections that discharge into temporarily plugged sewer length are to be stopped off themselves and a pre-approved system of over-pumping installed.

3.10 Pumping Equipment

A Over-pumping shall be carried out from one manhole to another located downstream and the pumping system shall be of sufficient capacity to handle peak existing flow. Pumping shall be done by the Contractor in such a manner that no damage to public or private property results, and no nuisance or public health problem is created. Pumped sewage shall be in an enclosed hose or pipe that is free of all leaks and shall be re-inserted into the sewer system.

B The Contractor shall verify the peak average flows ahead of time and shall design the pumping system accordingly. The design shall be submitted for the Engineer's approval.

C A submersible electrically driven, non-clog sewage pump shall be installed in the manhole. The pump shall be capable of handling all the required sewage flow and any likely material transported to the host manhole and shall be slender capable of passing through the manhole cover. Bottom side of the pump, i.e. suction inlet, shall be connected to a suction stand constructed of cast iron or protected steel and resting on the manhole bottom. Discharge side of the pump shall be connected to the external pipe by means of a flexible hose or other material as deemed appropriate. The pump shall be controlled by float switches installed to operate at levels pre-approved by the Engineer.

D In areas where the submersible pump described above is not sufficient to handle the existing flow, the Contractor may use one or more suction lift pumps installed temporarily on the street level with suction hose(s) lifting from one or more or manholes as necessary. Pumps shall be centrifugal of a special design suitable to this work and shall be electrically driven with sufficient lift capacity in the suction side.

E The Contractor shall make his own arrangements to provide power to the site for running the pumping equipment.

3.11 Over-pumping of Flow

A To bypass a length of sewer undergoing replacement or renovation work, the flow of sewage shall be over-pumped and discharge into a downstream manhole on the sewer line. Subject to the Contractor obtaining the necessary approval from the Engineer, the sewage may be over-pumped utilizing an adjacent surface water drain where it is impractical to use the sewer system. It must be clearly demonstrated by the Contractor that no sewer is available for the diversion of the flow before proposing to use storm drain lines for diversion of the sewage. In such a case, the sewage flow shall be returned to the sewage network at a suitable point downstream of the work in progress.

B Open end of the pump discharge pipe shall be laid so as to minimise turbulence of the pumped flow into the sewer system.

C Upon completion of over-pumping, the Contractor shall carry out sewer, or storm drain when utilized, cleaning by jetting, flushing or any other means required to return the pipes to serviceable condition to the satisfaction of the Engineer.

D Upon completion of all works, the Contractor shall be responsible for ensuring that the sewage system is clean, free from blockages, and free flowing. The Contractor shall employ any means necessary to ensure that the system is fit and in a serviceable condition.

3.12 Temporary Diversion of Flow

A Where the Contractor considers it necessary for the expediency of the works, the temporary diversion of a sewer by discharging the pumped flow into another branch or main sewer, whether connected or not, may be allowed. The Contractor shall notify the Engineer of his intentions and submit his proposals before the implementation of any such diversion to ensure that the receiving sewer is capable of handling the additional flow.

B The Contractor shall give full details of pipe diameter, route, and levels in proposals for temporary diversions, subject to the Engineer's approval.

C The Contractor shall be totally responsible for obtaining all other permissions and approval relevant to any flow diversions.

D All diversionary work shall be subject to the requirements of the Contract as if they formed part of the Permanent Works.

3.13 Payment

No separate payment shall be made for over pumping or flow diversion, including furnishing and operation of pumps, the cost of which will be included in other work requiring over pumping or flow diversion.

END OF SECTION 02712

SECTION 02720

Pipe Jacking

Part 1 General

1.01 Section Includes

A This Section covers the Works required to install underground pipelines from one manhole to another using trenchless method.

B The envisaged construction method involves jacking a sewer pipe. This Specification is intended to be primarily functional in nature and to define in general terms the work to be accomplished. The Contractor shall have full discretion to select the method of tunnel construction, subject to review and approval by the Engineer.

C The Contractor will be allowed to select the construction method for tunnelling, such as hand tunnelling or work in a shield or tunnel boring machine (TBM), provided that the Contractor shall demonstrate to the Engineer that the proposed methods will complete the works in accordance with the Specifications, applicable safety codes, and schedules. Full directional guidance is a prerequisite of any method of tunnel construction, which also provides for man-access to the tunnel excavation face.

D The Contractor shall be responsible for the final constructed product, materials, and tools used, and for furnishing the labour and qualified superintendents necessary for the method of tunnel construction.

E The Contractor must demonstrate that the chosen method will control the flow of water and prevent loss of soil into the tunnel and provide stability of the face under anticipated conditions.

F The Contractor shall furnish all items including but not limited to, the TBM or shield with excavation equipment, spoil transportation systems, hoists, signal systems, ventilation, safety equipment and survey controls necessary of the entire selected method of jacking operation.

Approval of such schedule shall not relieve the Contractor of his responsibility to provide a fully satisfactory installation. The Contractor shall include with his submission evidence that he has successfully completed a jacking installation using procedures similar to those proposed.

G The general soil profile along the route of the pipeline is given in the borelogs for the Contractor's information only. The Employer accepts no responsibility for the accuracy, reliability or completeness of this information. It shall be the responsibility of the Contractor to satisfy himself as to the soil conditions along the pipe jacking route and if he judges it to be necessary, he shall carry out additional soil investigations at his own cost.

H The Contractor shall be responsible for inspecting the location and familiarising himself with the conditions under which the work will be performed and with all necessary details as to the orderly execution of the work. The omission of any details in the Drawings shall not relieve the Contractor of full responsibility for the satisfactory

installation of the work in its entirety. No monetary other claims made by the Contractor will be entertained.

I Methods which require workmen to carry out excavation either manually or semi-mechanically in pipes or tunnels smaller than 1200mm in diameter or equivalent will also not be accepted.

1.02 Definition

A Pipe jacking shall be defined as a construction method by which the sewer pipe is installed below a surface obstruction by driving them successively through the in-situ soil from one pit (the jacking pit) to another pit. Method of construction shall be of the Contractor's selection in accordance with this Specification. The listing of methods or reviews by the Engineer of Contractor's submittal shall not be constructed by the Contractor as an endorsement by the Engineer that all such methods are constructible or will work for the specific subsurface soils encountered.

B Tunnelling Work Plans shall be defined as written descriptions together with sketches, drawings, schedules, and other documents defining Contractor's plans and procedures for tunnelling. The submission of Tunnelling Work Plans, including shop drawings required for the sole purpose of providing the progress is in accordance with the intent of the Works design and Specification requirements.

1.03 Submittals

A Review: Submittals shall be made in accordance with Section 01300, Submittals. The Engineer will review submitted shop drawing and data for compliance with the requirements of this Section. Such review shall not be construed to relieve the Contractor in any way of his responsibilities under the Contract. Contractor shall not commence work on any items requiring a Tunnelling Work Plan or other submittals until the submittals have been reviewed and approved by the Engineer. All structural designs and other engineered components shall be signed by the Contractor's Professional Engineer.

B Pipe Jacked Tunnel Operations:

1 Submit for review a Tunnelling Work Plan.

2 Depending on the Contractor's method of construction, the Tunnelling Work Plan, including shop drawings, shall address the following items but not necessarily be limited to,

a. If the use of mechanised excavating equipment (such as TBM or shielded excavators) is proposed, the Contractor shall submit arrangement drawings and technical specifications of the machine and trailing equipment (including any modifications), track record of the proposed type of machine, qualification and training records for the equipment operator, and a copy of the manufacturer's operation manual for the machine.

b. The Contractor may elect to use a tunnel shield that is separate from the mechanised excavation equipment or for use with hand excavation. If the use of a separate tunnel shield is proposed. Contractor shall submit arrangement drawings, design criteria, dimensional data and method of excavation and operation of the shield, including acceptable method for closing the face of the heading.

c. Method of controlling line and grade of tunnelling operation.

d. Method and details of spoil removal including equipment type and numbers, surface storage, processing and disposal.

e. Ventilation system.
f. Lighting layout.
g. Electrical system
h. Proposed contingency plans for critical phases and areas of tunnelling.
i. Grouting techniques to be used for over-excavation including equipment, pumping and injection procedures, pressure grout types, and mixtures.
j. Details of the pipe jacking method and operation including jack set-up for jack thrust reaction bearing and pipe lubrication system.
k. Details of method proposed to cushion and distribute jacking forces at pipe joints.
l. Plans for storage and handling of pipe.
m. Groundwater control methods.

C Quality Control Methods: At least 30 days prior to the start of tunnelling, the Contractor shall submit to the Engineer a description of the Quality Control Methods proposed for tunnelling operation. The submittal shall include but not necessarily be limited to,

1. Supervision: Supervisory control to ensure that work is performed in accordance with the Drawings, Specifications and Tunnelling Work Plan.

2. Line and Grade: Procedures for surveying, controlling and checking line and grade, including field forms.

3. Tunnelling Observation and Monitoring: Procedures for preparing and submitting daily logs of tunnelling operations including field forms, to meet the requirements of Article Jacking Operation Data, and Article Control of Line and Grade.

4. Products and Materials: A plan for testing and submittal of test results to demonstrate compliance with the Specifications and Contractor's criteria for permanent products, materials and installations. The plan shall identify all applicable standards and procedures for testing and acceptance.

D. Safety: Procedures to meet all applicable safety requirements of relevant authorities. These procedures shall be submitted for record purpose only and will not be subject to approval by the Engineer. As a minimum, provide the following:

1. Protection against soil instability and groundwater inflow.
2. Safety for tunnel and shaft access and exit including ladders, stairs, walkways , and hoists.
3. Protection against mechanical and hydraulic equipment operations, and for lifting and hoisting equipment and material.
4. Ventilation.

5. Lighting
6. Communication system
7. Monitoring for hazardous gases
8. Protection against flooding
9. Means for emergency evacuation and self-rescue.
10. Protection of shaft including traffic barriers, accidental or unauthorised entry, and falling objects.
11. Emergency protection and self-rescue equipment
12. Safety supervising responsibilities.

E. The Contractor's design and proposal shall be based on the general arrangements shown on the tender drawings which accompany the tender document as far as possible to suit the Contractor's proposed system.

1.04 Design of Jacking Pipe

A The Contractor shall design the pipes to be jacked and the pipe joints in accordance with the jacking procedure and operation proposed by the Contractor. The design shall be submitted with full detailed calculations to the Engineer for approval before construction commences. The details of the jacking pipes are to be shown on the Drawings and the design shall take into account the following requirements:-

1 M.S. Pipe Sleeve

a) The pipes for jacking operation shall be mild steel pipes

b) The length of each pipe shall not exceed 3 m and the pipe ends shall be able to accommodate a M.S. collar. The collar shall be designed to take the jacking load applied and transfer the load to the next pipe.

c) The Contractor shall submit full details of his proposal for the pipes jacking/giving detailed drawings showing sizes, joint details, calculations, name and address of proposed manufacturer and the manufacturing processes to the Engineer for approval. A Professional Engineer shall endorse the proposal.

2 Reinforced Concrete Pipe

a) The nominal diameter and internal concrete lining for the jacking pipes shall be in accordance to the Specification. The pipes shall be of reinforced concrete.

b) The pipe ends shall have an external rebate suitable to accommodate a joint/thrust collar. The collar shall be designed to take the jacking force applied and transfer the force through the reinforced concrete pipe to the next pipe.

c) The thrust collar shall be fitted onto the pipes with concrete slurry to prevent the ingress of water into the pipe from outside.

d) The Contractor shall submit full details of his proposal for the pipes giving detailed drawings showing sizes, reinforcement and joint details, calculations, name and address of proposed manufacturer and the manufacturing processes to the Engineer for approval. A Professional Engineer shall endorse the proposal.

2 Vitrified Clay Jacking Pipes

a) The nominal diameter for the jacking pipes shall be in accordance to the Specification.

b) The jointing sleeve shall be fitted onto the pipes to prevent ingress of water into the pipe from outside and shall be suitable for direct jacking.

c) The Contractor shall submit full details of his proposal for the pipes giving detailed drawings showing sizes and joint details, calculation, name and

address of proposed manufacturer and the manufacturing process to the Engineer for Approval. A Professional Engineer shall endorse the proposal.

B The jacked pipes shall be designed to withstand, in conjunction with the jacking load applied, the following external loads :-

1 Train load distribution for 20-ton driving axle locomotive, for pipe jacking under railway.

2 Highway loading of 45 units of Type HB loading in accordance with BS 5400, for pipe jacking under JKR roads/Highways.

4 Overburden load as shown on the Drawings.

5 A load factor of not less than 1.5 shall be used in calculations to determine the strength of the pipes required.

1.05 Performance Requirements

The centre-line of the fully jacked pipes forming a continuous sleeve shall at all points along its length be within 75 mm of the required alignment in the horizontal plane and 25 mm in the vertical plane.

No movement, upheaval or settlement of soil that in the opinion of the Engineer may cause damage to structures, utilities or pavements shall be permitted.

The fully jacked pipeline or the pipeline laid in the jacked pipe sleeves shall pass the water tightness test specified for the pipelines in trench.

1.06 Approval of Owner

Before commencing preparations for pipe jacking, the Contractor shall obtain the written consent to his proposed procedures of the Owner or Owners of the land, various authorities, details of services and structures below which (or close to which) the jacked pipeline will pass.

Although the Engineer may assist in obtaining such consent, it will be the sole responsibility of the Contractor to ensure that relevant approvals have been attained before commencing works on that section.

Part 2 Products

2.01 Precast Concrete Pipes

A The pre-cast concrete pipes shall meet the requirements of Section 02700 – Pipework and Section 02712 – Sewerage.

B The pipes for jacking operation shall be pre-cast concrete pipes. The pipes shall be manufactured by a centrifugal or other equivalent process to be approved by the Engineer Design, manufacture and factory testing of the pipes and specials shall be to BS 5911 or other acceptable Standard. The clear cover of concrete over steel reinforcement shall be as designed and specified by the pipe manufacturer and shall not be less than 20mm.

C All pipes except for those less than 900mm diameter shall be manufactured with two sets of grout holes. Each set shall consist of three grout holes spaced at 120º on centres circumferentially located at the quarter points from either end of the pipe. Two of these grout holes shall be at the soffit of the pipe.

D The pre-cast reinforced concrete pipes shall be sufficiently reinforced with steel to withstand all stresses induced by handling, jacking, earth and water pressures and all working loads at the depths at which they are to be used without cracking, spalling or distortion. The pipes shall be of at least strength Class 'H'. A load factor of not larger than 1.5 shall be used in the calculations to determine the strength of the pipes required. The strength of the pipes shall be tested by the three edge-bearing test. When subjected to the design load in such a test, the maximum crack width developed on the pipe shall not exceed 0.25mm. All such tests shall be carried out at the expense of the Contractor.

E All workmanship and materials used in the manufacture shall be subject to the approval of the Engineer who shall be from time to time be permitted to inspect materials at source and the manufacturing processes in the factory.

F The pipes shall be sufficiently matured before they are used in the construction of the Works. They shall be handled with extreme care to prevent the edges of the pipes from chipping. Repaired pipes shall not be allowed for use in the Contract. The Engineer may reject any pipes he considers not suitable for the Works and these rejected pipes shall be removed from the site immediately. After factory testing and before despatch, every pipe and special shall be marked with a number corresponding with the order of manufacture. Test certificates from the manufacturers or other relevant authority shall be submitted to the Engineer.

G Where steel shield is utilized during the jacking operation, this steel shield shall be bolted to or by other approved means joined to the first piece of pipe which is being jacked.

H The Contractor shall be required to use a jacking ring. The jacking ring may be either of steel or concrete construction and shall be used at all times when a pipe is being jacked. The jacking ring will allow the jacking pressure to be distributed evenly to the jacking ring.

I The Contractor shall also be required to use a jacking frame during all operations. The jacking frame shall be designed to distribute the stresses from the jacks evenly to the jacking ring.

2.02 Vitrified Clay Pipes and Joints for Trenchless Construction

A The following sets out the requirements for flexibly jointed vitrified clay pipes for construction by trenchless installation technique including pipe jacking.

1 Vitrified Clay pipes shall be capable of resisting the jacking forces involves across the pipe and external loads requirement as specified in this Specification.

2 The manufacturer shall declare the design jacking load.

3 All pipes or pipe sections shall be sampled after any grinding or cutting of ends and tested to the requirements of the relevant Standards.

4 When tested in accordance with EN 295-3:1991, the deviation from squareness measured at the pipe ends should be not greater than 1 mm.

B Jointing Sleeves

The joints of the vitrified clay pipes shall be of the double spigot type that are suitable for direct jacking or micro-tunnelling. The jointing sleeves shall be made of Type 316 stainless steel.

C Rubber Rings

The rubber sealing rings and other jointing materials used in the joint assemblies shall comply with the requirements as specified in the relevant Standards.

D Buffer Rings

The buffer ring shall be made of standard flooring grade chipboard sheets.

2.03 Jointing Collars

Where steel collars are used for pipe joints, it shall be made of austenitic Stainless Steel of Type 316 with minimum chrome content of 17% and minimum nickel content of 8%. The jointing collar shall be of dimension and thickness to be approved by the Engineer.

Part 3 Execution

3.01 Preparation

A The Contractor shall be responsible for means and methods of tunnelling and pipe jacking operations and shall ensure the safety of the works, the Contractor's employees, the public and adjacent structures whether public or private.

B Tunnelling and pipe jacking operations shall be so executed that ground settlement or loss will be minimised. The completed jacking pipe shall have full bearing against earth, no voids or pockets shall be left in any portion of the works. Fill the annular space between the installed jacking pipe and the ground with grout.

C Maintain clean working conditions inside the tunnel excavation and jacking operation area and remove spoil, debris, equipment and other material not required for operations.

D The Contractor shall be fully responsible for the design and construction of the jacking and receiving pits, thrusting wall, installation of jacking equipment, sheeting, bracing, etc., and for the efficient execution of the jacking operation. Full details, of the proposals, including plant, shield machine, equipment, operating procedures, jacking pit and intermediate jacking stations etc., shall be submitted to the Engineer and shall be fully satisfactory to him before construction. However, review of the plans shall not relieve the Contractor from his responsibility to provide a safe and satisfactory jacking pit. On successful completion of the jacking operation (i.e. the jointing of the length of jacked pipes, jointing and installing of the M.S. pipeline, hydraulic pressure testing of the pipelines and after the connections at the extreme ends of the M.S. pipeline have been made), the Contractor shall remove completely the jacking pits and receiving pits together with all the temporary works.

E For the sections of the pipeline crossing under roads, railway or structures along the pipeline route, the Contractor shall be required to incorporate in his tunnelling method measures to arrest settlement or upheaval of the soil so as to safeguard the integrity of

the structures and other property. The Contractor shall ensure that the traffic flows along railway lines and roads are not affected in any way by his work.

F Where the Contractor proposes to use compressed air for pipes of diameter 1200mm and above, his proposal must comply with the requirements of the Specification under "Working in Compressed Air" and "Specification for work in Compressed Air".

3.02 Groundwater Control and Ground Stabilisation

A The Contractor shall provide the necessary groundwater control measures to perform the work and to provide safe working conditions. Contractor shall prevent excessive inflow of water into the excavation during construction of the tunnel. The Contractor's Groundwater Control Method shall provide means to prevent piping of fines into shafts or tunnel and other adverse effects due to groundwater inflow.

B The excavation will be below the groundwater table and portions may be in cohesionless sands and in conditions which may require a groundwater control system for the tunnelling operations. Use eductors, well pointing, deep well pumping or other means to remove water and to achieve stable conditions. Apply measures as described in Item Control of Water in Section 02200 – Earthworks and Site Preparation. If dewatering is the sole means of groundwater control, draw groundwater level down below the elevation of the invert of the tunnel.

C Tunnelling operations for which groundwater control is necessary shall not proceed until monitoring data show that it is safe to do so.

D The dewatering method used shall not caused damage to adjacent structures or property. Contractor's dewatering method shall provide means for controlling water inflows to prevent inflow of fines and other adverse effects due to groundwater. In the event damage does occur, the Contractor shall be fully responsible for correction of damage and settlement of any claims arising from such damage.

E It shall be the responsibility of the Contractor to maintain stable soil conditions at the jacking face to prevent loss of ground above the jacking operation and movement of the surrounding earth. The methods of maintaining face stability and preventing ground movement and subsidence shall be by means of compressed air or other plenum methods where fluid slurry or earth pressure is applied to the tunnel face. Alternatively, unstable ground ahead of the jacking face may be stabilised by the injection of suitable chemicals. Methods that require dewatering of the ground will not be accepted, nor will methods that may lead to significant ground loss. The Contractor's proposal must be submitted to the Engineer for his approval.

F Movement or settlement of structures, utilities and pavement shall be monitored by the Contractor during the jacking operation and reported to the Engineer. If movement or settlement occurs which in the opinion of the Engineer may cause damage, the Contractor shall take immediate action to prevent further movement, settlement or damage. He shall repair at his own cost any damage and restore structures or pavements to the satisfaction of the Engineer.

G Install and maintain ground monitoring instrumentation system to monitor the water level and to detect any movement in adjacent structures as specified in Section 02722 - Instrumentation and Monitoring for Pipe Jacking.

H If eductors, well points, or deep wells are used, space them adequately to provide the necessary groundwater control. Sand packing and other means shall be used to prevent piping of fine sands and silts from the subsurface and to minimise ground subsidence.

Ensure that subsurface soil is not being removed by the dewatering operation or subsurface drainage into the shafts.

I Keep sufficient pumping equipment and other machinery available at the site to assure that the operation of the dewatering system can be maintained.

J The dewatering system shall remain in operation until the jacking pipe is installed.

3.03 Equipment

A Any method or equipment which the Contractor can demonstrate, based on past experience, will produce the specified results for the ground conditions will be considered, provided it complies with all requirements of relevant authorities.

B No gasoline-powered equipment shall be permitted in the tunnelling operation or shafts. Diesel, electrical, or air-powered equipment will be acceptable subject to applicable requirements of relevant authorities. Diesel engines equipped with scrubbers are acceptable only when tunnelling in free air, and with adequate ventilation.

C Tunnel Boring Machine: If a TBM is used, Contractor shall employ equipment that will be capable of handling the various anticipated ground conditions. In addition, the TBM shall conform to the following, as a minimum:

1. Be capable of minimising loss of ground ahead and around the machine and providing satisfactory support of the excavated face. Provide means for maintaining the tunnel face under wet and adverse soil conditions. Use, if necessary for ground control, closure doors on the cutter wheel or other means, such as pressure balance or slurry shield.

2. Depending upon Contractor's selected equipment, the TBM shall conform to either of the following:

   a. Have propulsion jacks capable of moving the machine in a forward direction while maintaining the construction tolerances with respect to line and grade, without damage to the pipes. Design the propulsion system so that in the event of failure of any element of the system, there is no movement backward and there is no over-stressing of the pipes.

   b. Be moved forward by the pipe jacking equipment while maintaining the construction tolerances with respect to line and grade with steering jacks in an articulated machine.

   c. Have a display available to the operator showing the position of the TBM in relation to a design reference.

   d. Incorporate a suitable seal between the TBM and the loading pipe to prevent loss of bentonite.

   e. Electric or hydraulic motors and operating controls to be protected against water inflows.

   f. Use a bi-directional drive on the cutter head wheel, fins, or grippers to minimise roll due to rotation.

D Tunnel Shield: If a tunnel shield is used (with or without attached mechanised excavating equipment), the Contractor shall employ a shield that will be capable

of handling the various anticipated ground conditions. The Contractor must provide proof that the particular model of shield has been successfully in soils similar to that on the site. The crew for the operation of the shield must be specialist, with experience in the use of that particular type of machine. In addition, the shield shall:

1. Conform to the shape of the tunnel with a uniform perimeter that is free of projections that could produce over excavation or voids. An appropriately sized over-cutting bead or taper along the length of the shield may be provided to facilitate steering. Although it is recognised that a capability to over excavate beyond the perimeter of the shield may be necessary under certain conditions, provisions to prevent accidental over excavation should be provided.

2. Have a hood, poling or breasting plates, shelves and breast jacks, breast tables and combinations of these and such other bracing as necessary to fully support the face of the tunnel excavation without loss of ground.

3. Depending upon Contractor's selected equipment, the shield shall conform to either of the following:
   a. Have a propulsion system moving the shield in a forward direction, while maintain the construction tolerances with respect to line and grade, without damage to previously installed pipe.
      Design the propulsion system so that in the event of failure of any element of the system, there is no movement backward and there is no over-stressing of the pipes.
   b. Be moved forward by the pipe jacking equipment while maintaining the construction tolerances with respect to line and grade, with steering jacks in the shield.
   c. Have survey controls showing the location of the shield in relation to the design references.
   d. Have motor and controls protected against water inflow.
   e. Incorporate a suitable seal between the shield and the leading pipe to prevent loss of bentonite.

E Pipe Jacking Equipment: Provide a tunnelling operation which includes a pipe jacking system with the following features:

1. The main jacks mounted in a jacking frame located in the starting shaft. To the greatest extent possible jacking loads will be taken by the shaft base slab and not walls.

2. A jacking frame which successively pushes a string of connected pipes following the tunnelling excavation equipment toward the receiving shaft.

3. Sufficient jacking capacity to push the tunnelling excavation equipment and the string of pipe through the ground. Incorporates intermediate jacking stations, if required.

4. Hydraulic cylinder extension rates which are synchronised with the excavation rate of the TBM, as determined by the soil conditions, if advanced by the pipe jacks.

5. Develops a uniform distribution of jacking forces on the end of the pipe by use of spreader rings and packing, measured by operating gauges.

6. Provides and maintains a pipe lubrication system at all times to lower the friction developed on the surface of the pipe during jacking.

7. The Contractor shall be required to furnish and install and remove to the extent required, thrust blocks or whatever provisions that may be required for backing-up the jacks employed in jacking the pipe forward. The jacking pit shall also be equipped with steel rails or beams embedded in concrete for placement and alignment of each pipe during the jacking operation. Other method may be used subject to the approval of the Engineer.

F Air Quality: Provide equipment to adequately ventilate the entire tunnel operation during construction.

1. Provide portable testing equipment for carbon monoxide gas, hydrogen sulphide gas, oxygen deficiency, explosive gases and other hazardous gases.

2. Provide an audible automatic gas alarm to detect explosive gases on the TBM. The alarm shall be located near the tunnel face.

3. Equip motors and controls with an automatic shutoff methane monitoring system.

G Equip electrical systems utilised on the TBM with an appropriate ground fault system. Insulate electrical systems and do not permit any bare wire exposures.

H Provide adequate lighting with lights at 15 metres, maximum. Enclose fixtures in watertight enclosures with suitable guards. Provide separate circuits for lighting and other equipment.

I Provide necessary safety devices for locomotives or cars used for personnel transport.

J Necessary equipment for tunnel excavation shall include signal systems, fire extinguishers, safety equipment and other equipment required by the Contractor's method of construction. Maintain such equipment in good repair and have readily available at the place of work.

K Thrust Blocks: Use thrust blocks for pipe jacking that are properly designed and constructed. Position thrust blocks normal to the proposed pipe alignment. Use thrust blocks designed to support the maximum obtainable jacking pressure developed by the main jacking system. Special care shall be taken when setting the pipe guide rails in the jacking shaft to ensure correctness of the alignment, grade, and stability. Thrust blocks shall be designed to cause no damage to the shaft floors or sidewalks.

3.04 Excavation and Jacking of Pipe

A Tunnel Excavation:

1. Conduct tunnelling operations in accordance with applicable safety rules and regulations and use methods which include due regard for safety of workmen, adjacent structures, utilities and the public.

2. Keep tunnel excavation within the easements and right-of-way, to the lines and grades designated on the Drawings. Methods of tunnel excavation are at the Contractor's option, subject to review by the Engineer.

3. Locate equipment powered by combustible fuel at suitable distances from shafts and protect equipment to prevent the possibility of explosion and fire in shafts or the casing pipe.

4. During Open-Face Excavation:

   a. Excavate the face commencing at the crown and proceed down to the invert. Keep the hood buried in the soil ahead where soils include sands and silts. Excavate the heading so that both sides of the heading are excavated simultaneously.
   b. Keep the face breasted or otherwise supported; employ other means as necessary to maintain face stability and prevent falls, excessive ravelling, or erosion. At all times maintain standby face supports to allow for immediate use when needed.
   c. During shutdown periods, support the face of the excavation by positive means; no support shall rely solely on hydraulic pressure. When required by the Engineer, and in all cases when the face is untouched for more than 24 hours, fully breast the face and shove the shield tight against it.

5. During Closed-Face Excavation:

   a. Carefully control and monitor volume of spoil removed. Balance spoil removed with advance rate and excavation rate to avoid over excavation.
   b. When cutting face is withdrawn for any purpose, keep excavated face stabilised by means necessary.
   c. Advancing Shield: During forward movement of the shield, provide sufficient support at the excavation face to prevent loss of ground.
   d. Size of Tunnel Excavation: Make the excavation of a minimum sufficient size to permit pipe installation by jacking with allowance for bentonite slurry or other similar material injection into the annular space.

B Pipe Jacking:

1. For pipe jacking, use pipe that is round with a smooth, even outer surface and has joints that allow for easy connections between pipes. Pipe joints shall be watertight. Pipe ends shall be such that jacking loads are evenly distributed around the entire pipe joint and such that point loads will not occur when the pipe is installed. Pipe used for pipe jacking shall be capable of withstanding all forces that will be imposed by the process of installation as well as the final in-place loading conditions. Protect the driving ends of the pipe and joints against damage.

2. Maintain an envelope of bentonite slurry or other similar material, around the exterior of the pipe during the jacking and excavation operation to reduce the exterior friction and possibility of the pipe seizing in place. Water jetting of the ground to advance the pipe is not permitted.

3. In the event a section of pipe is damaged during the jacking operation, or joint failure occurs as evidenced by inspection, visible groundwater inflow or other observations, use one of the following procedures to correct the damage as directed by the Engineer.
   a. Slightly damaged pipe which maintains pipe barrel and joint structural integrity may be repaired in place with a method approved by the pipe manufacturer, and subject to review and approval by the Engineer.
   b. Severely damaged pipe or pipe where structural pipe barrel or joint failure is evident, shall be removed from the excavation by jacking it through the

excavation and removing it at the receiving shaft or by surface access subject to review and approval by the Engineer.

4. After the jacking operation has begun, the Contractor shall work continuously and expeditiously in accordance to programme until the complete length of jacked pipes is installed. This continuous work where required shall not be construed as overtime work.

5. During jacking and excavation, the Contractor shall constantly ensure that the internal surface of the jacking pipes is not damaged, and he shall remove the excavated spoil to the jacking pit by conveyor or by other means so as to minimise traffic on the invert.

6. The pipes for the jacking operation shall not exceed 3 m long. The pipe ends shall be jointed by stainless steel collar before the pipe is jacked. Details of how the pipes are to be lowered into the pit and jointed shall be submitted to the Engineer for approval.

7. There shall be provision to prevent the relative movement between pipes at the joints by the use of steel gaiters or other approved methods during jacking operation. A packing piece of compressible material shall be provided at each joint and shall be securely held before the pipes are lowered into the thrust pit. Details of proposals shall be submitted to the Engineer for approval.

8. It is responsibility of the Contractor to ensure that the complete tunnels are watertight. If leakage occurs before completion or during the maintenance period, the Contractor shall carry out any remedial work that may be necessary to make the Works watertight all at his own expense.

9. The Contractor shall arrange for closed circuit television (CCTV) to inspect newly constructed pipeline smaller than 900mm in diameter laid by the jacking method. Prior to the television inspection, the lengths of pipeline must be thoroughly cleaned out. The CCTV recording shall be carried out in the presence of the Engineer or his representative and a video tape recording of the inspection together with a written report shall be submitted to the Engineer for viewing and record purposes. If need be, the Engineer may request for re-inspection by CCTV so that selected parts of the pipeline can be studied in detail. Any defects detected shall be rectified immediately and the rectification work shall be confirmed by CCTV inspection.

C Grouting:

1. Completely fill voids outside the pipeline outside diameter (OD). Fill with pressure-injected cement grout or similar material.
2. Furnish and operate suitable equipment for any required grouting operations depending on the condition of the application.
3. Take care in grouting operations to prevent damage to adjacent utilities or other properties. Grout at a pressure that will not distort or imperil any portion of the work or existing installation or structures.
4. Where chemical stabilisation of soil is used, a chemical grout shall be pressure injected into the soil over and ahead of the pipe jacking to stabilise the soil. The chemical grout used shall have a demonstrated history of success for stabilising soils similar to that through which the pipe is to be jacked.
5. The Contractor shall be fully responsible for preventing the occurrence of voids outside the pipe and if they occur he shall fill them with cement grout.

6. Immediately following the jacking operation the Contractor shall pressure grout the jacked section to fill all voids existing outside the pipe. Grouting shall be from the interior of the pipe through grouting holes as specified.
7. Systems of standard pipe, fittings, hose and special grouting outlets embedded in the pipe walls shall be provided by the Contractor. Care shall be taken to ensure that all parts of the system are maintained free from dirt. Grout composed of cement, sand and other approved compound and water shall be forced under pressure into the grouting connections at the invert and shall proceed until grout begins to flow from upper connections. Connections shall then be made to these holes and the operation continued to completion.
8. Apparatus for mixing and placing grout shall be of a type approved by the Engineer and shall be capable of mixing effectively and stirring the grout and then forcing it into the grout connections in a continuous uninterrupted flow.
9. After grouting is completed, pressure shall be maintained by means of stop cocks, or other suitable devices until the grout has set sufficiently. After the grout is set, grout holes shall be completely filled with dense concrete and finished neatly without evidence of voids or projections.
10. For pipes with PVC or HDPE linings, grouting shall be carried out and the Contractor shall ensure that the pipeline is watertight before proceeding with the jointing of the linings of the pipes and the patching of the lining over the filled grout holes.

3.05 Jacking Operation Data

A Shift logs of construction events and observations shall be submitted within 24 hours of the operations which shall include, but not necessarily be limited to:

1. Location of TBM face or shield by station and progress of tunnel drive during shift .
2. Hours worked per shift.
3. Completed field forms for checking line and grade, with achieved tolerance relative to design alignment. Copies of steering control data will generally acceptable.
4. Thrusting pressures and rate of thrusting
5. Maximum pipe jacking pressures per shove and rams used.
6. Location, elevation and brief soil descriptions of significant soil strata.
7. Groundwater control operations and piezometric levels.
8. Observation of lost ground or other ground movement and settlement of existing structure.
9. Indications of damaged pipe joint or pipe.
10. Any unusual conditions or event.
11. Operation shutdown periods or other interruptions in the work and reason.

3.06 Control of Line and Grade

A Construction Control:

1. The Engineer will establish the baseline and benchmarks on site for the Contractor's use. Contractor shall check baseline and benchmarks at the beginning of the Works and report any errors or discrepancies to the Engineer.

2. The Contractor shall use the baseline and benchmarks established by the Engineer to furnish and maintain reference control lines and grades for the casing pipe construction. Use these lines and grades to establish the exact location of the tunnel excavation, casing pipe and structures.

3. The Contractor shall establish and be responsible for accuracy of control for the construction of the entire Works including access shaft locations, structures, excavation, pipe alignment and grade.

4. Establish control points sufficiently far from the tunnel operation not to be affected by ground movement.

5. Maintain daily surveying records of alignment and grade. Submit three copies of these records to Engineer within 24 hours of the operation. The Contractor remains fully responsible for the accuracy of the work and the correction of it as required.

6. Check the primary control for the excavation against an above ground undisturbed reference at least once a week and once for each 75m of tunnel constructed or more often as needed or directed by the Engineer.

B Earth Movement: The Contractor shall be responsible for damage due to settlement from any construction-induced activities.

1. Take precautions to avoid damage or settlement to the buildings, structures, roads and utilities in close proximity to the work. Use of construction methods and equipment to minimise loss of earth at the excavation face and settlement of earth around the casing pipe.

2. In the event any movement of ground is detected, the Engineer may order the work stopped and secured. Before proceeding, the Contractor shall correct any problems causing or resulting from such movement.

3. The Contractor shall be aware that if settlement of the ground surface should occur during construction which will affect the accuracy of the temporary benchmarks established by the Engineer, it shall be the Contractor's responsibility to detect and report such movement.

C Line and Grade;

1. Record the exact and position of the TBM or shield at each shift to ensure the alignment is within specified tolerances. Carry out the survey immediately behind the excavation face to allow immediate correction of misalignment before allowable tolerances are exceeded.

2. When excavation is off line and grade, make alignment corrections immediately.

3. Perform a verification survey of each joint of the installed casing pipe from shaft to shaft after removal of the tunnelling equipment. Document measured conformance to design line and grade of the casing pipe together with locations and deviation (distance and direction) of any out-of-tolerance locations.

4. The pipes shall be jacked into place true to line and level. The maximum tolerance allowable in the displacement of the centreline of the jacked pipe from the design centreline is 75 mm in the horizontal plane and 25 mm in the vertical plane but there shall be no backfall at any point. Any pipe which is not laid in its correct position must be removed and relaid or adjusted to obtain its correct position.

5. If line and grade benchmarks are disturbed or destroyed, the Contractor shall re-established at Contractor's own cost.

3.07 Safety

A The Contractor shall design his operation to ensure optimum number of plants to be used in the pits and any of which produces noxious gases or is operated by electricity at a greater voltage than 240V shall be permanently located outside the pit at ground level.

B A ladder shall be fixed permanently in the receiving pit. Two ladders shall be permanently fixed on opposite sides of the driving pit, one on each side of the pipe jacking line. These ladders shall be kept clear of obstructions to allow rapid exit in an emergency. Excavated materials and plant other than small tools shall not be passed via the ladder but shall be handled by crane.

C Pits shall be securely fenced to prevent unauthorised persons from entering in. Where necessary, the Engineer may instruct the Contractor to provide 24 hours guards at these facilities at no extra cost to the Contract.

D All persons entering the pits shall wear safety helmets constantly, and shall leave the pits for meal breaks, rests and the like.

E At the beginning of each shift and after any break for refreshment or other reason, the Contractor shall provide and use an approved instrument to check for noxious gases before anyone re-enters either pit.

F All costs associated with the provision of safety equipment and measures shall be deemed included in the Contract Rates.

3.08 Ultrasonic Examinations of Welded Joints

A All welded joints of pipes through the pipe sleeves and welded joint of reinforced concrete M.S. pipes shall be inspected visually and tested by ultrasonic examination in accordance with BS 3923 in the presence of the Engineer or his representatives.

B The Contractor shall submit his proposals to the Engineer for site ultrasonic examination. The size, number and make of ultrasonic equipment proposed shall be stated. The Contractor shall provide adequate equipment and qualified and experienced personnel to conduct the ultrasonic examination.

C The Engineer's instructions given as a result of the examination of ultrasonic results shall be final.

D The Engineer reserves the right to carry out any independent ultrasonic examination of the welded joints as he may deem fit. Such independent ultrasonic examination shall be carried out by an Inspector, appointed by Engineer and paid through items in the Bill of Quantities. The Contractor shall provide such assistance, labour, materials, electricity, supply ultrasonic examination equipment and other apparatus as may be necessary to allow a thorough and extensive independent examination to be carried out.

3.09 Laying and Connections of Pipeline in Jacked Pipe Sleeves

A The laying of the M.S. pipeline shall only commence after the full completion of the jacking of the pipe sleeves to the approval of the Engineer. The M.S. pipes shall be jointed by welded split collars as specified in this Specification. In addition, all welded joints shall be inspected visually and tested by ultrasonic examination as specified in this Specification.

B After each section is jointed by welding and approved by the Engineer or his representatives, the M.S. pipe shall be pushed through the sleeve. The bottom of the M.S. pipes shall be suitably supported on rollers or other means to prevent scouring of the M.S. pipe external surfaces. Care shall be taken to ensure that the internal concrete linings are not damaged during the operation.

C The pipe ends shall be properly braced to prevent damage. The end of the jacked pipe sleeve shall be grouted after the full length of M.S. pipe has been jacked/pushed through.

3.10 Laying and Connection of Reinforced Concrete Pipe

A After jacking of the pipe length is completed, the pipe shall be jointed to the next pipe by welded split collars as specified in this Specification. In addition, all welded joints shall be inspected visually and tested by ultrasonic examination as specified in this Specification.

B After each section is jointed by welding and approved by the Engineer or his representatives, the pipe shall then be jointed by external thrust collar and grouted prior to the jacking of the next length.

3.11 Grouting at Welded Joints

A After the Engineer has advised the Contractor in writing that a welded joint has cleared the ultrasonic examination, the void at the joint between the thrust collar and the welded collar shall be completed by pressure grouting. The Contractor shall provide all plant and equipment for mixing and injecting grout. The composition of the grout shall consist of 1 part of cement to 2 part of sand slurry, the crushing strength of which when set shall be equal to that of the internal lining of the pipe.

B Grout shall be injected at a pressure that will enable the whole void between the thrust collar and the internal collar to be filled up completely. Grout pipes shall be secured to the grout holes in such manner that no leakage shall occur during grouting. Grouting shall start from the bottom hole upwards with all other holes left open and shall continue until grout escapes from the holes on the horizontal diameter of the collar joint. The bottom hole shall then be plugged and sealed off by welding. Grout shall be injected through both the horizontal holes. When grout escapes through the vertical hole at the crown of the collar, the two horizontal holes shall be plugged by welding. Grouting shall continue through the top most hole until all air is expelled by the grout escaping through the air release hole. The grout hole and the air release hole at the crown of the collar shall finally be plugged. All grout holes and the air release hole shall be plugged by depositing weld to the full depth of the thickness of the internal collar.

C The Contractor shall ensure that fouling of the equipment and lines is prevented by constant circulation of grout and by periodic flushing out of the system with water. Flushing shall be undertaken with the grout intake valve closed, the water supply valve open, and the pump running at full speed.

3.12 Connections at Ends of Pipeline

A Connections at the extreme ends of the jacked pipeline shall be made only upon successful completion of the hydraulic pressure test of the pipeline as specified in this Specification.

B The connections at the two ends of the jacked pipeline will be made at the jacking or receiving pits. The Contractor shall maintain and keep these pits intact and in a safe condition to facilitate the connections. The Contractor shall remove all other temporary

works and any concrete blocks including cutting and removing part of the walls of the pits that are in the way of the pipework connections.

C When the Contractor has completed the connections of the pipelines and has completed the protection of these connections with sand or concrete surround, he shall then backfill the pits with well-compacted suitable approved materials. The removal of the temporary bracings and strutting shall be carried out systematically together with the backfilling of the pits to prevent collapse of the pit walls. The walls of the pits shall only be removed when the backfilling of the pits is completed.

D Seal terminations of pipes which are not connected to permanent structures by a temporary blind flanges.

3.13 Long Distance and Curved Pipejacking

A General

1 In mechanical tunnel driving, it is vitally important to have a permanent check on the position of the tunnel-boring machine (TBM) with respect to the designed tunnel axis (DTA) to allow corrective action to be taken well in advance of any deviation and prevent the TBM drifting out of tolerance.

2 In pipe jacking, it is essential to avoid sudden changes in direction and in point loading the outer edges of the pipe, as damage in the area of the seal cannot be tolerated if the water tightness of the drive is to be maintained. Changes in direction cause more resistance to the movement of the machine and all the following pipes that in turn require greater hydraulic forces to overcome the increased friction.

3 In the case of long distance or curved pipejacking however, there is one fundamental difference in the supply of the guidance information to the machine operator. This is the positioning of the laser reference in a stable position once the machine has advanced to a point where the laser beam can no longer activate the Target from the start shaft. At this point the laser reference most be positioned within the moving pipe. As soon as the laser reference is no longer in a stable position it is necessary to accommodate this fact.

4 Control surveys shall be taken in static situations. This absolute measurement shall be applied to the guidance of the machine in the dynamic situation where the hydraulic forces used and varying geological conditions cause short-term anomalies in the position of the elements of the pipeline and components within it.

B References

Reference shall be made to the Specification for required accuracy and tolerances and other matters affecting the operation of the system.

C Technical Aspects

1 The tunnelling system shall be designed to maintain a clear space for the guidance system and laser beam, irrespective of shield / TBM orientation.

2 The guidance system, including cabling and connectors, shall be robust. It shall be capable of sustained, safe operation within the onerous environmental conditions of a tunnel under construction, where dust, water, high humidity,

varying quality of power supply, sustained vibration and repeated shocks are to be expected.

3 The guidance system shall be self-checking, with redundancy in essential components, and shall generate and record appropriate status messages for delivery when remotely or locally interrogated and to alert the operator to fault conditions immediately they occur.

4 Loss of primary power to the guidance system in the tunnel shall not result in data loss, which would prevent the system self-starting on resumption of primary power supply.

5 During forward movement of the shield or TBM, the guidance system shall provide as a minimum the following real-time data for the shield or TBM, with reference to the designed tunnel alignment at the machine head:-

a Station (chainage)
b Horizontal / line displacement
c Vertical / level / grade displacement
d Left or right lead / yaw
e Overhang or look-up / pitch
f Main axis rotation / roll

6 This information shall be presented in numerical and graphical form, refreshed every 20 seconds or faster. With historical tendency diagram for analysis of machine steering characteristics.

7 The system shall have an accuracy of at least ± 50mm over a self-referenced jacking range of 100m.

8 The data shall be presented on displays at the Machine Operators position and if required at the offices on surface of the Contractor and the Engineer. Facilities to download data electronically (for further transmission) and for paper printout, independently of the current display, shall be provided.

9 Data shall be recorded in a medium unaffected by primary power loss in a store of sufficient capacity to hold the entire tunnels production records.

D Procedural Aspects

1 The operation of the guidance system shall be a specific feature of the Contractor's Tunnelling Work Plan should clearly address:-

a Definition of responsibility and authority of personnel maintaining and operating the guidance system.

b Intervals between manual checking of data produced by the guidance system (intervals may be adopted as experience is gained).

c Intervals at which control surveys are to be carried out, based upon tunnel geometry, rate of advance and tolerance requirements, but not greater than 100m.

d Detection and correction of trends to non-conformance, (requiring long-term data storage).

2 It shall be clearly stated that the guidance system must be fully operational whenever the shield or TBM is advancing.

3 The guidance system shall permit the following operations:-

a Input of machine and project parameters.
b Standard geometric elements of tunnel alignment and subsequent computation of alignment data for stations at 1m intervals.
c Fully computed Designed Tunnel Alignment data
d Input of initial survey data, control survey data and reference line data, clearly recording each input for future reference.
e Automatic determination of Target position and orientation with respect to the laser reference.
f Control of the motorised laser theodolite, capable of continuously maintaining its operation during the forward advance of the pipeline.
g Verification of laser reference position in the advancing pipeline with Manual or Automatic initiation of the survey measurement cycle.
h Automatic measurement of the pipe advance.
i Automatic input of measurement cycle data into reference line editing program for easy smoothing.

3.14 Alternative Method of Pipe Jacking

A Methods of pipe jacking other than described above may be proposed by the Contractor and subject to the approval of the Engineer.

END OF SECTION 02720

SECTION 02722

Instrumentation and Monitoring for Pipe Jacking

Part 1 General

1.01 Section Includes

A To ensure that the stability of the structures in the vicinity of the proposed works, the Contractor is required to implement a programme to monitor the surface and subsurface ground movements, the variation of ground water table and pore pressure and the settlement and distortion of buildings and structures.

B The Contractor shall submit full details of his proposed monitoring procedures and instrumentation to the Engineer for approval within 4 weeks from the date of site possession. The monitoring programme shall include the setting up of settlement points, stand pipes and inclinometers as specified below. Additional monitoring stations, devices and procedures shall be provided if deemed necessary or if so directed by the Engineer during the progress of the work.

C The Contractor shall commence the monitoring programme at once after the award of the Contract. The on-going rate of intrinsic settlement and subsurface ground movement, if any, at the site shall be determined during this period for the purpose of differentiation when the sewerage work is in progress.

` D The Contractor shall be solely responsible for determining the locations and types of geotechnical instruments to be installed on site. The actual instrumentation locations will be chosen to accommodate construction operations, subject to the review and approval of the Engineer.

E The Contractor shall be responsible for ascertaining the safety limits for soil/geotechnical movements or changes to ensure that all structures and properties are not endangered. The safety limits shall be submitted to the Engineer for information. The Engineer reserves the rights to improve on the safety limits when deemed necessary.

F All readings and measurements shall be properly taken, recorded and interpreted by qualified personnel, endorsed by P.E. and one set shall be submitted to the Engineer immediately. It shall be clearly understood that the submission of the reports on monitoring to the Engineer are for the Engineer's information. The Contractor shall be solely responsible for the analysis and interpretation of all the readings and measurements and for taking all rectification measures where necessary. When abnormal readings or measurements are obtained, the Contractor shall immediately stop all movements or changes, and shall immediately investigate the causes of the abnormalities. The Contractor shall take all necessary rectification measures before resuming such activities, all at the Contractor's own cost.

G The Contractor shall maintain in good working condition all monitoring instruments and devices throughout the Contract period. If in the opinion of the Engineer, any instrument or device is not functioning properly or accurately, it shall be replaced immediately at the expense of the Contractor.

H The instruments shall be removed from site by the Contractor upon completion of the Works or as and when directed by the Engineer. All costs incurred for the removal of

the instruments shall be deemed to have been included in the rates for the items on instrumentation in the Bills of Quantities. All read out units and the instruments shall remain the property of the Contractor.

I The Contractor shall allow in his rates for carrying out the monitoring programme as specified, including any additional stations, devices and procedures as may be directed by the Engineer.

Part 2 Not Used

Part 3 Execution

3.01 Frequency of Readings

The frequency of readings for the various instruments throughout the duration of the contract shall be:-

1 Standpipes - Readings shall be taken at least once a week;

2 Piezometers - Readings shall be taken at least once daily;

3 Inclinometers - Readings shall be taken at least once daily.

3.02 Settlement Points

A A grid of surface settlement points shall be established along the alignment of the pipeline. The grid shall consist of points at 10m intervals perpendicular to the centre-line of the proposed pipeline. Each line shall consist of a minimum of 5 points at 5m centres with the middle point on the centreline of the pipe.

B These settlement points shall be surveyed by the use of precise survey instruments and at least 3 permanent bench marks shall be established on stable and firm ground away from the working area for this purpose.

C As the excavation proceeds, all surface settlement points within an area of 100m ahead and 100m behind the ends of the trench shall be surveyed daily. Outside this area, selected points at intervals as determined by the contractor's PE shall be surveyed at least once a week.

3.03 Installation of Standpipes

A Standpipes shall be installed in boreholes as instructed by the Engineer for recording the highest ground water level encountered and changes in this level.

B Standpipes shall consist of steel or uPVC tubing of at least 12mm diameter. Slots or holes shall be formed in the lower 1.5m of pipe, or porous element shall be provided. The lower end shall be plugged to prevent entry of soil during installation and the total length of each standpipe shall be recorded.

C A layer of suitably graded filter material shall be placed on the bottom of the borehole prior to installation the standpipe.

D The boring shall be backfilled with clean gravel or coarse sand to within 1 m of ground level unless otherwise specified, and thereafter with impervious material so as to prevent the entry of surface water.

E Approved arrangements shall be made by the Contractor to protect the top of the standpipe.

F The ground water level shall be recorded immediately before and after the installation of the standpipe and the sounding device shall also be used to check the total length of standpipe installed.

3.04 Installation of Piezometers

A When measurements of water pressure (in terms of head of water) in a particular stratum are required a piezometer shall be installed.

B Piezometers may be of the following types:

1 Casagrande single tube;
2 Hydraulic or pneumatic twin tube;
3 Electrical transducer;

and shall consist of a filter tip, uPVC tubing and/or pressure transducer and all the necessary accessories for the purpose of measurement pressure.

C The method of installation is generally as for standpipes with the following exceptions:

1 For cell lengths above the base of the borehole a plug of bentonite-cement shall be provided to prevent upward flow of water into the cell.

2 A suitable cell length of graded filter material shall be provided and the top shall be placed centrally within this length.

3 Above the cell a seal shall be provided by a plug of stiff bentonite in the form of bentonite balls tamped into place, and this shall be covered with bentonite-cement grout to a thickness of 0.5mm above the cell.

3.05 Installation of Inclinometer Tubing

A Inclinometer tubing shall be installed in boreholes to monitor horizontal deformations in the ground.

B The inclinometer tubing shall be installed centrally within the borehole. Joints between tubes shall be made watertight.

C The inclinometer tubing shall be sealed into the borehole using a suitable grout. The grout shall be introduced into the bore-hole using a tremie pipe extending to the base of the borehole. The grout shall be designed so that the deformation modulus of the grout is similar to that of the ground in which the inclinometer is installed.

D In permeable soils of jointed rocks where there is a possibility of grout flowing away from the borehole, the borehole shall be pre-grouted to seal the permeable soils and rocks. The borehole shall be redrilled, regrouted and the inclinometer tubing installed.

E The level and plan position of the head of the inclinometer casing shall be measured to an accuracy ± 2mm within one week of installation and records shall be submitted to the Engineer.

3.06 Calibration

A All gauges and other instruments used for monitoring must be calibrated before hand and copies of the calibration certificates provided to the Engineer.

B All gauges and other instruments used for calibration must be re-calibrated at appropriate intervals, and copies of the calibration certificates provided to the Engineer.

3.07 Settlement/Deformations

All monitoring instrumentation shall be designed to allow for any ground settlements, heaves or deformations which may occur.

3.08 Other Requirements

All monitoring instrumentation shall be strong and durable, exhibit watertightness, corrosion resistance and long term stability to extreme temperature changes or gradient.

3.09 Testing

Within one week of installation the Contractor shall demonstrate to the Engineer that the instrumentation is functioning correctly. Such testing shall include, inter-alia:

1 that the central tube of any piezometer or inclinometer is clear to the full design depth;

2 rising and falling head permeability tests on piezometers; and

3 an initial survey of inclinometer tubes which will provide a baseline and also demonstrate that the tubes are clear.

END OF SECTION 02722

Section 02724

Working in Compressed Air

Part 1 General

1.01 Description

A The provision of compressed air facilities shall include the welfare and control measures to be carried out as specified in this Section – Work in Compressed Air.

B Where the Contractor's proposals incorporate, the use of compressed air, he shall ensure that the compressed air plant is available before work is allowed to commence.

C The compressed air plant shall consist of a main and a standby plant. The main plant shall be electrically driven from a PUB mains supply, whilst the standby plant shall be operated by other means such as on site generator. The standby plant shall be used in lieu of the main plant to supply the tunnel with air for a minimum period of 1 hour each week.

D The Engineer may at any time during the use of compressed air, require tests to be carried out to determine the minimum pressure needed. For this purpose, the air pressure shall be reduced or increased in stages as ordered by the Engineer. During the test period, observations will be made on the conditions of the working face. The Contractor shall not be entitled to any extra payment for carrying out such tests.

E When the Engineer agrees that the work can be continued in free air, he may order that the compressed air plant be kept available at no extra cost.

1.02 Specification for Work in Compressed Air

A This specification shall be read in conjunction with the specifications on Pipe Jacking.

B It may be necessary for the Contractor to work in compressed air in conjunction with heading, tunnelling or pipejacking if the ground conditions necessitate it. The Contractor is required to engage a Professional Engineer to submit all his proposals for the use of compressed air in heading, tunnelling or pipejacking and to obtain the approval of the Engineer before work starts on this section.

C The Contractor shall submit to the Engineer complete details of the following:

1 Bulkhead, air lock, man-lock, medical lock if the working pressure exceeds 1 bar, and other structures used in connection with work in compressed in air.

2 Plant and equipment for the production and supply of compressed air and standby arrangements complete with pipework; including dehumidifier and chiller etc. air flow control valves; pressure gauges; thermostatic control system and thermometers.

3 Emergency exit from and entrance to working chambers; alarm system; fire-fighting equipment.

4 Electrical control panel, lighting system and DC emergency reserve circuit.*

5 Comprehensive communication system.

6 Schedule of working pressures; compression and decompression procedures.

7 Schedule of work shifts.

8 Ventilation system including oxygen and explosive gas meters.

9 Noise suppression measures for the plant and equipment as well as for the air-lock, man-lock.

10 Name and address of medical officer or hospital to which workers will be referred.

11 Location of nearest decompression chamber (medical lock).

12 Any other details as directed by the Engineer.

D The Contractor shall submit full details of the operational procedures that will be followed in working in compressed air and to obtain the approval of the Engineer before work starts on this section.

E The Contractor shall, after installation and prior to commencing work in compressed air, subject the plant to a 24 hour continuous running test during which it must operate to the satisfaction of the Engineer. All plant and equipment shall be maintained in satisfactory working conditions at all times.

F The Contractor shall not employ any person on work in compressed air unless he has been certified fit for such employment by a medical officer not more than 3 days before commencing work. No person suffering from a cold in the head, chest infection, sore throat or earache shall work in compressed air and any person from work for more than 3 days must be re-examined and certified to be fit by a medical officer before he resumes work in compressed air. During employment in compressed air, a person must be re-examined by a medical officer once every 3 months if the maximum working pressure does not exceed 1 bar, or, once every 4 weeks if the maximum working pressure exceeds, or liable to exceed, 1 bar. The Contractor shall be responsible for arranging these medical examinations at his own expense.

* Note:
1 All electrical power supply shall be at a 100 volts, 50 hz.
2 All lighting shall be sodium vapour types and explosion proof.

G The Contractor shall not employ any person on work in compressed air unless the person has had previous experience in such work, or, if he has not had such experience, is under the supervision of a person experienced in such work. In the case of a person not previously employed in compressed air, compression shall not be carried out unless he is accompanied in the man-lock by a person competent to advise him on the appropriate conduct of persons during compression. When the working pressure is 1 bar or above, new workers should not work more than 4 hours on the first working day.

H The Contractor shall fully inform all compressed air workers of the hazards of working in compressed air. The Contractor shall supply all compressed air workers with pamphlets containing advice as to precautions to be taken and regulations to be obeyed in connection with such work. If the working pressure exceeds 1 bar, the Contractor shall supply all the workers with suitable durable labels, to be worn next to the body at all times, indicating that the wearer is compressed air worker and giving the address of the medical lock to which he should be conveyed if taken ill. In particular, the

Contractor shall inform all compressed air workers that consumption of alcohol and smoking are strictly forbidden in all compressed air areas at all times.

I The Contractor shall make arrangements to ensure that whilst any person is in compressed air, a person competent to take charge of compressed air operations is in charge of the operations and in attendance on the Site.

J The Contractor must ensure that, when the working pressure is 1 bar or above, each person must spend at least 12 consecutive hours at atmospheric pressure and not be subjected to more than 3 exposures to pressure in any 24 hour period.

K Every man-lock shall be in the charge of a competent lock attendant when any person is in the man-lock or in a working chamber to which the man-lock affords direct or indirect access. The lock attendants must be familiar with the procedures and problems associated with compression, decompression, decompression sickness and the keeping of records.

L When the pressure in a working chamber exceeds 1 bar, the Contractor shall provide and maintain a suitably constructed medical lock situated as near as possible to the man-lock. The medical lock shall at all times be kept ready for immediate use. A medical lock attendant must be on duty at all times when the working pressure is 1 bar or above and for 24 hours after the last ma-lock decompression for pressures of 1 bar or above and when any patient is in the medical lock. Any medical lock attendant shall be a qualified nurse, hold a current certificate of proficiency in first aid and trained in the medical aspects of compressed air work.

M The Contractor shall provide and maintain for the use of all compressed air workers the following:

1 Clothes and adequate and suitable facilities for the changing and drying of clothes and footwear.

2 Adequate and suitable facilities for washing, including soap and clean towels and showers with hot water.

N The Contractor shall maintain for all compressed air workers a proper record of the following:

1 Individual results of all medical examinations.

2 Accurate details of all cases of decompression sickness.

3 Details of each exposure to compressed air of each person.

The Contractor shall submit relevant extracts of the records to the Engineer as and when directed. The Contractor shall indemnify the Board against all claims that may be made by the workers for working in compressed air.

O The Contractor shall allow in his Tender for the Works in compressed air for complying with all the above requirements and the latest requirement by the relevant authority of the Government of the Project country on the use of compressed air and all other requirements which he deems necessary to complete the work successfully and no claim to the contrary will be entertained by the Contractor.

END OF SECTION 02724

SECTION 02730

Soil Stabilisation for Pipework

Part 1 General

1.01 Section Includes

A The Contractor's responsibilities for any damage to persons or properties shall be in accordance with the Conditions of Contract and the Specifications.

B This Section is for application of soil stabilisation to achieve the following:

1 Formation of a layer to resist base heave within excavations for shafts and trenches;
2 Strengthen the ground and prevent soil heave at manhole/ chamber/ open cut trench locations;
3 Protection against water flow and soil loss at all manholes, chambers, jacking/receiving shafts and open cut trenches; and
4 Prevent surrounding ground movement caused by construction activities.

C This section specifies certain materials and workmanship requirements for the construction of jet grout piles as the means of stabilising the sub-soil for the applications mentioned above. The Contractor is to note that jet grouting is meant for works and timbering. The Contractor is fully responsible for the effectiveness of the jet grouting works and any approval to carry out the works given by the Engineer will not absolve the Contractor of his responsibility towards the work.

D Soil stabilisation works for additional working shafts apart from those needed to construct manholes/chambers shall be at the Contractor's own cost.

1.02 Design and Supervision

A The Contractor shall engage a Professional Engineer to carry out a detailed study including any additional soil investigation deemed necessary of the whole site as specified to identify sites that require soil stabilisation. The Professional Engineer engaged by the Contractor shall be responsible for the design, supervision and submission of reports for all soil stabilisation works as specified, during the whole duration of the Contract. The Contractor shall submit a detailed report endorsed by the Professional Engineer for the study with recommendations on all sites that require soil stabilisation within two (2) months of award of tender. An item has been allowed for in the Bills of Quantities for the engagement of a Professional Engineer for the whole duration of the Contract, to carry out the works as mentioned above. The rate shall also include for all the necessary additional soil investigation works.

1 the sequence of forming the jet grout piles and the sequence of piling;

2 the method of monitoring and checking the stability of neighbouring properties, roads, services and other underground structures;

3 the method of monitoring the location, depth and vertically of the jet grout nozzle, including a plan showing the grid of the jet grout pile centres;

4 the specifications and details of the following equipment to be used:
   a grout mixers;
   b injection pumps
   c injection nozzles; and
   d nozzle drilling equipment

5 the method of measuring and controlling the following parameters:
   a injection pump pressure;
   b injection nozzle rod rotational speed;
   c injection air pressure; and
   d nozzle level.

6 the method of drilling and contingencies for different conditions which may be encountered.

7 the method of mixing and pumping the grout including:
   a cement type, properties and test certificates;
   b mix proportions;
   c technical details and test reports on chemical admixtures (if any);
   d trial mix details;
   e details of the storage and mixture of the elements; and
   f testing and monitoring methods

8 the method of measurement and control of surface heave and settlement due to the treatment including:
   a trial tests;
   b instrumentation and settlement monitoring locations and details;
   c identification of critical buildings and sub-surface utilities; and
   d measures to be taken to limit the effects of the treatment.

9 the method of containing excess grout and soil at the surface and disposal of the spoil.

10 the methods of verification and measurement of the grout strength and zone of treatment.

11 a comprehensive risk analysis which shall identify any safety hazards arising from the works and describe measures that will be taken to mitigate the risks.

B The Contractor is to note that certain sites under this Contract have been specifically identified for soil stabilisation works and items have been allowed in the Bills of Quantities for the Contractor to price for the soil stabilisation work (where applicable). Notwithstanding this, the Contractor shall be responsible for protecting all surrounding properties and services throughout his work. The rate shall also be deemed to include for all additional measures that the Contractor shall undertake to ensure that the jet grouting works so carried out by him is functional for the applications mentioned above.

C The Contractor's Professional Engineer is to carry out the detailed design of all soil stabilisation works including those sites specified under this contract (where applicable), submit method statements, submit trial test and final reports and to supervise the whole of the soil stabilisation works. All costs relating to this is deemed to be included in the rates for the engagement of the Professional Engineer as mentioned above.

Part 2 Not Used

Part 3 Execution

3.01 Soil Stabilisation Using Jet Grout Piles

A Jet Grout Pile Construction

1 Jet grouting is a technique whereby a mix of cement, water, air and, optionally, chemical additives is injected continuously at high pressure from a nozzle which is progressively removed from below the ground from a depth to which it had previously been bored. The grout, which has been injected under pressure, mixes with and replaces the sub-soil. When it hardens, the grout forms a column of hardened material. A series of columns are formed at a close spacing to form a hardened layer.

2 The recommendations of BS 8004:1986 "Code of Practice of Foundations" shall apply to these works in so far as they are applicable to jet grout pile construction, except that, in the event of conflict or ambiguity, this Specification shall take precedence.

B Method Statement

1 The Contractor shall submit a comprehensive method statement, endorsed by the Contractor's Professional Engineer, giving full details of the materials, plant and operations involved in the different types of jet grout pile applications. The Method Statement shall include the following details:-

a location of the jet grout piles;
b dimensions of the jet grouted layer including founding level, layer thickness and cut-off level:
c dimensions of the grout pile columns including theoretical diameter and spacing;

2 Construction of the jet grout piling works shall not commence until the Contractor's proposals have been accepted by the Engineer. The Contractor shall then carry out the jet grouting work, under the supervision of the Professional Engineer engaged by him, strictly in accordance with the design parameters adopted by the Professional Engineer.

C Levels of Work

Jet grout piles shall be constructed to the base levels of all manholes/chambers/open cut trenches as specified to achieve the objectives as set out under Clause 9.1(b).

D Zone of Treatment

The plan area of the zone to be jet grouted shall be defined in the Contractor's Professional Engineer's design and method statement and shall be subject to the acceptance of the Engineer. The zone may be reviewed by the Engineer depending on the conditions encountered during the treatment works. Grouting shall be carried out such that the entire specified zone is treated.

E Tolerances

1 Construction shall be carried out in accordance with the following tolerances:

a The jet grout piles shall be vertical to within a tolerance of 1:50; and

b The jet grout piles shall be located with a plan tolerance of plus or minus 100mm of the location shown on the plan of the pile grid.

2 If the during the testing, the above tolerances are shown to have been exceeded, the Contractor shall propose and carry out the following at his own costs:

a further testing of the jet grout layer to verify that there are no gaps in the treatment; and

b if there are any gaps, submit proposals endorsed by the Contractor's Professional Engineer for rectifying the defects.

3 If the tolerances are exceeded consistently, the Engineer may call upon the Contractor to submit for his approval an amended method statement for all future jet grout piling works. All works ordered or done under this sub-clause shall be at the Contractor's own expense and no extension of time will be granted for such works.

F Headroom

A The Contractor shall note any restricted headroom on portions of the Works and shall satisfy the Engineer that his method of construction of the jet grout piles can be accommodated within these restrictions.

G Grout

1 The grout to be used shall consist of a mixture of cement, water and, if necessary, chemical admixtures. The proportion of each constituent shall be specified in the Contractor's method statement together with a target strength for the grout mix and a target strength for the completed treated layer.

2 Cement shall be Ordinary Portland cement complying with BS 12 but containing not less than 4% and not more that 13% proportion by weight of tri-calcium aluminate.

3 Suitable admixtures may be used in the grout mix with the prior approval of the Engineer. The type and source of the admixture, amount to be added and method of use shall be to the acceptance of the Engineer who shall be provided with the following data:

a the manufacturer's recommended dosage and detrimental effects of under dosing and over dosing;

b the chemical name(s) of the main active ingredient(s) in the admixture;

c whether or not the admixture contains chlorides and, if so the chloride content of the admixture expressed as a percentage of equivalent anhydrous calcium chloride by weight of admixture;

d whether or not the admixture leads to the entrapment of air when used at the manufacturer's recommended dosage;

e information on the toxicity of the admixture; and

f evidence of previous satisfactory usage of the admixture in grout for jet grouting works.

4 The grout and admixtures used must be chemically inert, non-pollutive and present no environmental risks.

5 Prior to the commencement of the work, test cubes for the grout mixture shall be made and tested in accordance with BS 1881. Eight test cubes shall be taken and half are to be tested at 7 days with the remainder tested at 28 days to verify the target compressive strength of the grout mix.

H Jet Grouting – Trial Test

1 Well in advance of the planned commencement date for the jet grouting works the Contractor shall conduct a trial of the jet grouting method to prove the suitability of the method. An item has been allowed for in the Bills of Quantities for the Contractor to price for the trial of the jet grouting.

2 The trial shall be conducted using the materials and equipment to be used in the actual jet grouting works.

3 The trial shall demonstrate that the procedures used will produce an homogenous grouted pile of the required diameter.

4 The location and the depth of the jet grouting for the trial shall be proposed by the Contractor for acceptance by the Engineer.

5 Prior to the commencement of the trial the Contractor shall prepare for the acceptance of the Engineer a method statement specifically for the trial. The trial shall not commence until the Engineer accepts the method statement. The method statement shall set out clearly the following:

a the objective of the trial;

b any deviations from the method statement for the jet grouting works and the reasons for the deviations; and

` c tests to be performed and the testing procedure. The tests shall include methods of verification of the homogeneity of the grouted piles and shall include:

- visual inspection of at least two piles which shall be constructed to about 1.5m of the ground surface and exposed by careful excavation; and
- coring of at least one pile at a location on the pile to be determined by the Engineer, together with standard penetration tests at intervals of not greater than one metre. At least two samples for each core shall be tested by unconfined compression tests.

6 After completion of the tests, the Contractor shall submit to the Engineer a full report containing the results of all tests carried out during the trial. The report shall conclude with the column diameter and spacing, grout mix design, grouting pressure, relief hole spacing etc., to achieve the jet grouting layer specified in the Contractor's design. the jet grouting works proper shall not commence until the Engineer has approved the trial test report.

7 In the event that the trial test fails, the Contractor's Professional Engineer shall re-evaluate the design of the jet grout piles and the Contractor is to carry out another trial test. All works ordered or done under this sub-clause shall be at the Contractor's own expense and no extension of time will be granted for such works.

I Tests and Testing

1 The Contractor's P.E. shall propose in the method statement the type and frequency of tests to be carried out to verify the uniformity of the final jet grouting layer and its compliance with the design criteria. All costs for carrying out the tests shall be deemed to be included in the pricing for jet grouting works.

2 The tests shall consist of the following:

a coring of the completed jet grouting mass at a frequency of no less than one core for every $100m^2$ of plan area of treated soil or 1% of the number of treated columns, whichever is the greater. The coring shall be of 50mm diameter.

b compressive strength tests on the core samples; and

c standard penetration tests or cone penetration tests at a frequency to be proposed by the Contractor for the acceptance of the Engineer.

3 In the event that the testing shows any defects or deficiencies in the jet grouting treatment the Contractor shall propose for the Engineer's acceptance measures that will be taken to correct the deficiencies. All works ordered or done under this sub-clause shall be at the Contractor's own expense and no extension of time will be granted for such works.

J Records

1 The Contractor shall submit to the Engineer daily records of the previous day's work. The daily records shall include the following information:

a the equipment being used including the diameter of the drilling rod and the nozzles sizes;

b the jet grouting column nominal diameter, spacing mix, pressure and other relevant equipment settings;

c the location and reference number of each of the columns grouted;

d the levels of the beginning and ending of the grouting for each column;

e the grout mix proportions and any changes in the materials used;

f details of any tests taken;

g monitoring results as specified in Clause 9.4 (e) below;

h a log of the soil type encountered so far as can be ascertained from the drilling and the spoil; and

i the volume of grout used.

2 Upon completion of the jet grouting works in each area, the Contractor shall submit to the Engineer two (2) copies of the final report, endorsed by the Contractor's Professional Engineer, on the results of the treatment which shall include but not limited to the following:

a a full set of all test results; and

b a description of any deviations from the design giving reasons for the deviations and proposals for any remedial works.

3.02 Ground Movements

A The Contractor's responsibilities for any damage to persons or property in relation to the soil stabilisation works shall be in accordance with the Conditions of Contract and the Contract Specification.

B Prior to starting work, all sub-surface utilities shall be located and protected to the satisfaction of the appropriate authority.

C Soil stabilisation shall be carried out with the utmost care to prevent disturbances to the nearby services and properties. Care shall be taken to prevent undesirable ground movements. Care should also be taken to prevent intrusion of grout or other material into services or properties as a result of the soil stabilisation works. The Contractor shall be responsible to rectify any damage to services as a result of intrusion of grout or other material to the satisfaction of the Engineer or other relevant authorities. No claims whatsoever shall be entertained for the lack of such knowledge or otherwise.

D The Contractor shall establish suitable temporary bench marks for the purposes of monitoring ground movements during ground treatment. Such bench marks shall be outside the zone of influence of the soil stabilisation works.

E The Contractor's attention is brought to the Contract Specification, "Instrumentation and Monitoring Programme" Section. Over and above the requirements set out in Section 7, the Contractor shall monitor ground movements due to the soil stabilisation works at least twice a day. All readings and measurements shall be properly taken, recorded and interpreted by qualified personnel, endorsed by the Professional Engineer and one set of reports shall be submitted to the Engineer daily. An item has been allowed in the Bills of Quantities for the Contractor to price for compliance with the above requirements.

F In the event of undesirable ground movements, the Contractor shall immediately stop treatment works and propose alternative treatment methods for the acceptance of the Engineer. It is the Contractor's responsibility to ensure that all surrounding properties in the vicinity of the site such as the road and pedestrian bridges, the utilities installations, road facilities, foundation structures of building, underground services, conservation building, etc. are not disturbed or damaged as a result of the soil stabilisation works. The Contractor shall be responsible to protect all the surrounding properties throughout his operations. No claims whatsoever shall be entertained for lack of such knowledge or otherwise.

3.03 Obstructions

Upon encountering any sub-surface obstruction which prevents the soil stabilisation equipment from reaching the specified of the treated layer, the Contractor shall immediately inform the Engineer and shall review and propose to the Engineer the steps to be taken to ensure that the ground is treated satisfactorily.

3.04 Disposal of Spoil

A The Contractor shall construct bunds or walls, as necessary, to contain excess grout and soil from the soil stabilisation works. The Contractor shall also construct sediment settlement tanks to extract grout and soil sediment from any water disposed to the surface drainage system.

B The spoil and grout shall be disposed of at the appropriate dumping site, approved by the Engineer.

3.05 Temporary Sites Required for Soil Stabilisation Works

A The Contractor shall be responsible for obtaining approval from the relevant authorities for all temporary site areas required for carrying out the soil stabilisation works. All temporary occupation licenses, rental charges and related costs in connection with this shall be borne entirely by the Contractor. The Contractor shall be deemed to have allowed for this in his rates.

END OF SECTION 02730

Section 02830

Chain Link Fence and Gates

Part 1 General

1.01 Description

A The work included in this section comprises furnishing all plant, equipment, appliances and materials and performing all operations in connection with chain link fencing.

1.02 Quality Assurance

A The manufacturer shall be a company specializing in commercial quality chain link fencing with five years experience and installation shall be in accordance with BS 1722: Part 10

1.03 Submittals

A. Two samples of the following shall be submitted:
   1. Mesh size : 300 x 300 mm
   2. Line wire: 300 mm long
   3. Tying wire: 300 mm long
   4. Stirrup wire: 300 mm long
   5. Barbed wire: 300 mm long
   6. Fence fittings

B. Shop Drawings shall include plan layout, grid, and spacing of components, accessories, fittings, tension bracing, hardware, anchorages, height elevations of same and schedule of components.

Part 2 Products

2.01 Materials

A. Materials shall conform to BS 1722: Part 10 and be designed to withstand 120 km/hr wind speed with a 25 percent safety factor. All metal parts shall be galvanized to comply with BS 729. Fittings shall be 'clamp on type' and all chain link fence materials and fittings shall be coated with green plastic to comply with grade A of BS 4102. Fabric shall be 50 x 50 mm mesh and shall be woven from galvanized wire 3.0 mm core dia x 4.0 mm OD. Both ends of the fabric shall have knuckled selvage. Core wire shall have a minimum zinc coating weight of 92 g/sq m and a minimum breaking strength of 5700 N. Line wire shall be 3.55 mm core dia x 4.75 mm OD in four rows. Tying wire shall be 1.80 mm core dia x 2.60 mm OD. Stirrup wire shall be 2.50 mm core dia x 3.55 mm OD. Barbed wire shall comply with the requirements of BS 4102; be 1.80 mm core dia x 2.60 mm OD; and be 2-ply wires, 4- point barbs at 100 c/c. Three strands of barbed wire shall be provided along all perimeter fences; or as shown on the Drawings.

B. Posts and brace rails shall be galvanized steel tubes galvanized in accordance with BS 729 and then polyester powder coated to a minimum thickness of 60 microns. Posts/Rails shall be of dimensions shown below:

Type of Post/Rail	OD (mm)	Wall Thickness (mm)	Spacing of Posts
Line Post	60	2.90	Maximum 3 m intervals
Intermediate Post	76	3.25	Maximum 65.0 m intervals
Corner Post	76	3.25	Any change in the line of the fence where the angle of deflection is more than 15°.
End Post	76	3.25	Where the fence begins or ends.
Brace Rail	42	2.65	To be installed on all Intermediate, Corner and End Posts.

C. Extension arms shall be a continuation of the tubular post or clamp on type and shall form an angle of 40° to 45° with the vertical line of the post.

D. Fence fittings shall be pressed steel or malleable iron fittings, hot dip galvanized to comply with BS 729 in the following dimensions:

Brace Bands	25 mm wide x 4 mm thick
Tensions Bands	25 mm wide x 4 mm thick
Truss Rods	10 mm dia
Tension Bar	20 mm wide x 4.5 mm thick
Carriage Bolts & Nuts	M8 x 32 mm (galvanized only)

D. Posts shall be of dimensions shown below.

WIDTH OF GATE	POSTS		STIFFENER
	OD (mm)	Wall Thickness (mm)	
Single Gate < 1.8 m	76	3.20	
Double Gate < 3.7 m			
4.0 m < Single Gate > 1.8 m			1 No. diagonal bar
7.9 m < Double Gate > 3.7 m	114	4.50	2 Nos. vertical bars
11.0 m < Double Gate > 7.9 m	166	4.85	3 Nos. vertical bars

Gate frames shall be 48 mm OD pipe with wall thickness of 3.25 mm. gate frames over 1.8 m wide shall be provided with centre vertical stiffener of 48 mm OD pipe with wall thickness of 2.9 mm. Gates shall be hung by at least two steel, or malleable iron, hinges not less than 80 mm in width, so designed as to securely clamp to the gate post, and permit the gate to the swung back against the fence. The bottom hinge shall have a socket to take the ball end of the gate frame. Gates shall be provided with: a combination steel, or malleable iron, catch and locking attachment of approved design; stops to hold gates open, and a centre rest with catch shall be provided where required; and standard hardware and heavy duty padlocks. All padlocks shall conform to Federal Specification FF-P-101E and shall be master keyed. Padlocks shall be 50 mm, Types EPC, 5 pin tumbler mechanism, brass or bronze, solid case, with chain and as required by the Engineer.

2.02 Polyester Powder Coating

A. Coating shall conform to BS 6496 and BS 6497 and be weather resistant; resistant to chalking from UV exposure; resistant against chemicals and have colour stability from effects of heat. The coating shall have the following mechanical, chemical and durability properties:

TEST	METHOD	TYPICAL RESULTS
Flexibility (Conical Mandrel)		Pass 3 mm
Adhesion (2 mm Crosshatch)	BS 3900 : Part E6 : 1992	Pass GTO
Erichsen Cupping	BS 3900 Part E4 : 1995	Pass > 7 mm
Hardness (400 gms)	BS 3900 : Part E2 : 1992	Pass - No Penetration to substrate
Impact Resistance	BS 6496 : Clause 16	Pass 2.3J direct and reverse
Salt Spray at 35° C	ASTM B 117	Pass at 1000 hrs.
Acetic Acid/Salt spray	BS 6496 : Clause 15	no corrosion area more than 2 mm from scribe
Cyclic Humidity	BS 8900 : Part F2 : 1973	Pass at 1000 hrs. no blistering or loss of gloss
Distilled Water Immersion	BS 3900 Part G5 : 1993	Pass - no blistering or loss of glass after 24 hours
Sulphur Dioxide	BS 3900 : Part 8:1993	Pass - no blistering loss of gloss or discolouration after 240 hours.
Exterior Durability 12months Florida 40 deg. South	BS 6496 : Clause 4.10	Excellent performance. Slight even loss of gloss, no checking, cracking or flaking.
Chalking		None in excess of minimum in ASTM D659 : 1980

Part 3 Execution

A. Drilling and welding of GI tubes shall not be allowed.

B. Spacing shall be as shown in the first table above, or as directed by the Engineer. Changes in line where the angle of deflection is 15 degrees or more shall be considered as corners and corner posts shall be installed. All intermediate corner and end posts shall be braced in the direction of the line of fence, using brace rail pipes as compression members and truss rods with turn buckles as tension members. Intermediate and corner posts shall be horizontally braced to the nearest line posts in both directions. End posts shall be horizontally braced in one direction only. Standard straining fittings like truss rod, turn-buckle, tension bar, brace and tension bands, rail ends, brace rail ends, nuts and bolts etc. shall be used for all posts.

C. Fabric shall be stretched and securely fastened to posts at 350 mm intervals and brace rails at 500 mm intervals, using stirrup wire. Between posts, the fabric shall be fastened to top and bottom line wires at 150 mm intervals and other line wires at 450 mm intervals, using tying wires.

D. Concrete foundations shall be as followings:

Line Posts : 300 mm diameter x 900 mm deep.
Intermediate, Corner, and End posts : 400 mm diameter x 1000 mm deep.
Gate Posts : 600 mm diameter x 1100 mm deep.

A continuous concrete sill 200 mm wide x 300 mm high for the full length between the posts shall be cast with the top at ground level approximately 25 mm below the bottom of the chain

link mesh. Grade 25 sulphate resisting Portland Cement concrete shall be used for post footings and sill.

END OF SECTION 02830

Section 02850

Gabions

Part 1 General

1.01 Description

The work included in this section comprises furnishing all plant, equipment, appliances and materials and performing all operations in connection with gabion mattresses and box gabions.

1.02 Quality Assurance

The manufacturer shall be a company specializing in commercial quality gabions with five years experience.

1.03 Submittals

A. Two samples of the following shall be submitted:
   1. Wire fabric: 600 x 600 mm
   2. Binding wire: 600 mm long

B. Shop Drawings shall include plan layout, grid, spacing of components, accessories, fittings, height elevations of same and schedule of components.

Part 2 Products

2.01 Gabions

The gabions shall be flexible zinc coated gabions of the sizes as stated in contract documents and fabricated of wire mesh of the type and size, and selvedged as specified below. Each gabion shall be divided by diaphragms into cells whose length shall not be greater than the width of the gabion plus 100 mm, or otherwise as stated.

2.02 Wire Fabric for Gabions

A The fabric shall be triple-twisted hexagonal woven, 2.7 mm diameter steel wire mesh complying with BS 1485. The wire shall be galvanized before weaving, and test samples shall meet the requirements of BS 443, followed by a PVC coating. Wire thickness and mesh size shall be as follows:

	Minimum Wire Diameter	Mesh Size
Gabion mattress	2.0 mm	60 x 80 mm
Box gabions	2.7 mm	80 x 100 mm

B The wire mesh shall have elasticity to permit elongation of the mesh equivalent to a minimum of 10 percent of the length of a section of mesh under test without reducing the diameter or tensile strength of the individual wires.

C All edges of the gabions, diaphragms and end panels shall be selvedged with a wire of diameter not less than 20 percent greater than that of the mesh wire.

D The selvedging must be such that the mesh will not unravel and such that the strength of the connection between the selvedge wire and the mesh shall be equal to or greater than the breaking strength of the mesh.

2.03 Binding and Connecting Wire

A Sufficient binding and connecting wire must be supplied with the gabions to perform all the wiring operations to be carried out in the construction of the gabion work. The diameter of the wire should be minimum 2 mm.

B Binding and connecting wire shall be manufactured by the manufacturer of the gabions, unless otherwise approved by the Engineer.

2.04 Tolerances for Gabions and Gabion Wire

Gabions and gabion materials shall be manufactured to the following tolerances:

1 Gabion dimensions
A tolerance of ± 5 percent on the width and height of the gabion and a tolerance of ± 3 percent on the length shall be permitted.

2 Mesh dimensions
A tolerance of ± 15 percent on the nominal size of the mesh shall be permitted.

3 Wire thicknesses
A tolerance on the diameter of all wire in the above clauses of ± 2.5 percent shall be permitted in accordance with BS 1052. The weight of gabions is therefore subject to a tolerance of ± 5 percent.

2.05 Stones for Gabions

Stone used for gabions and gabion mattress shall be clean, natural, hard and durable with a minimum density of 2400 kg/m^3 and shall be approved by the Engineer. Stone shall be well graded within the following limits:

	Minimum Dimension	Maximum Dimension
250 mm mattress	125 mm	200 mm
Box gabions	150 mm	300 mm

Part 3 Execution

3.01 Method of Construction of Gabions

A The embankment against which the gabions are to be placed shall be suitably trimmed and the base shall be properly levelled by packing with rubble to a thickness of 300 mm before placing the gabion. The surface below and behind the gabion box and which is in contact with the backfill material shall be covered with a geotextile fabric conforming to the requirements of Section 02520. After placing the geotextile fabric the backfilling behind the gabions shall be carried out in accordance with Section 02222

B Gabion mattresses and box gabions shall have internal diaphragms of the same mesh as the enclosing fabric. Diaphragms shall be positioned such as to give compartments in gabion mattresses with a maximum width of 1 m and a maximum length of 3 m. In box gabions the maximum compartment size shall be 1.0 m x 1.0 m x 1.0 m.

C Adjoining gabions shall be firmly wired together to give a continuous join along all adjacent edges. Binding wire shall be laced around selvedges or wire mesh with single loops and double loops in turn at intervals equivalent to one mesh length. Units should be placed on headers and stretchers in alternate courses, and vertical joints should not be continuous but staggered.

D Before filling, the gabions shall be accurately positioned in their required location, straightened to remove all kinks in the wire mesh and tensioned to avoid bulges occurring during filling. The method adopted for tensioning the gabions shall be to the approval of the Engineer. Completed gabions shall be inspected and approved by the Engineer before filling commences.

E Gabions may be filled by hand or by machine, but whichever method is adopted, the stones must be tightly packed to minimize the formation of voids. Particular care must be taken to avoid the use of flat stones as these do not compact properly and cause the gabions to bulge.

F Gabions shall be overfilled by 25 to 50 mm to allow for settlement. Gabion lids shall be stretched tightly over the fill material and securely wired down. If voids are formed between the fill and the gabion lid, then these may be filled with small stones provided that no small stones occur on an exposed face.

G Where shown or otherwise directed by the Engineer, the gabion mesh shall be cut, folded and wired together to form mitre joints, angles, curves or slopes which are not possible to obtain in the structures with the standard rectangular gabions. The mesh must be cleanly cut, and the surplus mesh cut completely out, or folded back or on to, and neatly wired to an adjacent gabion face. The cut edges of the mesh shall be securely laced together with binding wire.

END OF SECTION 02850

Section 02900

Landscaping and Planting

Part 1 General

1.01 Description

The work included in this section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with landscape works and planting soil mix.

1.02 Ordinances and Regulations

All local ministry and municipality laws, rules and regulations governing, or relating to, any portion of this work are hereby incorporated into, and made a part of, these specifications and their provisions shall be carried out by the Contractor. Anything contained in the Specifications shall not be construed to conflict with any of the above rules and regulations or requirements of same. When the Specifications and/or Drawings, call for, or describe materials, workmanship or construction of a better quality, higher standard or larger size, Specifications and/or Drawings shall take precedence over the requirements of said rules and regulations.

1.03 Job Conditions

Prior to any landscape work, the Contractor shall locate all existing underground installations and protect the same. Any damage to these installations shall be repaired at no extra cost to the Employer. Work with other trades shall be coordinated so that conflicts will not exist nor delay the work in any way. At all landscaped areas, the landscape contractor shall be responsible for providing final grades in accordance with the requirements of the Drawings, soils report and site work specification requirements.

1.04 Quality Assurance

A Work must be performed with experienced personnel. The Contractor must show proof of the qualifications and experience of all personnel proposed for this contract. This must include details of major landscape and irrigation projects, on which the person has worked, the respective client, construction cost of each project and the specific responsibility and position of the person in question. These items must be included within each individual's curriculum vitae in addition to experience and/or education. This information must be submitted to the Engineer for review and approval at least six weeks prior to construction.

B This Contract will require a minimum of the following personnel:

1 landscape architect who must have a BS degree in agriculture, ornamental horticulture or landscape architecture and a minimum of eight years experience in landscape construction. Must have a minimum of four years experience as overall project manager on major landscape projects. Experience in farming operations shall not be acceptable. Seven years of additional experience in landscape construction may substitute for the degree.

2 landscape foreman must be skilled in the installation of planting and associated landscape elements with a minimum of ten years experience in landscape construction.

a layout/planting pits/clean-up foreman

b planting foreman - small plants (under 2 m)
c planting foreman - large plants (2 m and over)

3 all landscape labourers must be skilled in the installation of planting and associated landscape elements with a minimum of two years experience in landscape construction.

4 horticulturist/arborist must have a BS degree in ornamental horticulture and a minimum of three years field experience. Five years additional field experience in ornamental horticulture may be substituted for BS degree. Forestry or agriculture degrees or experience may not be substituted.

C The Contractor must show proof of his ability to mobilize the following list of equipment (or a list which has been previously approved by the Engineer) and shall have equipment on site when beginning a particular part of the work for which that piece of equipment is necessary:

1 air compressor
2 mini loaders
3 dumper
4 earth compactor
5 loaders
6 trenchers - sizes as needed
7 tractor with disk harrow
8 water tanker with spray mister hose attachment
9 pruning Equipment
10 crane for loading and planting large trees
11 back hoes
12 concrete mixer
13 dump trucks
14 jack hammer
15 rotovator
16 truck
17 augers of required sizes
18 rotary type mowers
19 tractor trailer for transporting large trees

1.05 Submittals

The Contractor shall submit the following:

1 manufacturer's certified analysis of standard packaged products
2 an independent laboratory analysis of all materials submitted
3 manufacturer's or vendor's certified analysis for fertilizer materials
4 an analysis of the organic amendment material prior to shipping to the project
5 prior to placement of prepared soil mix in the landscape, a laboratory analysis showing items in fertility and agricultural suitability as required
6 1.5 l water sample of irrigation water
7 1 kg fertilizer sample.

1.06 Delivery, Storage and Handling

Packaged materials will be delivered in labelled sealed containers showing the weight, analysis and name of manufacturer, point of origin and dealer, including expiration date. Fertilizer shall be stored separately from pesticides in a dry storage area away from contaminants and plant materials as approved by the Engineer. All pesticides shall be stored in a locked container in an air-conditioned room. Herbicides shall be stored separately from other chemicals and all storage areas shall be locked. Bulk materials stockpiled on site shall be covered and protected to prevent deterioration from sun and wind.

1.07 Guarantee

A Guarantee period for all plant material shall begin at the date of acceptance of the planting operation as complete. Planting operations will be accepted as complete when the Contractor receives a Notice of Substantial Completion from the Engineer.

B All plant material shall be guaranteed by the Contractor, for a period of two years from the date of notice of substantial completion, to be in good, healthy, and flourishing condition. When the work is accepted in parts, the guarantee periods shall extend from each of the partial acceptances to the terminal date of the last guarantee period. Thus, all guarantee periods terminate at one time.

C The Contractor shall replace, immediately and without extra cost to the Employer all dead plants and all plants not in vigorous, thriving condition. Plants shall be free of dead or dying branches and branch tips and shall bear foliage of a normal density, size and colour. Replacements shall match adjacent specimens of the same species, shall be provided immediately and shall be subject to all requirements stated in this Specification. Guarantees of all replacement plants shall extend until the end of the two year guarantee period. Any plant not found in an acceptable condition during the guarantee period will be replaced immediately. If said replacement occurs within 120 days of the end of the guarantee period this period will be extended by 120 days from the date the last plant was installed.

D The Contractor shall make all necessary repairs due to plant replacements and such repairs shall be done at no extra cost to the Employer and within a reasonable time as determined by the Engineer.

1.08 Acceptance

A The Engineer shall inspect all work for substantial completion upon written request of the Contractor and such request shall be received at least ten calendar days before the anticipated date of inspection. Acceptance of plant material by the Engineer will be for general conformance to specified size, character and quality and this shall not relieve the Contractor of responsibility for full conformance to the contract documents including correct species. Upon completion and re-inspection of all repairs or renewals necessary in the judgement of the Engineer, the Engineer will recommend to the Employer that he accept the work as substantially complete. Work may be accepted as substantially complete in parts when it is deemed to be in the Employer best interest to do so, and when permission is given to the Contractor in writing to complete the work in parts. Acceptance and use of such areas by the Owner shall not waive any other provisions of this contract. The guarantee period shall commence upon acceptance as substantially complete.

B At the end of the maintenance and guarantee periods, the Engineer will inspect all work for Final Acceptance upon written request of the Contractor and such request shall be received at least thirty calendar days before the anticipated date for Final Inspection. Upon completion and re-inspection of all repairs or renewals necessary in the judgement of the Engineer, the Engineer shall certify in writing to the Owner as to the Final Acceptance of the work.

1.09 As-built Drawings

The Contractor shall keep Mylar reproducibles of the Drawings exclusively for the purpose of recording all changes and deviations in the locations of plants or materials. All changes shall be indicated thereon as the job progresses. The Contractor shall deliver these modified reproducibles to the Engineer upon completion of the work.

Part 2 Products

2.01 Prepared Soil Mix Components

A Material for prepared soil mixes shall be obtained from approved borrow sources and shall conform to the following physical and chemical characteristics:

1	salinity (ECe x 1000)	less than 2
2	SAR (sodium absorption ratio)	less than 1
3	boron (saturation extract)	less than 0.5 mg/l
4	pH	less than 8

Sieve Size	% by Weight Passing
No. 10	100
No. 35	90-100
No. 140	0-10
No. 270	0-3

B Organic Amendment - Bark Mulch. Organic amendment shall be coniferous fir bark mulch with the following chemical and physical characteristics:

1	bulk density:	300-400 kg/m^3
2	organic matter	greater than 80 percent
3	pH	5.0-6.5
4	salinity (ECe x 1000)	0.5-2.0
5	total nitrogen	0.7-2.0
6	available phosphorous	100-500 mg/l
7	CEC (meg/100 gms)	80-120 mg/l
8	boron (by hot water extraction)	less than 5 mg/l
9	SAR	less than 2.0

Sieve Size	% by Weight Passing
9.5 mm	100
6.35 mm	90-100
2.4 mm	50-60

C Fertilizers shall be provided as indicated below for soil mix:

1 organic resin coated complete fertilizer with an analysis of 20-10-5+Fe and a release longevity of 12-14 months at 21° C soil temperature

2 agriculture grade sulphur, 99 percent sulphur content with 100 percent passing a 16 mesh screen and 50 percent passing a 100 mesh screen

3 controlled release fertilizer shall be Osmocote as manufactured by Sierra Chemical Company, Strijkviertel 35 II, 3454 PJ De Meern, Netherlands, or approved equal.

Part 3 Execution

3.01 Preparation

A Soil mix shall conform to the following requirements:

1	salinity (ECe x 1000)	less than 4.0
2	SAR	less than 4.0
3	pH	6.5 to 7.5
4	boron (by saturation extraction)	less than 0.7 mg/l

B Soil mix is to be mixed in the quantities of proportions as indicated below according to the procedures outlined in paragraph 3.01 E:

1 65 percent sand

2 35 percent coniferous fir bark mulch

3 2 kg controlled release fertilizer per cubic metre.

4 2 kg soil sulphur per cubic metre

C In the event that the pH of soil mix exceeds 7.5 the portion of the mix will be amended with suitable additives (soil sulphur, sulphuric acid, or other approved amendments) to bring the resultant soil mix into the specified range of 6.5 to 7.5. Such additives will be added prior to addition of the organic amendment. After adding such additives the mixture will be leached to bring the salinity, SAR, pH and boron of the resultant mix within the ranges indicated in paragraph 3.01 A hereof.

D One trial lot, of two cubic metres shall be prepared by the Contractor prior to the start of full soil mixing operations. Samples of these trials shall be submitted for analysis. The Contractor shall submit such analysis and recommendations to the Engineer. An analysis will include specific recommendations for changes in the soil mix formulations. The Contractor may begin full soil mixing operations after obtaining approval.

E The physical ingredients shall be mixed to a uniform mixture. The mixing method shall be by wind rowing/tilling on an approved hard surface area and according to acceptable horticultural practices as approved by the Engineer. The organic portion should be moist. Apply fertilizer ingredients and mix until homogenous. The resultant mix will be moistened to about 5 to 10 percent.

3.02 Clean up

A The Contractor shall clean up all areas on a, regularly, scheduled basis, or whenever deemed necessary by the Engineer, as well as upon completion of the work before acceptance and during the guarantee period. Adjacent walks, paved surfaces and road shoulders shall be kept clean during the installation of landscape works. Waste materials shall be removed daily and the Contractor shall restore previously established grade elevations caused by irrigation equipment, rainfall, or other natural or manmade causes, such as contour grading. Prepared planting soil mix and mulch top dressing shall also be restored to levels and conditions shown on the plans and in the specifications. This work shall be incidental to all other work, and no additional compensation shall be made for it.

B The Contractor shall protect new plants from injury during installation and until acceptance of the work as specified herein.

END OF SECTION 02900

DIVISION 3.

CONCRETE

Section 03100

Formwork

Part 1 General

1.01 Description

This section provides the specification of formwork for cast-in-place concrete.

1.02 Quality Assurance

A Formwork design, fabrication and erection shall comply with BS 5328 and BS 5975

B Erection of formwork shall be executed and supervised by fully qualified personnel with a minimum of five years experience. Formwork systems shall be designed by a registered structural engineer.

C Formwork Design Criteria:

1 The erected forms shall be watertight from the ingress of external liquids and egress of internal liquids.
2 The design of formwork shall take into account; height and rate of pour; thickness of member; concrete slump and density; placing temperature; texture of finish; construction joints; wind load.
3 On soffit forms (in addition to concrete weight) an additional live load of 2.5 kN/m^2, or an additional live load of 3.75 kN/m^2 if a motorised cart is used.
4 The minimum design load for combined dead and live load shall be 6.50 kN/m^2, or, if a motorised cart is used, 7.75 kN/m^2.
5 In the assessment of loads, the worst combination of self-weight, formwork forces, reinforcement weight, wet concrete weight, construction loads, wind loads, incidental dynamic effects caused by placing, vibrating and compacting concrete, the use of externally applied vibrators, method of concrete discharge and access for concrete placement and vibration shall be used.
6 Formwork shall be designed to be demountable without shock, disturbance or damage to concrete, and sufficiently rigid to maintain the correct position, shape and profile so that the final concrete structure is within the dimensional tolerances specified in Section 01050 hereof and BS 5328.
7 Soffit formwork, properly supported on shores only, shall be capable of being retained in position during concrete maturing period.
8 Adjustable steel supports and shores shall allow form-boards and framework to be accurately adjusted to line and level.
9 The design shall allow free movement and accessibility under formwork.
10 Shores for abnormal ceiling heights shall be specially designed.
11 Forms shall incorporate 20 mm chamfers on exposed corners of columns, walls and beams, except where plaster or rendered finish is specified.
12 The Contractor shall ensure that adequate ground support for shoring and supports is available, and if not, shall take measures to make them suitable.

1.03 Submittals

A Shop Drawings

1 Shop drawings shall be in accordance with Section 01300 hereof.

2 Shop drawings shall include plans and sections, giving the following minimum information for each level: details of individual panels, position, size and spacing of adjustable steel shores, position, size and spacing of joists, soldiers, ties, details of formwork for columns, beams, parapets, slab and kickers; details of construction joints and movement joints; details of retaining walls and deep beams showing the position and size of ties, joints, soldiers and sheeting, together with detailed information on erection and casting sequences and construction joints; general assembly details; full calculation sheets; details of all penetrations through concrete; proposed sequence of shoring/re-shoring beams and slabs for different spans and floor heights and number of floors shored, and the stripping time for supported and suspended structural elements, clearly identifying the supported element and suspended element.

3 The Contractor shall allow twenty one (21) days for the Engineer's review.

B Samples

1 The Contractor shall provide samples of all formwork materials proposed.

2 The Contractor shall provide samples of ties proposed for general situations and for fair faced concrete.

3 The Contractor shall allow twenty one days for Engineer's review of samples.

1.04 Job Example

A Prior to commencement of related formwork operations the Contractor shall erect a job example, to a reasonable size including all items such as sheeting, stiffeners, soldiers, ties etc. (and including release agents, where used) for columns, slabs and beams and staircases, and obtain approval before proceeding. For fair face concrete the Contractor shall demonstrate the method used to conceal tie holes. Upon prior consultation, agreement of location and approval, the job mock-ups may remain as part of the finished work.

1.05 Methods

A Prior to commencing work, submit to the Engineer details of methods and techniques proposed for the design and completion of formwork.

Part 2 Products

2.01 Form Materials

A Form materials shall conform to requirements of BS 5328 and BS 5975 unless stated otherwise.

B Unformed surfaces

1 Unformed surfaces shall be classified as either:

a U4, timber trowel finish

b U3, steel trowel finish

c U2, brush finished

d U1, other finish designated by the Engineer.

2 The type of finish will be specified on the drawings or as directed by the Engineer. Before beginning any concrete pour with unformed surfaces, the Contractor shall obtain confirmation of the type of finish required from the Engineer.

3 Initial finishing of unformed surfaces shall commence immediately after placing and compaction have taken place.

4 Suitable access boards or platforms shall be provided to allow access to all parts of

unformed surfaces to be finished.

5 Where a protective treatment or topping layer is to be applied to the concrete the manufacturer's and supplier's recommendations shall be followed concerning the required finish.

6 Brush finish shall be obtained by carrying out a steel trial finish and then using a suitable stiff nylon brush dragged lightly across the surface.

7 The addition of small quantities of water to the finishing trowel will be permitted to aid finishing.

C Formed surfaces

1 Finishes to formed surfaces of concrete shall be classified as F1, F2 and F3, or such other special finish as may be particularly specified.

2 Where the class of finish is not specified, all internal concrete shall be finished to Class F3 and external concrete below ground shall be finished to Class F1.

3 Where surfaces are covered with paint or sheeting, the formwork shall be capable of achieving a finish suitable for the proposed covering as approved by the Engineer.

4 Formwork for Class F3 finish shall be lined with as large panels as possible of non-staining material with a smooth unblemished surface such as sanded plywood or hard compressed fibre board, arranged in a uniform approved pattern and fixed to back formwork by oval nails. The same type of lining shall be used throughout any one structure. Unfaced wrought boarding or standard steel panels shall not be permitted.

5 Formwork for Class F2 finish shall be faced with wrought tongued and grooved boards or plywood arranged in a uniform approved pattern free from defects likely to detract from the appearance of the surface.

6 Formwork for Class F1 finish shall be constructed of timber, or any suitable materials which will prevent loss of grout when the concrete is vibrated.

7 Grooves in exposed concrete shall be formed by attaching tapered, planed timber battens accurately aligned, to the face of formwork.

D Exposed Concrete Surface Finishes:

1 Exposed concrete surfaces shall have Class F3 finish.

2 Great care shall be taken to ensure that the finish to the exposed concrete on the external and internal surfaces is of the highest quality to produce a smooth concrete surface of uniform texture and appearance without visible imprint of grains, steppings or ridges.

a Formwork to the wetted surfaces of water retaining structures shall be Class F3.

b All exposed concrete corners and edges shall have 20 mm x 20 mm chamfers.

E Form Ties: Form ties shall be; factory-fabricated; adjustable in length; removable or snap-off metal form ties; cone ends if required by the drawings; designed to prevent formwork deflection and to prevent the spalling of concrete surfaces on removal. No metal shall be left closer than 38 mm to the surface of the concrete. Ties shall not leave a hole larger than 10 mm diameter in the concrete surface, when using snap ties.

F Form coatings shall be commercial formulation compounds that will not bond with, stain, nor adversely affect concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured.

G. Fillet/chamfer strips shall be PVC or timber to approval.

H Tape shall be plastic faced adhesive tape to approval; to seal joints of formwork panels for smooth finish concrete.

I Precast concrete moulds shall be rigid steel moulds.

J Form release agent shall be a colourless material which will not stain concrete, nor absorb moisture. All form release agents must be compatible with all materials applied to concrete surfaces.

K Flashing reglets shall be galvanised steel, longest possible length, alignment splines for joints securable to formwork.

Part 3 Execution

3.01 Formwork Erection

A The Contractor shall be responsible for the calculations and designs for the formwork and shall submit them to the Engineer prior to the start of construction. Formwork to external faces which will be permanently exposed, all horizontal and vertical formwork joints shall be so arranged that joint lines will form a uniform pattern on the face of the concrete. Where the Contractor proposes to make up the formwork from standard sized manufactured formwork panels, the size of such panels shall be approved by the Engineer before they are used in the construction of the Works. The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the pattern of joint lines caused by formwork and by construction joints to ensure continuity of horizontal and vertical lines.

B Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all formwork shall be clean and free from standing water, dirt, shavings, chippings or other foreign matter. Form joints and tie holes shall be watertight to prevent the escape of mortar or the formation of fins or other blemishes on the face of the concrete. The Contractor shall verify lines, levels and measurement before proceeding with formwork. The Contractor shall ensure that the sides and bottom of earth forms are hand trimmed.

C Formwork shall be provided for the top surfaces of sloping work where the slope exceeds fifteen degrees from the horizontal (except where such top surface is specified as spaded finish). The formwork shall be anchored to enable the concrete to be properly compacted and to prevent flotation, and care shall be taken to prevent air being trapped.

D Temporary openings for inspection of the inside of the formwork and for the removal of water used for washing down shall be provided and so formed as to be easily closed before placing concrete.

E Windows shall be provided in forms wherever directed or necessary for access for concrete placement and vibration. The windows shall be of sufficient size for tremies and vibrators to be placed, spaced at a maximum of 1.8m centres horizontally. Windows shall be tightly closed and sealed before placing higher concrete.

F Formwork in contact with the concrete shall be treated with suitable non-staining mild oil to prevent adherence of the concrete. Care shall be taken to prevent the oil from coming in contact with reinforcement or with concrete at construction joints. Surface retarding agents shall be used only where ordered by the Engineer. Release agents shall not be used where concrete surfaces receive special finishes or applied coatings which may be affected by agent, unless approved by the Engineer.

G The Contractor shall co-ordinate the work of other Sections in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchors and other inserts.

H Conduits or pipes shall be located so as not to reduce the strength of the construction. In no case shall pipes other than conduits be placed in a slab 125 mm in thickness. Conduits embedded in a concrete slab shall not have an outside diameter greater than 1/3 the thickness of the slab nor be placed below bottom-reinforcing steel or over top-reinforcing steel. Conduits may be embedded in walls provided they are not larger in outside diameter than 1/3 the thickness of the wall, are not spaced closer than 3 diameters on centre, and do not impair the strength of the structure. Embedded pipes and conduits shall be supported independently from reinforcing steel in a manner to prevent metallic contact and thereby prevent electrolytic deterioration. Pipes and conduits where embedded shall be placed as nearly as possible to the centre line of the concrete section. Conduits, piping, and other wall penetrations or reinforcements shall be subject to Engineer's review and approval.

I Position ties passing through concrete to approval of Engineer.

J Ties or bolts or other devices shall not be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer. The whole or part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer to the surface than the cover required for reinforcement. The surface of concrete shall be rubbed down smooth with carborundum and water in an approved manner within three days of removing the formwork and holes left after removal of such supports shall be neatly filled with non-shrink epoxy grout of suitable consistencies and matching colour.

K Where part of a metal tie remains embedded in concrete, it shall not have less cover than reinforcement.

L Position chamfer-moulding strips on exposed corners of columns, and beams.

M Do not use surface retarding agents.

N Cambers: Cambers shall be as indicated on the drawings. The depth of beams at all points in the span shall also be as indicated.

O Strip formwork carefully to avoid sudden shocks from removal of wedges, or vibration which might damage concrete.

P Where finished surfaces have re-entrant angles, remove formwork as early as possible to avoid shrinkage cracks.

Q Place re-shoring to beams and slabs, immediately after stripping formwork.

R Where re-shoring is required for early stripping while minimising sag or creep, the capacity and spacing of such re-shores shall be adequate for the purpose.

S All exterior angles to concrete exposed to view in the completed structure shall be cast to the true angles evenly throughout the length. Great care shall be taken to ensure that no waviness occurs along the angle and that no spalling occurs to the concrete on removal of the formwork.

T Devices of the tell-tale type shall be installed on supported forms and elsewhere as required to detect formwork movements and deflection during concrete placement. The required slab and beam cambers shall be checked and correctly maintained as concrete loads are applied on forms. Workmen shall be assigned to check forms during concrete placement and to promptly seal all mortar leaks.

U Holes formed in concrete surfaces by formwork supports or the like shall be filled neatly with non-shrink epoxy grout. The Contractor shall clean any hole that is to be filled with non-shrink epoxy grout. Where the concrete surface has been damaged, any loose, broken or cracked concrete or aggregate shall be broken out. The concrete surrounding the hole shall be then be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted with ordinary Portland cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement. Any dry cement in the hole shall be removed. Grout material shall then be placed and packed in layers having a compacted thickness per manufacturer's instructions. Compaction shall be carried out by the use of a hardwood stick and a hammer and shall extend over the full area of the layer, with particular care being taken to compact the dry-pack against the side of the hole. After compaction, the surface of each layer shall be scratched before further loose material is added. The hole shall not be over-filled and the surface shall be finished by layering a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

V Pipes through walls:

1 Pipes and pipe specials through concrete walls and floors shall as far as possible be positioned and built-in during construction and shall be located exactly in the positions shown on the drawings and shall be true to line and level.

2 The Contractor shall place orders for these items immediately after the Contract is awarded and shall make every effort possible to ensure early delivery to site. The supply and delivery of built-in pipework shall be clearly shown on the detailed construction program to be submitted by the Contractor.

3 The Contractor shall take particular care to ensure that fully compacted concrete is in contact with the pipe at all points.

4 Where it is not practicable to cast pipes and specials in the concrete, boxholes shall be formed in the formwork.

a The box shall have six or eight sides, depending on the pipe diameter, and shall be no larger in size than will give adequate clearance for the subsequent positioning and grouting in of the pipe.

b The sides of the box hole shall be provided with a tapered central annular recess to provide a positive key and shall allow rebar to extend across the opening.

c The boxhole shall be provided with a grout hole and, at the top of the central annular recess a vent hole.

d The boxhole shall be stripped with the main shuttering and the concrete surface thoroughly cleaned and roughened.

5 When the pipe is later fixed, the remaining hole shall be re-formed and filled with non-shrink epoxy grout or non-shrink concrete. In the case of water-retaining structures the Contractor shall ensure that measures adopted shall provide a finished joint which is adequately strong and free from leakage.

6 In either case, the Contractor shall be solely responsible and all additional costs, if any, shall be borne by the Contractor.

3.02 Removal of Formwork

A The Engineer shall be notified prior to the removal of any formwork.

B Concrete shall be thoroughly wetted as soon as forms are first loosened and shall be kept wet during the removal operations and until curing media is applied.

C Potable water supply with hoses having fine fog spray attachments shall be ready at each removal location before operation is commenced.

D The period of time elapsing between the placing of the concrete and the striking of the formwork shall be approved by the Engineer after consideration of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown below:

Type of formwork	Minimum period before stripping (times are exclusive of the day of concrete placement)
Beam sides, walls and column	1 day
Soffits of slabs-props left under	4 days
Soffits of beams-props left under	10 days
Props to slabs	10 days
Props to beams	14 days

E Stripping of formwork within the time limits listed above does not relieve the Contractor from successfully crushing test cubes and achieving specified compressive strength results.

F Notwithstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

END OF SECTION 03100

Section 03200

Concrete Reinforcement

Part 1 General

1.01 Description

The work includes furnishing, fabrication, and placement of reinforcement for cast-in-place concrete, including bars, welded wire fabric, ties, and supports.

1.02 Submittals

A Submittal requirements shall conform to Section 01300 hereof.

B Product Data

1 The Contractor shall provide the manufacturer's specification and installation instructions for proprietary materials and reinforcement accessories.

2 The Contractor shall furnish the manufacturer's records of chemical and physical properties of billet steel bars and a certificate that the respective material furnished meets the requirements for the steel reinforcement specified. The manufacturer's records shall include mill certificates as well as chemical analysis, tensile and bend tests.

3 Three copies of the steel test report shall be furnished with each consignment of steel reinforcement.

C Shop Drawings

1 Detail fabrication and placement drawings for all reinforcing steel which are correlated with forming and concrete placement techniques and requirements.

a Reinforcing steel shall be detailed based on construction joint locations which have been shown on shop drawings approved by the Engineer.

b Drawings shall be in such detail as to ensure that there will be a minimum of difficulties, if any, in execution of the work in the field.

c Drawings shall consist of sections, plans and details clearly showing locations, sizes, spacing and shapes of all reinforcing steel, caps and splices supporting bars and accessories.

d Include bar bending schedules and diagrams to indicate bends, sizes and lengths of all reinforcement prepared in accordance with BS 4466.

2 A separate set of shop drawings, showing construction joint locations, shall also be submitted for approval and shall indicate all floor openings, wall openings and edges of concrete. Floor openings, wall openings, pipe inserts and sleeves for all mechanical, plumbing and electrical work shall be co-ordinated with the respective trades and shown on these shop drawings in accordance with the criteria indicated on the Contract Drawings.

3 No work shall be fabricated until both sets of shop drawings (Reinforcement and Concrete Dimensions) have been reviewed by the Engineer (with corrections and re-submittals as required by the Contract Documents). After approval approved by the Engineer, the Contractor shall furnish all copies needed for fabrication and erection, and for the use of other trades.

4 The Contractor shall be fully responsible for furnishing and installing all materials called for or required by the Contract Documents even though these materials may have been omitted from the reviewed shop drawings.

5 The approval of shop drawings, or revised bar schedules shall in no way relieve the

Contractor of his responsibility for the correctness of such drawings or schedules.

D Samples

1 Representative samples of all reinforcing steel that the Contractor proposes to use in the Works must be submitted to the Engineer for his written approval, before work is commenced. The Contractor shall submit manufacturer's certificates stating clearly for each sample:
   a place of manufacture,
   b expected date and size of deliveries to site,
   c all relevant details of composition, manufacture, strengths and other qualities of the steel.

2 The Engineer reserves the right to sample and inspect all reinforcement steel upon its arrival at the work site.

3 The Contractor shall provide a certificate confirming that samples taken from the bars delivered to the works pass the re-bend test.

4 Frequency of sampling and the method of quality control shall be in accordance with Appendix E of BS 4449:1997.

1.03 Delivery, Storage and Handling

A Delivery

1 Bars in each lot shall be legibly tagged by the manufacturer. The tag shall show the manufacturer's test number and lot number and other applicable data that will identify the material with the certificate issued for that lot of steel.

2 Fabricator shall furnish three copies of a certification which shows the heat number or numbers from which each size of bar in the shipment was fabricated.

B Storage

1 Reinforcement shall be stored on suitable structures a minimum of 450 mm above the ground surface and covered to prevent damage and accumulation of dirt, rust and other deleterious matter.

2 The storage facilities shall be such as to permit easy access for inspection and identification.

3 Bundles of reinforcement shall be clearly tagged with bar schedule and bar mark reference and these shall not be removed until the material is at the location where it is to be incorporated into the works.

4 Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust, mill scale, oil, grease, earth, paint, or any other material which may impair the bond between the concrete and the reinforcement.

C Reinforcement shall not be handled roughly, dropped from a height, or subject to shock loading or mechanical damage.

Part 2 Products

2.01 Materials

A Reinforcing Steel:

1 Reinforcing steel shall conform to BS 4449 and shall have the following minimum yield strength. The yield strength of the reinforcing steel is defined as the stress corresponding to a strain of 0.35 percent, and shall correspond to that delivered by tests on full size bars.

Bars	Yield Strength	Symbol
Plain round mild steel	250 N/mm^2	R
Deformed high yield bars	460 N/mm^2	Y

2 All bars shall be sand blasted after fabrication. After fixing and immediately prior to placing of concrete the reinforcement shall be pressure-washed with fresh water.

B Welded steel wire fabric shall conform to BS 4483. Welded intersections shall not be spaced more than 310 mm for plain round bars or 400 mm apart for deformed high yield bars in direction of calculated stress except when used as stirrups.

C Tie wire shall conform to BS 4482. No wires smaller than size D-4 shall be used.

D Spacers shall be made of concrete, metal, or other as approved by the Engineer.

E Welding, if permitted by the Engineer, shall conform to the requirements of AWS D 1.4 or BS 5135

2.02 Testing of Reinforcement Steel

A Tests shall be carried out in strict accordance with BS 4449 and at the discretion of the Engineer from time to time.

B Tensile tests providing information on the following will be required from each lot delivered:
1 elastic limit,
2 ultimate strength,
3 stress-strain curve,
4 cross-sectional area,
5 deformation/bond characteristics of deformed bars

C The Contractor shall allow for all tensile, bond, re-bond and chemical tests for each size of bar to be used in the concrete construction. Test results for each bar size shall be submitted to the Engineer in accordance with the requirements of Section 01300. Further tests may be called for when the source of supply of reinforcement changes. When any test results do not conform to the relevant standard, the reinforcement steel shall be removed from the Site.

Part 3 Execution

3.01 Installation

A General
1 All reinforcement shall be securely and accurately fixed in positions shown on the Drawings to ensure that the reinforcement steel framework as a whole shall retain its shape. The reinforcement framework shall be so temporarily supported as to retain its correct position in the forms during the process of depositing and consolidating the concrete.
2 The ends of all tying wires shall be turned into the main body of the concrete and not allowed to project towards the surface.
3 No part of the reinforcement shall be used to support access ways, working platform or for the conducting of an electric current.

4 Specific attention is drawn to the following general requirements:
   a lapped joints shall be as indicated on the Drawings and/or in accordance with the requirements of BS 8110.
   b hooks shall be semi-circular with a straight length of at least four bar diameters for mild steel and six diameters for high yield steel.

B Welding
1 Welding shall not be permitted unless authorised by the Engineer and recommended by the reinforcement manufacturer.
2 Welding shall be executed under controlled conditions in a factory or workshop.
3 Welding on site shall not be permitted unless suitable safeguards and techniques are employed and the types of steel have the required welding properties.
4 Welding if approved, may be used for:
   a Fixing crossing or lapping reinforcement in position;
   b Fixing bars to other steel members;
   c Structural welds involving transfer of loads between reinforcement or between bars and other steel members.
5 Lap welding between bars is not permitted.
6 Make butt welds by flash butt welding or metal-arc welding. Other methods may be approved, subject to their satisfactory performance in trial joints.
7 Metal-arc welding or electrical resistance welding may be used for fixing suitable steels or for lapped joints.
8 Flash butt welding shall be executed with the correct combination of flashing, heating, upsetting and annealing, using only machines which automatically control this cycle of operations.
9 Metal-arc welding shall comply with AWS Dl.4 and the recommendations of the reinforcement manufacturer.
10 Welded joints cannot be used to make bends in reinforcement.
11 Weldable reinforcement where shown on the Drawings shall conform to ASTM A706.

C Mechanical splices shall be submitted for approval and shall comply with BS 8110. Their use shall be as indicated on the structural drawings.

D Bundling and splicing of bars shall be in accordance with BS 8110. Splicing, except where indicated on the Drawings or approved shop drawings, will not be permitted without the approval of the Engineer.

E The Engineer shall be notified at least 24 hours before commencing fixing reinforcement for inspection of formwork. Spaces to receive reinforcement shall be thoroughly cleaned.

F Reinforcement shall not be fixed or placed in contact with non-ferrous metals.

G Correct concrete cover to reinforcement shall be maintained with the aid of approved spacer pieces. Concrete cover to any and all reinforcement shall be a minimum of 60 mm unless detailed otherwise on the Drawings.

H Spacers, chairs and other supports shall be provided as necessary to maintain reinforcement in its correct position. Spacer bars of same diameter as longitudinal bars, but not less than 25 mm diameter, shall be fixed between the two layers at 1.5m centres, except where bundled bars are detailed.

I Placing of all reinforcement will be checked by the Engineer and in no case is concrete to be placed around any reinforcement that has not been approved by the Engineer. Insertion

of bars into or the removal of bars from concrete already placed will not be permitted. Reinforcement temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer.

J Forms and linings shall not be damaged when fixing reinforcement.

K Reinforcement shall not be fixed until after the placing of any concrete lining protection.

L The position of reinforcement prior to and during placing concrete shall be checked. Particular attention shall be given to the position of top reinforcement in cantilever sections. Reinforcement shall be clean and free from corrosive pitting, loose rust, loose mill scale, oil and other substances which may adversely affect reinforcement, concrete, or the bond between the two. Projecting reinforcement shall be protected from the weather where rust staining of exposed concrete surfaces may occur. At the time of concreting, all reinforcement shall have been thoroughly cleaned and freed from all mud, oil or any other coatings that might destroy or reduce the bond. Immediately prior to concrete placing the reinforcing steel shall be washed thoroughly with high-pressure potable water jets to remove any deposited salts.

3.02 Fabrication

Reinforcement shall not be cut and heated to bend into shape. Cut and bent reinforcement shall be to bar schedules and details, unless otherwise instructed. The Contractor shall provide on-site facilities for hand-bending of small rebar only to deal with approved minor adjustments. All bending shall be done cold with the use of an approved bending machine.

3.03 Field Quality Control

A Inspection of reinforcing steel and the installation thereof will be conducted by the Engineer. The Contractor shall give 24-hour notice to the Engineer before closing forms or placing concrete.

B The Engineer may instruct the Contractor to break out and remove completely all sections of the work already constructed under any of the following circumstances.

1 reinforcing steel sample under test fails to meet the specification requirements at any time,

2 the Engineer considers that samples which were presented to him for test were not truly representative,

3 it becomes apparent that reinforcing steel, which has not been approved, has been used on the Works.

END OF SECTION 03200

Section 03300

Cast-in-place Concrete

Part 1 General

1.01 Description

A The Contractor shall furnish all materials and construct structures of the forms, shapes, dimensions and elevations shown on the Drawings, and as specified.

B The work includes furnishing all materials and facilities necessary for producing, placing, curing and finishing cast-in-place concrete.

C The Contractor shall use Portland Cement for construction of the Works.

1.02 Definitions

A Water/Cement Ratio: the ratio by weight of water to cement in a mix, expressed as a decimal fraction. Water being that which is free to combine with cement, including free water in aggregate but excluding that absorbed by the aggregate.

B Hot Weather: a shade air temperature of 37° C. and rising.

C Construction Joint: a joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement. The surface where two successive placements of concrete meet, across which it is desirable to develop and maintain bond between the two concrete placements and through which any reinforcement which may be present is not interrupted.

D Movement Joints: a joint intended to accommodate movement between adjoining parts of a structure, special provision being made where necessary for maintaining the watertightness of the joint. Typical movement joints provided are: expansion joints; complete contraction joints; partial contraction joints; sliding joints.

E Expansion Joint: a separation between adjoining parts of a concrete structure which is provided to allow small relative movements such as those caused by thermal changes to occur independently.

F Contraction Joint: formed, sawed, or tooled groove in a concrete structure to create a weakened plane and/or to regulate the location of cracking resulting from the dimensional change of different parts of the structure.

G Control Joint: as contraction joint.

H Fair Face Concrete: a concrete surface which, on completion of the forming process, requires no further (concrete) treatment other than curing (See also architectural concrete).

I Architectural Concrete: concrete which will be permanently exposed to view and which therefore requires special care in selection of the concrete materials, forming, placing, and finishing to obtain the desired architectural appearance.

J Water retaining structure: any structure or any part of which will contain water or process liquids, or which protects spaces from groundwater.

1.03 Submittals

A Product Data

1 Cement:
  a source of cement shall be subject to the Engineer's approval
  b manufacturer's test sheets shall be supplied with each consignment of cement certifying compliance with the relevant standard
  c the Contractor shall submit the date of manufacture and proof that the specifications have been complied with, certified by an independent agency in the country of origin.
2 The Contractor shall submit details of proposed aggregate sources for approval by the Engineer.
3 The Contractor shall submit details of proposed water source for approval by the Engineer. the details shall include the chemical analysis and a certificate from an independent testing agency that the specifications have been complied with.
4 The Contractor shall submit the manufacturer's technical recommendations and specifications for any additives proposed.
5 Current test reports and written certificates for waterstops, joint filler board, joint sealant and primer, slip membrane, sealing strip membrane and repair materials shall be submitted to the Engineer for review and approval.

B During the mobilisation period the Contractor shall submit for the approval of the Engineer a method statement detailing his proposals for the organisation of concreting activities for each structure or type of structure. The method statements shall be approved before any concrete is placed. Any alteration in the source of quality or proportioning of any of the materials in the mix will necessitate a new method statement. Method statements shall be prepared for each grade and type of concrete in the Contract and shall include, but not limited to, the following details:

1 plant proposed,
2 layout of concrete production facility,
3 proposed method for production of concrete,
4 quality control procedures for concrete and concrete materials,
4 transport and placing of concrete including the use of chutes, conveyor belts or pumps as a means of transporting concrete.

C Shop Drawings shall follow the requirements detailed in Section 01300. The Contractor shall submit shop drawings showing the proposed layout of all construction joints; details for the installation of waterstops in movement joints including location of joints, intersections and changes of direction with cross sections; consolidated shop drawings showing all mechanical penetrations.

D Samples

1 Slide bearings: The Contractor shall provide at least three samples of material proposed, including the manufacturer's technical specifications, application recommendations, and anticipated performance.
2 Slip joints: The Contractor shall provide at least three samples of materials proposed including manufacturer's technical specifications, application recommendations, and anticipated performance.

3 Waterstops & membranes: The Contractor shall provide at least three samples of proposed types, including prefabricated joints and junctions, if applicable. If joints are to be made up on site, provide worked samples including samples for each make of waterstop and membrane, where different manufacturers are used.
4 Cement samples shall be provided from each consignment delivered to the Site as required by the Engineer for testing.
5 Aggregate: The Contractor shall provide samples of both fine and coarse aggregates to the Engineer for testing. Samples shall be taken in the presence of the Engineer or Engineer's representative. Aggregate samples shall be provided at least one month prior to beginning deliveries to site.

E Trial mixes: for each grade and type of concrete in the contract and shall include:

1 Definition of the method of design of the mix, by reference to a recognised published design method.
2 Designed aggregated proportions shall be based on measured and not assumed relative densities.
3 Proposed mix proportions including any proposed admixture and for new batching installations, results of preliminary batch testing.
4 Results of testing of trial mixes to demonstrate that the proposed mix complies with the strength and workability requirements of this specification.
5 For concrete mix designs that include an admixture, trial mixes shall be prepared and tested both with and without the admixture to give a clear indication of its effects on the physical characteristics of the mix.

F In addition to the scheduling and programming requirements specified in other sections, the Contractor shall submit to the Engineer for his approval as soon as practicable, and not less than thirty days before commencement of concreting on a structure, a program detailing concrete placement sequences. The programme shall include details of: estimated time for pours; size of each pour; time of commencement and finish. If it is likely that placing of concrete will conflict with paragraph 3.06 'B' herein, then approval of the program will not be given.

1.04 Ready-mixed Concrete

A The use of ready-mixed concrete in any part of the Work shall require the Engineer's written approval and all sections of Specification 03300 also apply to ready-mixed concrete. The Contractor shall satisfy the Engineer on the following:

1 materials used in ready-mixed concrete comply with the specification in all respects
2 manufacturing and delivery resources of the proposed supplier are adequate to ensure proper and timely completion.

B The specified requirements as to the submittals, sampling, trial mixing, testing and quality of concrete, of various grades as herein, shall apply equally to ready-mixed concrete. Every additional facility, including but not limited to testing equipment, labour, laboratory facilities and transport, which the Engineer or persons authorised by him may require for the supervision and inspection of the batching, mixing, testing and transporting to Site of ready-mixed concrete shall be provided by the Contractor at no extra cost.

C A copy of the delivery note shall be given to the Engineer's site representative for each load. Copies of all delivery notes shall be submitted to the Engineer in duplicate, on computer-generated forms and shall include at least the following information.

1 name of supplier, serial number of ticket and date
2 truck number
3 name of Contractor
4 name of Contract and location of office
5 grade of concrete
6 specified workability
7 type and source of cement
8 source of aggregate
9 nominal maximum size of aggregate
10 quantity of each concrete ingredient
11 type of admixture and quantity
12 water content
13 time of loading and departure from ready-mix plant
14 arrival and departure times of truck
15 time of completion of discharge
16 notations to indicate equipment was checked and found to be free of contaminants prior to batching.

D Unless approved otherwise in advance of batching all concrete of single design mix for any one day's pour shall be from a single batch plant of a single supplier. Ready-mix concrete shall conform to BS 5328, except materials, testing and mix design shall be as specified in this Section. Transit mixers equipped with automatic devices for recording the number of revolutions of the drum shall be used. Excess water over the maximum allowed by the mix design shall not be added. Each mixer truck shall arrive at the job site with its water container full. In the event that a container is not full or concrete tests give a greater slump than acceptable, the load shall be rejected. No water shall be added at the Site.

E Shade temperature and concrete temperature shall be recorded at the point of discharge of the mixer and at placement for each load of concrete delivered to site. Maximum and minimum temperatures and wet bulb temperatures shall be recorded daily.

F Slump tests shall be performed in accordance with BS 1881 at the point of placement for each load delivered to the Site.

1.05 Delivery, Storage and Handling

A Delivery:

1 Cement shall be delivered in the manufacturer's bulk containers or in the original sealed and branded bags, bearing the manufacturer's name, cement type and date of manufacture, in batches not exceeding 100 tonnes.
2 Ready-mixed concrete delivery ticket shall record the actual batched weight of ingredients and the time of addition of water.

B Storage:

1 Cement: Immediately upon arrival at the Site, cement shall be stored in silos designed for the purpose, or dry, weather-tight and properly ventilated structures with floors raised 450 mm above ground level with adequate provision to prevent absorption of moisture. All storage facilities shall be subject to approval by the Engineer and shall be such as to permit easy access for inspection and identification. A free passage of at least one metre shall be left between the cement and the sidewalls of the structure. Each

consignment of cement shall be kept separately and the Contractor shall use the consignments in the order in which they are received. In no case shall bagged cement be stored in stacks more than eight bags high. Different types of cement shall be kept in clearly marked separate storage facilities. Cement delivered to the Site in drums or bags provided by the supplier or manufacturer shall be stored in the drums or bags until used in the Works. Any cement in drums or bags which have been opened shall be used immediately. Where site limitations preclude the storage of cement on site, cement shall be stored at a central location and shall be delivered daily as required to specific job sites. The Contractor shall provide weighing machines which shall be kept permanently in each shed for checking the weight of the bags or barrels of cement. The Engineer shall have access at all times to the cement storage sheds. During transport and storage the cement shall be fully protected from all-weather elements. The temperature of the cement entering the mixers shall not exceed 45° C. Any consignment of cement not used within two months from the date of manufacturer, and cement, which in the opinion of the Engineer is of doubtful quality, shall not be used in the Works until it has been re-tested and test result sheets showing that it complies in all respects with the relevant standard have been delivered to the Engineer.

2 Aggregate: The Contractor shall provide a means of storing the aggregates at each point where concrete is made such that:
   a each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times;
   b contamination of the aggregates by the ground or other foreign matter shall be effectively prevented at all times;
   c each stockpile of aggregate shall be capable of draining freely;
   d storage shall be such as to prevent segregation;
   e stockpiles shall be on hard and clean surfaces with not more than five per cent slope.

   Coarse aggregate shall be stockpiled in two separate gradings of 20 to 10 mm and 10 to 5 mm. Stockpiling is not necessary where a crushing-screening plant is used in tandem with a batching plant. Preparation, siting and size of stockpiles, and methods of segregation shall be to the approval of the Engineer.

3 Chemical curing compounds shall be stored in accordance with manufacturer's recommendations.

C Handling: Ready-mixed concrete: trucks shall be discharged within the approved period after addition of water to cement. Trucks still containing any concrete after the approved expiry time shall be rejected. The rejected concrete shall be disposed of in a legal manner.

Part 2 Products

2.01 Concrete Mix

A Grades of concrete to be used in the Works shall be as shown below. The criteria given are designed to produce a workable homogenous plastic mixture and to ensure a long service life under the particular exposure conditions at the site. Where adequate workability is difficult to obtain at the maximum water/cement ratio allowed, an increased cement content and/or the use of plasticizers or water-reducing admixtures may be considered at no additional cost to the Employer. Cement contents in excess of 400 kg/cu. m shall not be used unless special consideration has been given to reduce thermal stress in the concrete.

Concrete	Max. Size	Min. Cement	Max. Free	Cube Crushing at 28 days

Grade	Agg. mm	Content kg/m^3	Water/Cement Ratio	Trial Mix N/mm^2	Works Test N/mm^2
40	20	370	0.45	50	40
35A	20	325	0.45	45	35
30	20			40	30
20	20	310	0.60	30	20

B Blinding concrete shall be grade 20 unless otherwise specified and thickness shall be as shown on the Drawings but in any case not less than 75 mm thick.

C No-fines concrete shall be made using a coarse natural aggregate conforming to BS 882 and cement to BS 4027. No fines aggregate shall be used. Grading of the coarse aggregate shall be not less than 95 percent by weight passing a 20 mm BS sieve and not more than 5 percent by weight passing 10 mm BS sieve. The proportions of aggregate, cement and water shall be determined by trial mixes by the Contractor starting with a cement:aggregate ratio of one to eight by volume. All the aggregate particles shall be coated with a film of cement grout. The water content shall be just adequate to ensure that the cement paste completely coats the aggregate. No-fines concrete when placed shall contain no layers of Latinate. No-fines concrete shall not be mixed by hand. Vibration shall not be used to compact the no-fines concrete. Three test cubes of no-fines concrete shall be made of each preliminary mix. Minimum crushing strength of the chosen mix shall be 15 N/sq mm at 28 days. Porosity is such that water will pass through a slab 300 mm thick at the rate of not less than 7 litres/sec/m^2 of slab with a constant 100 mm depth of water on the slab. Where a slab incorporating vertical weep holes or drain holes is cast above a layer of no-fines concrete any polyethylene sheeting shall be pierced below the pipes forming such drain holes and the edges of the sheeting sealed to the lower end of the pipe to prevent the ingress of grout and fine particles from the slab concrete into the no-fines concrete.

D Design of Concrete Mixes: At the commencement of the Works the Contractor shall design a mix for each grade of concrete listed above that is required to be constructed on the Works. The Contractor shall submit full details of the mix designs to the Engineer for approval. For concrete using other than sulphate resisting Portland cement, or incorporating admixtures, the strengths shall not be less than those specified above, but the mix designs shall be revised and agreed with the Engineer. Each mix design shall be such that:

1 aggregate shall comprise fine aggregate and coarse aggregate of the maximum size specified,
2 combined aggregate grading shall be continuous,
3 aggregate quantity shall be calculated by weight,
4 mixes shall be designed to produce a concrete cube strength at twenty eight days after manufacture of not less than the cube strength specified above.

2.02 Portland Cement Concrete

A Consists of a mixture of Portland Cement, fine aggregate, coarse aggregate, water, and additives (when required). The proportion, mix and placing shall be in accordance with BS 5328 and BS 8110 for framed building structures and BS 8007:1987 for water retaining structures. Where these specifications conflict with, or are inconsistent with, the requirements of BS 5328/BS 8110/BS 8007, the requirements in these specifications shall prevail. Specific design requirements shall be as defined in these specifications. All concrete mixes shall be designed for special or ordinary concrete as defined in BS 8110, Clause 6.3.

2.03 Cement

A. The specification requirements for ASTM cement types I, II and V and Ordinary Portland Cement, Rapid Hardening Portland Cement, Sulphate Resisting Portland Cement, low heat cement and Portland Pulverised Fuel Ash Cement are:

Compound		ASTM Type			BS 12		BS 4027	BS6588	
		I	II	V	OPC	RHP	SRPC	low heat	PPFAC
Silica, S, (SiO_2)	≥	-	21.0	-	-	-	-	-	-
Alumina, A, (Al_2O_3)	≤	-	6.0	-	-	-	-	-	-
Ferric Oxide, F, (Fe_2O_3)	≤	-	6.0	-	-	-	-	-	-
Magnesia (MgO)	≤	6.0	6.0	6.0	4.0	4.0	4.0	4.0	4.0
Sulphur trioxide (SO_3)									
When tricalcium aluminate ≤8%	≤	3.0	3.0	2.3	-	-	-	-	-
When tricalcium aluminate ≥8%	≤	3.5	-	-	-	-	-	-	-
When tricalcium aluminate ≤5%	≤	-	-	-	2.5	3.0	-	2.5	-
When tricalcium aluminate ≥5%	≤	-	-	-	3.0	3.5	2.5	3.1	-
Loss of ignition	≤	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Insoluble residue	≤	0.75	0.75	0.7	1.5	1.5	1.5	1.5	
Tricalcium silicate (C_3S)	≤	-	-	-	-	-	-	-	
Dicalcium silicate (C_2S)	≥	-	-	-	-	-	-	-	
Tricalcium aluminate (C_3A)	≤	-	8.0	5.0	-	-	3.5	-	
Tetra calcium alumino ferrite $C_4AF+2(C_3A)$)	≤	-	-	20.	-	-	-	-	
C_3A for moderate sulphate resistance	≤	-	-	-	-	-	-	-	
C_3A for high sulphate resistance	≤	-	-	-	-	-	-	-	
C_3S+C_3A for moderate heat of hydration	≤	-	58.0	-	-	-	-	-	
Alkalis ($NaO_2+0.658K_2O$) For low alkali cement	≤	0.6	0.6	0.6	-	-	0.6	-	

Note: Abbreviations commonly used to describe compounds and oxides present in Portland cement:

A	alumina	C_2S	dicalcium silicate	F	ferric oxide
C	lime	C_3S	tricalcium silicate	H	water
C_3A	tricalcium aluminate	C_4AF	tetracalcium alumino ferrite	S	silica

		ASTM Type					BS 12		BS 4027	BS 1370
		I	II	III	IV	V	OPC	RHPC	SRPC	low heat
Setting Time (min) Initial	≥	45	45	45	45	45	45	45	45	60

			ASTM Type					BS 12		BS 4027	BS 1370
			I	II	III	IV	V	OPC	RHPC	SRPC	low heat
(Vicat test) (h) Final		≤	8	8	8	8	8	10	10	10	10
(Gillourne test) (min) Initial		≥	60	60	60	60	60	-	-	-	-
(h)		≤	10	10	10	10	10	-	-	-	-
Final											
Fineness											
Air Permeability (m^2/kg)		≥	28	28	-	28	28	225	325	250	27
Turbidimeter (m^2/kg)		≥	16	16	-	16	16	-	-	-	-
Soundness											
Autoclave expansion (%)		≤	0.8	0.8	0.8	0.8	0.8	-	-	-	-
Le Chatteler (mm)		≤	-	-	-	-	-	10	10	10	10
Compressive strength (Mpa)≥											
mortar cubes	1 d		-	-	12.	-	-	-	-	-	-
	3 d		12.	10.	24.	-	8	23	29	20	10
	7 d		19.	17.	-	6.9	15	-	-	-	-
	28		-	-	-	17.	20	41	46	39	28
Concrete cubes	3 d		-	-	-	-	-	13	18	10	5
	28		-	-	-	-	-	29	33	27	19
Heat of Hydration (kJ/kg)		≤									
(1 cal/g = 4.2kJ/kg)	7 d		-	29	-	25	-	-	-	-	250
	28		-	33	-	29	-	-	-	-	290

B Ordinary Portland cement and rapid hardening Portland cement shall meet the requirements of BS 12. Low heat Portland cement shall conform to the requirements of BS 1370. Sulphate resisting Portland cement shall conform to the requirements of BS 4027. Portland blast furnace cement and low heat blast-furnace cement shall conform to the requirements of BS 146. Different brands or types of cement shall not be mixed together for use in the works

C ASTM cement types I, II, III, IV and V shall meet the requirements of ASTM C-150.

D The testing of cement shall be carried out in accordance with the provisions of BS 4550 Parts 2 and 3

E Any cement that is, in the opinion of the Engineer, unsuitable for use in the Works shall be rejected and the Contractor shall promptly remove such cement from the Site.

2.04 Aggregates

A General

1 Shall consist of tough, hard durable and uncoated particles containing no harmful material in quantities sufficient to adversely affect the concrete or reinforcing steel.
2 Shall comply with the requirements of BS 882 except as modified hereunder and shall be washed clean with potable water, if necessary to comply with these requirements.
3 Contractor shall provide all data as specified in Appendix A of BS 882.
4 Contractor shall satisfy the Engineer that the aggregates to be supplied will not give rise to an alkali reaction with the cement.
5 Should have a low coefficient of thermal expansion.

6 Sampling and testing of aggregates shall be carried out in accordance with the requirements of the appropriate section of BS 812.
7 Fine aggregate shall be natural crushed sand.
8 Beach sand shall not be permitted for use in concrete mixes.
9 Aggregates shall meet the requirements of Table 1 hereunder
10 Frequency of routine testing of aggregates shall be in accordance with Table 2 hereunder.
11 Mineralogical tests are to be carried out as and when directed by the Engineer.
12 No aggregate deliveries shall be made to the site until the Engineer has approved the samples as complying with these specifications.
13 Samples of aggregates will be tested at intervals during construction of the works and the Contractor shall provide the necessary equipment and labour.

TABLE 1

	Requirement	Test Methods		Permissible Limits	
		BS 812	ASTM	FINES	COARSE
1.	Grading	Part 103 (dry)		Standard	Standard
2.	Material finer than 0.075 mm Natural, uncrushed/ Crushed	Part 103 (wet)		max. 3%	Max. 1%
	Crushed rock			max. 5%	Max. 3%
3.	Clay lumps and friable particles		C142	max. 3%	Max. 2%
4.	Light weight pieces		C123	max. 0.5%	Max.0.5 %
5.	Organic impurities		C40	Colour standard not darker than Plate No. 3	
6.	Water absorption		C128/C127	max. 2%	Max. 2%
7.	Specific Gravity (apparent)		C128/C127	min. 2.6	Min. 2.6
8.	Shell content: Coarser than 10 mm Between 5 mm & 10 mm	Part 106			Max. 3% max. 3%
	Between 2.36 mm & 5 mm Finer than 2.36 mm			max. 10% Note 1	
9.	Particle shape: Flakiness index	Part 105.1			Max. 25%
	Elongation index	Part 105.2			Max. 25%
10.	Acid Soluble Chlorides: A. For reinforced concrete with: SRPC OPC & MSRPC	Part 117, Appendix C		 max. 0.06% max. 0.06%	 max. 0.03% max. 0.03%
	B. For mass concrete made with: SRPC OPC & MSRPC			 Max. 0.06% Max. 0.06%	 max. 0.03% max. 0.03%
	C. For prestressed & Steam cured structural concrete			max. 0.01%	Max. 0.01%
11.	Acid Soluble Sulphates	Part 118		max. 0.3%	Max. 0.3%
12.	Soundness, (MgSo4 - 5 Cycles		C88	max. 10%	Max.

	Requirement	Test Methods		Permissible Limits	
		BS 812	ASTM	FINES	COARSE
					10%
13.	Mechanical Strength:10% fines value	Part 111			Min 150 kN
	Impact value	Part 112			Max. 30%
	Loss Angeles Abrasion		C131/C535		Max. 20%
14.	Drying Shrinkage	Part 120			Max. 0.05%
15.	Potential reactivity: Note 2 of Aggregates, Chemical Method		C289	Not Reactive	Not Reactive
	Of Cement-Aggregate Combination		C227	6-month expansion 0.10% max.	

Note 1: There is no requirement of shell content in sands passing 2.36 mm sieve size.

Note 2: Aggregates may initially be assessed for its reactivity in accordance with ASTM C289 and if potential reactivity is indicated, then mortar bar tests in accordance with ASTM C227 shall be carried out.

TABLE 2

	Requirement	Test Method	Test Frequency
1.	Grading	BS 812 : Part 103	Every 500m^3 aggregate
2.	Material finer than 0.075 mm	BS 812 : Part 103	-do-
3.	Clay lumps and Friable Particles	ASTM C 142	-do-
4.	Organic Impurities	ASTM C 40	-do-
5.	Water Absorption	ASTM C128/C127	-do-
6.	Specific Gravity	ASTM C128/C127	-do-
7.	Shell Content	BS 812 : Part 106	-do-
8.	Particle Shape	BS 812 : Part 105.1 & 105.2	-do-
9.	Acid Soluble Chlorides, Cl Quantitative	BS 812 : Part 117, Appendices A/B	On each delivery to site
	Quantitative	BS 812 : Part 117, Appendix C	Each week, if result is more than 75% of the limit and each month if result is less than 75% of the limit.
10.	Acid Soluble Sulphates, S03	BS 812 : Part 118	Each two weeks if result is more than 75% of the limit & each two months if result is less than 75% of the limit.
11.	Soundness (Mg S04 - 5 cycles)	ASTM C88	Each month.
12.	Mechanical Strength		
	10% Fines or Impact Value	BS 812 : Parts 111/ 112	Each month
	Los Angeles Abrasion	ASTM C 131/C 535	-do-
13.	Moisture variation in sand - by Moisture Meters		Twice daily
14.	Drying Shrinkage	BS 812 : Part 120	At the start of the project and whenever there is a change in the source of supply.
15.	Potential Reactivity: Of aggregates	ASTM C295/C289	At the start of the project and

Requirement	Test Method	Test Frequency
Of carbonate Of cement aggregate combination	ASTM C586 ASTM P124/C227	wherever there is a change in the source of supply.

2.05 Fine Aggregate for Concrete and Mortar

Fine Aggregate Grading

BS 410 Test Sieve	Percentage Weight Passing BS Sieves		
	Zone 1	Zone 2	Zone 3
Mm			
10.00	100	100	100
5.00	90-100	90-100	90-100
2.36	60-95	75-100	85-100
1.18	30-70	55-90	75-100
μm			
600	15-34	35-59	60-79
300	5-20	8-30	12-40
150 (natural sands)	0-10	0-10	0-10
150 (crushed rock)	0-20	0-20	0-20

A Gradation shall be in accordance with BS 882 excluding grading designation F. Fine aggregate shall be clean, sharp, natural and/or crushed sand.

B Each batch of aggregate delivered to site shall be kept separate from previous batches and shall be stored for at least three working days before use to allow inspection and tests to be carried out.

C The Contractor shall mechanically wash aggregate to remove salts and other impurities in order to meet the requirements specified.

2.06 Coarse Aggregates for Concrete

A Coarse aggregates shall be prepared as single sized aggregate and blended to produce normal size grading. Combined grading shall be within the appropriate grading limits given in BS 882.

B Aggregates that are deliriously reactive with the alkalis in the cement in an amount sufficient to cause excessive expansion of concrete shall not be used.

C The Contractor shall mechanically wash aggregate to remove salts and other impurities in order to meet the requirements specified.

Coarse Aggregate Grading

BS 410 Test Sieve	Percentage Weight Passing BS Sieves							
	Nominal Size of Graded Aggregate			Nominal Size of Single Sized Aggregate				
	40mm to 5mm	20mm to 5mm	14mm to 5mm	63mm	40mm	20mm	14mm	10mm

mm								
75.5	100	-	-	100	-	-	-	-
63.0	-	-	-	85-100	100	-	-	-
37.5	95-100	100	-	0-30	85-100	100	-	-
20.0	35-70	95-100	100	0-5	0-25	85-100	100	-
14.0	-	-	90-100	-	-	-	85-100	100
10.0	10-40	30-60	50-85	-	0-5	0-25	0-50	5-100
5.0	0-5	0-10	0-10	-	-	0-5	0-10	0-25
2.36	-	-	-	-	-	-	-	0-5

2.07 Combined Aggregate

A Approved coarse aggregate and fine aggregate in each batch shall be combined in proportions as specified in BS 882 and as approved by the Engineer.

B In no case shall materials passing the 0.05 mm sieve exceed three percent by weight of the combined aggregate.

C Combined aggregate gradation used in the work shall be as specified, except when otherwise approved or directed by the Engineer.

D Changes from gradation to another shall not be made during progress of the work unless approved by the Engineer.

2.08 Water

A. Water used for concrete-mixes, washing of equipment, wetting of surface or ponding during curing or for wetting formwork and washing reinforcement shall be potable water and shall comply with the requirements of BS 3148 except as modified hereunder. The Contractor shall make his own arrangements and obtain approval for the supply of water.

B. The pH of water used in concrete works shall be not less than 7.0 or more than 9.0.

C The temperature of water for concrete shall not be less than 5°C nor more than 25°C. Water may be cooled to not less than 5°C by the gradual addition of chilled water or ice. No ice particles shall be present in the mix. Ice to be used shall be crushed and shall be product of frozen water which complies with acceptance criteria as follows:

	Test Method	Limits
Compressive strength, min. % control at 7 days	ASTM C109	90
Setting time, deviation from control, h:min	ASTM C191	from 1:00 early to 1:30 later
Chloride (as CI)	ASTM D512	250 mg/l
Sulphates (as $S0_3$)	ASTM D516	350 mg/l
Alkali carbonates and bicarbonates	ASTM D513	500 mg/l
Total dissolved ions, including above	ASTM D1888	2000 mg/l
pH	-	7 - 9

C. Every effort should be made to protect water pipes and tanks from the sun, e.g., burying, shading, insulation or painting white.

D. Water for curing concrete shall not contain impurities in sufficient amounts to cause discolouration of the concrete. Source of water shall be maintained in such a manner as to exclude silt, mud, grass and other foreign matter.

E. Whenever required to do so by the Engineer the Contractor shall take samples of the water being used or which it is proposed to use for mixing concrete and test them for quality. Samples of water not less than 5 litres shall be taken, sealed and sent for testing at an approved independent laboratory prior to the approval of any water source and periodically during the continuance of its use.

F. Water of questionable quality should comply with the physical and chemical limitations listed above.

I. No source of water shall be used until the required tests have demonstrated its suitability for concreting.

2.09 Admixtures

A. Admixtures shall mean materials added to the concrete materials during mixing for the purpose of altering the properties of the concrete mix.

B Where approved and or directed by the Engineer, admixtures shall be used as a means of increasing concrete durability; increasing workability of the concrete without increasing the water/cement contents; or controlling and limiting retardation of setting.

C Admixtures shall comply with the requirements given below:

Water Reducing Admixture	ASTM C494	Type A
Retarding Admixture	ASTM C494	Type B
Water Reducing, high range and retarding admixtures	ASTM C494	Type G

D The methods of use and the quantities of admixture used shall be subject to the Engineer's approval and shall in no way limit the Contractor's obligations under the contract to produce concrete with the specified strength, workability and durability.

E In addition to the standard requirements for approval of materials, approval of admixtures shall be subject to extensive trials to demonstrate the suitability, adequacy of dosing arrangements and performance.

F The Contractor shall provide sufficiently large capacity in his concrete producing plant and concrete transporting arrangements and use an appropriate admixture to avoid cold joints. The Contractor shall be entirely responsible for the use of any approved admixture at no additional cost to the Employer and in strict accordance with the Manufacturer's instructions.

G The Contractor shall provide the following data and ensure that the product complies with the following specifications:

1 Admixtures that comply with ASTM C494 Type G shall be employed to:
   a Produce highly flowable and self-compacting concrete at the lowest possible water cement ratio or as specified.
   b Produce a consistency of concrete that is free of bleeding and segregation.
   c Provide slump retention and set control as and when applicable.

d Offer the user impermeability and durability.

2 Admixture shall be based on naphthalene sulphonates. Where deemed necessary lignosulphonate admixtures conforming to ASTM C494 Type B may also be employed providing this is to the satisfaction of the Engineer.

3 No admixtures containing chlorides shall be used.

4 The use of the admixtures shall be controlled i.e. strict quality control to ensure correct dosages as prescribed by the manufacturer are used. Admixture is to be dispensed by a transparent unit that enables the operator to see the discharge.

5 Concrete supplier shall furnish a series of at least 10 trial mixes that clearly indicate that the use of the admixture has consistently exhibited the specified pouring values. These are to be verified by an approved independent laboratory. The concrete supplier shall also conduct (with the above) a trial showing that a control mix without the admixture does not exhibit a greater density than that incorporating the admixture.

H Hydrophobic Pore Blocking Admixtures: If in the opinion of the Contractor a hydrophobic pore-blocking admixture is required to achieve the requirements specified herein, the Contractor may use an admixture based on ammonium stearates and hydrocarbon resin at no additional cost to the Employer. The admixture is to be added at a rate of 30 litres/m^3 at the time of mixing. The manufacturer's representative is to be present for all additions of the hydrophobic pore-blocking compound to ensure correct dosage rates are used.

2.10 Water Stops

A. Materials shall be sourced and supplied by a single manufacturer with a minimum of ten years experience. The manufacturer shall operate a quality system which is registered to ISO 9001. Technical back-up service during installation to be provided by the manufacturer at no additional cost to the Employer.

B. PVC or nitrile rubber waterstops shall be extruded from a high grade elastromeric polyvinyl chloride compound which contains plasticizers, resin stabilizers and other materials necessary to meet the performance requirements of this specification. Rubber and PVC waterstops shall be suitable for storage, handling, installation and service within a range of 15°C to 50°C.

C PVC waterstops shall be manufactured from PVC to BS 2571, or approved equal and shall not contain recycled or filler material. The minimum tensile strength shall be 13.8 N/mm^2. Elongation at break shall be minimum 300 percent and Shore A hardness shall be 80-90. The waterstop shall be fully continuous and coordinated four bulbed section. Testing shall be carried out in accordance with BS 2782, US Corps of Engineers specification CRD C572-74.

D Rubber waterstops shall be to US Federal Specification 22R-601a, except that compression shall be to ASTM D395-52 and hardness shall be to ASTM D676. Minimum tensile strength shall be 20.7 N/mm^2 and elongation at break shall be minimum 450 percent.

E Waterstop intersection & transition pieces shall be pre-formed and/or prefabricated factory moulded type. Joints shall be heat sealed.

F External waterstops for base slab expansion joints shall be minimum 250 mm wide with four bulbs and ten parallel lines of fins. Centre box section shall be 25 mm wide and flat to accept a filler board. It shall have an outer nailing flange with a reinforced and profiled edge to resist tear when fixed to shuttering with double headed nails and shall be provided with an additional key when cast into the concrete.

G External waterstops for base slab construction and contraction joints shall be minimum 250 mm wide with four bulbs and ten parallel lines of fins and shall incorporate a central fin 22 mm high, as a shutter stop. They shall have an outer nailing flange with a reinforced and profiled edge to resist tear when fixed to shuttering with double headed nails and shall be provided with an additional key when cast into the concrete.

H Internal waterstops for wall and roof expansion joints shall have a centre box to accommodate movement and shall be minimum 250 mm wide with four bulbs and ten parallel lines of fins. The centre box section shall be flat to accept a filler board. The web shall be 10 mm thick with a thickened central section to transfer stresses to the centre bulbs. The waterstop shall have a reinforced eyelet outer flange for secure fixing of the waterstops into position.

I Internal waterstops for wall and roof construction and contraction joints shall be minimum 250 mm wide with four bulbs and ten parallel lines of fins. The web shall be 100 mm thick with a thickened central section to transfer stresses to the centre bulbs. The waterstop shall have a reinforced eyelet outer flange for secure fixing of the waterstop into position.

J Water bars shall be arranged so that there is a minimum distance of 25 mm from the water bar to the reinforcement. Waterstops shall not be nailed or damaged in any way. The Contractor shall ensure that the concrete surrounding the waterstop is fully compacted without the waterstop being displaced. Waterstops shall be WRC approved for use in contact with potable water.

2.11 Movement Joints

A. Joint fillers shall be non-absorbent, semi rigid, closed cell, heat laminated polyethylene filler board and shall be non-tainting in accordance with BS 6920. They shall be fully compatible with the surface sealants and if elastometric sealants are used the joint filler shall act as a bond breaker. Performance properties of the joint filler shall be as follows:

Recovery	Greater than 98% after 50% compression
Extrusion	Nil (three edges restrained and sample compressed by 50%)
Density	100 kg/m^3 $\pm$ 5 kg/m^3
Water Absorption	less than 1%

B. Joint sealants shall be two part polysulphide complying with BS 4254 and must, in all cases, be carefully selected as appropriate for their climatic and environmental exposure. Where appropriate, they shall be resistant to biodegradation. Movement capacity of the sealant must be at least 20 percent of the joint width. The Contractor must apply written recommendations and guarantees from the manufacturers as to the suitability of the product for each individual structure and the method of installation. Primers shall have no harmful effects on concrete. Where required, masking tape shall be applied to protect the concrete surface on either side of the joint during priming and sealing operations. Masking tape must be stripped carefully away after joint sealing to leave near edges to the seal. Sealant shall be Feb Masterflex 700 or approved equal.

C Primer shall be as recommended by the sealant manufacturer.

D Bond breaker shall be forced, non-absorbent polyethylene backing strip or equals as recommended by sealant manufacturer to prevent adherence of sealant to backup material.

2.12 Accessories

A Vapour barrier/separation layer shall comprise two layers to underside of blinding concrete and ground slabs of gauge 1000 clear polyethylene sheets conforming to ASTM C 171. The physical properties for materials shall conform to ASTM E154.

B Non-shrink grout shall be as specified in Section 03600 hereof.

C Slip membrane shall be preformed low friction bearing strip to form a thin sliding joint with a minimum bearing capacity of 0.7 N/mm^2. It shall be extruded from specially formulated polyethylene to form a durable lamina, resistant to most chemicals, solvents and weathering. It shall be applied in two layers with bottom layer bonded to substrate with high quality solvent borne adhesive based on polychloroprene rubber. The thickness shall be 1.5 mm minimum. Coefficient of static friction shall be 0.15 and it shall be suitable for operating temperatures up to 50°C.

D Sealing strip membrane: Where indicated on the Drawings, expansion joints shall be sealed with a sealing strip system. The joints shall be pre-sealed using sealant prior to laying sealing strip membrane. The sealing strip system shall comprise of hypalon high-polymer flexible sheeting bonded to the concrete surfaces on either side of the joint using suitable epoxy resin adhesive. The system proposed shall have high performance and shall allow considerable movements in more than one direction while maintaining a high quality seal. The width of the flexible membrane shall be 250 mm and the minimum thickness shall be 3 mm. The minimum unbonded width of the membrane shall be 50 mm, centred on the joint, to allow greater movement potentials. Masking tape shall be applied to achieve the required debonded width. The final sealing strip system shall be able to accommodate movement which results in the debonded area being extended up to 100 percent of the debonded width. The performance properties shall be:

Density	~1.65 kg/litre (adhesive) ~1.50 kg/m^2 (hypalon /mm)
Service Temperature	~30°C to +70°C
Application Temperatures	Type Normal min. 10°C Type Rapid 5°C to 15°C
Bond Strength to Concrete	Dry or Damp =~ 4N/mm^2 (concrete failure)
Bond Strength to Steel	~6 N/mm^2 (strip failure)
Tensile Strength	~6 N/mm^2
Peel Strength	~4,5 N/mm^2
Elongation	>400 %

E Liquid membrane forming curing compounds shall be ASTM C309 approved standard product; shall be fugitive-dye resin or silicone type, free of wax or oil and shall be compatible with subsequently applied finished or coverings. They shall not be deleterious to bond of cementitious materials to concrete and shall be delivered in unopened labelled containers.

G Curing sheet materials shall conform to ASTM C171 and shall be waterproof paper, polyethylene film or white burlap-polyethylene sheet and be non-staining.

Part 3 Execution

3.01 Trial Mixes

A As soon as the Engineer has approved the concrete mix design for each grade of concrete and during or following the carrying out of the preliminary tests the Contractor shall prepare a trial mix of each grade in the presence of the Engineer at least 35 days before commencement of concreting.

B Trial mixes shall be mixed for the same time and handled by means of the same which the Contractor proposes to use in the Works. Each mix shall be not less than 0.5 cu m of concrete.

C The proportions of cement, aggregate and water shall be carefully determined by weight in accordance with the Contractor's approved mix design (or modified mix design after preliminary tests). Sieve analyses shall be made, by the method described in BS 812, of the fine aggregate and of each nominal size of coarse aggregate used.

D The slump of each batch of each trial mix shall be measured immediately after mixing by the method described in BS 1881 and shall be within the limits as specified.

E Contractor shall make three separate batches for each trial mix and six 150 mm compression test cubes shall be made from each batch in the presence of the Engineer. Temperature, workability and density of concrete in each batch shall be determined. Three cubes shall be tested at seven days and three at 28 days, after manufacture in accordance with the method described in BS 1881. If the average value of the strength of the nine cubes tested at 28 days is less than the trial mix strength given in Table 3.3, and/or the difference between the greatest and the least strengths is more than 20 percent of the average strengths, the Contractor shall remove from site, materials from which the trial mix was prepared and shall provide new materials and prepare and test further trial mixes until specified requirements are achieved.

F A full scale test of the workability of each trial mix of each grade of concrete shall be made by the Contractor in the presence of the Engineer. Trial mixes of each grade of concrete shall be batched, mixed and then transported a representative distance in the manner that the Contractor proposes to batch, mix and transport the concrete to be placed in the Works. After discarding the first batch so made, the concrete from later batches shall be placed and compacted in trial moulds both for reinforced and mass concrete with dimensions typical of the Works in accordance with the procedures described in later clauses. The sides of the moulds shall be capable of being stripped without undue disturbance of the concrete placed therein. The sides of the moulds shall be stripped after the concrete has set and the workability judged on the compaction obtained. If the workability test shows that the workability required is not attained for any trial mix for any class of concrete, the trial mix shall be re-designed by the Contractor. A further full-scale workability test shall be undertaken for that trial-mix of concrete.

G Re-design of the concrete mixes, and the making and testing of preliminary and trial mixes of concrete, shall be repeated for each grade of concrete until trial mixes of concrete meet the specified requirements and have the workability required to place it in the Works as demonstrated in the full scale workability test described above.

H The Contractor shall only use the approved mix of each grade of concrete in the Works. If, at any time during the construction of the Works, the source of cement or aggregate is changed, or the grading of the aggregate alters to such an extent that the fraction of aggregate retained on any sieve cannot be maintained within two percent of the total quantity of fine and coarse aggregate when adjusted in accordance with paragraph 3.01 here-in, then further trial mixes of concrete shall be made, tested and approved for use.

Preliminary laboratory tests shall be carried out to determine the mixes to satisfy the specification with the approved materials. Trial mixes shall be tested to determine the following properties of mixes proposed for initial field tests. If the values obtained are unacceptable, the mixes shall be re-designed:

1 bleeding in accordance with ASTM C232 (non-vibrating) shall not exceed 0.5 percent
2 shrinkage in accordance with BS 1881:Part 5 or BS 6073:Part 1 Appendix D
3 air content to BS 1881: Part 106.
4 free water/cement ratio
5 workability to BS 1881:Part 102.
6 fresh and hardened concrete densities to BS 1881:Parts 107 and 114 respectively.
7 compressive strength to BS 1881:Part 116
8 water permeability to DIN 1048 shall be a maximum 10mm at 28 days

J Approval of the job-mix proportions by the Engineer or his assistance to the Contractor in establishing those proportions, in no way relieves the Contractor of the responsibility of producing concrete which meets the requirements of these Specification.

K The Engineer may also require practical tests to be made on the Site by filling trial moulds to confirm the suitability of:
1 mix for the works,
2 type of plant used for mixing,
3 method of compaction used,
4 formwork face intended for use in the works.

L. All costs connected with the preparations of trial mixes shall be borne by the Contractor.

M Whenever a change of brand or source for any of the concrete ingredients occurs, additional "preliminary tests" will be required and the cost of these tests shall be borne by the Contractor.

3.02 Measurement of Ingredients

A All cement used in the manufacture of concrete shall be measured by weight either with an approved weighing machine or by making the size of each batch of concrete such as to require an integral number of complete bags or drums of cement.

B In concrete of Grade 20, the fine and coarse aggregates shall be measured separately by weigh batching machines which shall provide facilities for the accurate control and measurement of the materials either singly or cumulatively. The machines shall be capable of immediate adjustment by semi-skilled operators in order to permit variations to be made to the mix. All weight dials shall be easily visible from the place at which filling and emptying of the hoppers are controlled.

C Every concrete-mixing machine shall be fitted with a water-measuring device which shall be so constructed that the inlet and outlet valves are interlocked so that either one of them cannot be opened unless the other is fully closed. The device shall be provided with an overflow with a cross-sectional area at least four times that of the outlet pipe and with its discharge point clear off the mixing plant. The entire water system shall be maintained free of leaks at all times. The measuring device shall be fitted with a drain pipe which allows the full quantity of water being measured to be drained off for checking the measurement. The outlet arrangements of the measuring device shall be such that between five and ten percent of the water enters the mixer before the other materials and a further five to ten percent of

the water enters the mixer after the other materials. The remainder of the water shall be added at a uniform rate with the other materials. It shall also be readily adjustable so that the quantity of water added to the mixer can, if necessary, be varied for each batch. Arrangements for cooling of the mixing water shall be approved by the Engineer.

D. Any admixtures which may be used shall be measured separately in calibrated and transparent dispensers. Admixture shall be added to the mixture with the water. The dispenser shall be capable of dispensing the agent in quantities varying by not more than 5 percent from the quantities required and in such a manner to ensure uniform distribution of the agent throughout the batch during the time of mixing. The capability of the dispenser to achieve the required dosing and mixing requirement shall be demonstrated to the Engineer and shall be checked each day before concrete mixing commences.

E. The amount of concrete mixed in any one batch shall not exceed the rated capacity of the mixer and the whole of the batch shall be removed before materials for a fresh batch enter the drum. On cessation of work, including all stoppages exceeding twenty minutes, the mixers and all handling plant shall be washed with clean water. All mixing and batching plants shall be maintained free of set concrete or cement and shall be clean before commencing mixing.

F. Contractor shall provide weights, containers and equipment necessary for testing the accuracy of the weighing plant, water-measuring plant and admixture dispenser.

G. The batching plant shall be calibrated each month.

H. Hand mixing of concrete is not allowed.

3.03 Mixing of Concrete

A All structural concrete to be placed in-situ shall be manufactured in a computer controlled batching plant. If necessary, the plant shall be complete with suitable water chilling and ice making facility to ensure concrete temperatures are maintained as specified. Batching and mixing concrete off-site shall only be with prior approval. Mixing and transporting of concrete produced off-site shall be in accordance with the requirements of ready mixed concrete BS 5328. Concrete shall be mixed in batches in plant capable of combining the aggregates, cement and water (including admixtures, if any) into a mixture of uniform colour and consistency and of discharging the mixture without segregation. On commencing work with a clean mixer the first batch shall contain only half the normal quantity of coarse aggregate to compensate for the adhesion of the other materials to the drum. The natural moisture contents of the aggregates shall be determined before the commencement of each day's concreting and at such intervals during each day as may be necessary. The Contractor shall make due allowance for the water contained in the aggregates when determining the quantity of water to be added to each mix and the amount of water added to each mix shall be adjusted to maintain the constant approved water/cement ratio of the mixed concrete. No concrete shall exceed the specified water/cement ratio. The quantity of water used in mixing shall be the least amount that will produce a workable homogeneous plastic mixture which can be worked into the forms and around the reinforcement. In no circumstances shall the consistency of the concrete be such as to permit a separation of the aggregate from the mortar during handling. Excess water shall not be permitted and any batch containing such excess will be rejected.

B The use of ready-mixed concrete in any part of the Work shall require the Engineer's written approval. The Contractor shall satisfy the Engineer that materials used in ready-

mixed concrete comply with the Specification in all respects and manufacturing and delivery resources of the proposed supplier are adequate to ensure proper and timely completion. The specified requirements as to the sampling, trial mixing, testing and quality of concrete of various grades shall apply equally to ready-mixed concrete. Every additional facility, including transport, which the Engineer or persons authorised by him may require for the supervision and inspection of the batching, mixing, testing and transporting to Site of ready-mixed concrete shall be provided by the Contractor. Each load shall be accompanied by a bonded weigh-master's certificate listing those items listed in Section 1.04 A 5 herein. A copy of the certificate shall be given to the Engineer's site representative for each load. Unless approved otherwise in advance of batching all concrete of single design mix for any one day's pour shall be from a single batch plant of a single supplier. Ready-mix concrete shall conform to BS 5328, except materials, testing and mix design shall be as specified herein. Transit mixers equipped with automatic devices for recording the number of revolutions of the drum shall be used. No water shall be added during transporting to site or at the site. Each mixer truck shall arrive at the job site with its water container full. In the event that a container is not full or concrete tests give a greater slump than acceptable the load shall be rejected. Shade temperature and concrete temperature shall be recorded at the point of discharge of the mixer and at placement for each load of concrete delivered to site. Maximum and minimum temperatures and wet bulb temperatures shall be recorded daily. Perform slump tests in accordance with BS 1881 at the point of placement for each load delivered to site. Test cement in accordance with BS 4027 or ASTM C150 for each delivery of cement. Tests of cement and aggregates shall be performed to ensure conformance with requirements specified.

C. Test reports for all concrete shall be submitted at weekly intervals giving test results for workability and strength. For trial mixes the following data shall be submitted:

1 slump,
2 strength at 7 days and 28 days,
3 maximum aggregate size,
4 unit weight of concrete mix,
5 water/cement ratio and quantity; water content, water adjustment,
6 type of cement and dosage,
7 type of Admixture and dosage,
8 gradation of coarse and fine aggregate,
9 combined coarse and fine aggregate ratio,
10 ratio of fine to coarse aggregate,
11 percentage of absorption for coarse and fine aggregate, based on saturated surface dry material,
13 volume of batch for trial mix.

3.04 Concrete Testing

A Preliminary (Trial) Test

1 Target mean strength: The concrete mix shall have at least the required minimum cement content and mean strength greater than the required characteristic strength by at least the current margin. The current margin shall be taken as the lesser of:

a 1.64 times the standard deviation of cube tests on at least 100 separate batches of concrete of nominally similar proportions of similar materials and produced over a period not exceeding 12 months by the same plant and under similar supervision,

but not less than one sixth (1/6) of the characteristic strength for concrete of Grade 15 or not less than 3.75N/mm^2 for concrete of Grade 20 or above.

b. 1.64 times the standard deviation of cube tests on at least 40 separate batches of concrete of nominally similar proportions of similar materials and produced over a period exceeding 5 days but not exceeding 6 months by the same plant under similar supervision, but not less than one third of the characteristic strength for concrete of Grade 15 or not less than 7.5 N/mm^2 for concrete of Grade 20 or above.

c If enough data are not available to satisfy the requirements of either (a) or (b) above, the margin shall be taken as two-thirds of the characteristic strength for concrete of grade 15 or 10 N/mm^2 for concrete of Grade 20 or above. When required characteristic strength approaches maximum possible strength of concrete a smaller margin but not less than 7.5 N/mm^2 shall be permitted. Evidence shall be submitted to the Engineer for each grade of concrete showing that at the intended workability the proposed mixed proportions and manufacturing method will produce concrete of the required quality.

2 To establish the suitability of any material used in the concrete work, unless specified otherwise, the Contractor shall make preliminary tests and prepare design mixes, in accordance with BS 5328, in a design laboratory acceptable to the Engineer.

3 In addition to the tests required to establish the suitability of materials, the Contractor shall make one test for each design mix to verify that the total chloride ion content and the total sulphate (SO_3) content of each mix is within the specified limits. Chloride tests shall be performed in accordance with BS 812:Part 117 and sulphate (SO_3) tests in accordance with BS 812:Part 118. Chloride and sulphate levels in the concrete mix shall comply with the following requirements:

	% by wt. of Cement	
Type of Concrete	**Chlorides as Cl**	**Sulphates as $S0_3$**
For reinforced concrete if made with OPC/MSRPC if made with SRPC	 max 0.30 max 0.06	 max 3.70 max 3.70
Pre-stressed concrete and heat-cured reinforced concrete	Max 0.10	max 3.70
For mass concrete if made with OPC/MSRPC if made with SRPC	 Max 0.60 Max 0.12	 max 3.70 max 3.70

Note:

a. OPC and MSRPC cements can also contain chlorides, the relevant standard BS 12 allows up to 0.1 percent of chloride ion.

b. Any chloride content present in the cement has to be taken into account while computing total chloride ion in the mix.

c. In case the cement contains the maximum limit of 0.1 percent of chloride ion then the aggregates, water and admixtures used for pre-stressed concrete or heat cured reinforced concrete should absolutely free of chlorides.

4 When the results of a sufficiently large number of tests show that the previously established margin is significantly too large or too small, a change in the current margin used for judging compliance with the specified characteristic strength may be appropriate. Recalculation of the margin shall be carried out as before, but the adoption of recalculated value will not generally be justified if the two values differ by less than 18 percent when based on tests on 40 separate batches or 11 percent when based on tests on 100 separate batches, or 5 percent when based on tests on 500 separate batches. This recalculated margin, if adopted, becomes the current margin for the judgement of compliance with the specified characteristic strength of concrete

B Under the supervision and direction of the Engineer the Contractor will take specimens, as per BS 1881, of each class of concrete from different locations on the site. Each set of cubes shall be made at the point of placement. For each grade of concrete a set of six works test cubes shall be made whenever the Engineer may require and not less frequently than as follows:

1 for concrete Grade 35 or above one set of cubes per 30 cubic metres or part thereof, concreted per day,
2 for concrete Grade 20 one set of cubes per 40 cubic metres or part thereof, concreted per day.

C Works Test Cubes

1 Take test cubes as specified from fresh mixed concrete which is being used in the Works and which has been prepared in the normal way.
2 Cubes shall be numbered consequently and marked with the date, section of work from which they are taken and any other relevant information.
3 Take at least six cubes for each sampling and test 3 at 7 days and 3 at 28 days.
4 Strength of cubes shall be not less than the minimum strength requirements for each type of concrete.
5 If the average strength of the three works test cubes fail at 7 days:
   a immediately stop all concreting until checks are made on material and equipment,
   b immediately rectify any defect which has become apparent as the result of checking,
   c at Contractor's option, defective concrete may be removed and replaced without awaiting the 28 day test results.
6 If works test cubes fail at 28 days as specified in paragraph 3.11 herein:
   a suspend concreting operations and do not proceed further without approval,
   b take test cores in accordance with BS 1881: Part 120, or conduct in situ load tests in accordance with BS 1881: Part 124 on suspect work, in the presence of the Engineer,
   c replace all defective work,
   d re-testing shall be executed to the Engineer's approval.

D Two cylinders shall be cast to determine the tensile strength of the concrete at 7 days and 28 days, as specified in BS 1881: Part 117. Samples shall be taken from every 100 batches, but at least once a week during concreting operations and shall coincide with samples taken for test cubes.

E Other Tests

1 When instructed by the Engineer, concrete shall be tested for drying shrinkage and wetting expansion. 75 x 75 mm prisms shall be prepared for testing in accordance with Test 5 of BS 1881: Part 5 or BS6073: Part 1, Appendix D. The maximum acceptable limits shall be 0.05 percent for drying shrinkage and 0.03 percent for wetting expansion.
2 Permeability tests shall be in accordance with the method described in DIN 1048 and the maximum acceptable penetration at 28 days shall be 10 mm.
3 Air content of air-entrained concrete shall be determined in accordance with ASTM C231 for each batch produced until consistency has been achieved, when batches may be tested. The maximum value shall not exceed one percent.

F Workability shall be assessed by the tests mentioned hereunder and shall be carried out as required during concreting of permanent works to control workability at the batching plant and at the site of pour. The degree of workability shall be as for the trial mixes and permitted tolerances shall be in accordance with BS 5328. Slump test shall be performed according to BS 1881: Part 102 (at site of pour) and the allowable slump shall be 150 - 175 mm. Compaction factor tests shall be performed according to BS 1881: Part 103 (at site laboratory) and the allowable limit shall be 0.85 - 0.92. Vebe time shall be performed according to BS 1881: Part 104 (at site laboratory). Flow test shall be performed according to BS 1881: Part 105 (at site laboratory).

3.05 Transporting Concrete

A Transportation, delivery and handling shall be as specified in BS 5328. Concrete shall be conveyed from the mixer to its place in the Works as rapidly as possible by methods which will prevent segregation or drying-out. The Contractor shall ensure that concrete is of the required workability at the point and time of placing. If segregation has nevertheless occurred in any instance the materials shall be remixed to the satisfaction of the Engineer or discarded. The Contractor shall be responsible for the concrete being placed and compacted within such a time from the addition of the water to the mixer that the previous lift of concrete has not commenced setting.

B Tolerances shall be to BS 5606 for concrete construction and materials.

C The Contractor shall record time, date, temperature and slump of all concrete at the mixer and point of placement. The Contractor shall render to the Engineer, not more than twenty-four hours in arrears, a daily return for each grade of concrete comprising:

1 number of batches mixed,
2 number of batches and total volume of concrete placed,
3 number of batches wasted or rejected,
4 weight of cement and admixtures used.

3.06 Placing Concrete

A No concrete shall be placed until the Engineer has inspected and approved the surfaces upon which the concrete is to be placed, the formwork and the reinforcing steel. The Contractor shall give the Engineer not less than 24 hours to enable this inspection to be carried out. If concrete is not placed within 24 hours of approval being given, approval shall be obtained again before concreting. An inspection shall be made immediately prior to concreting to check the cleanliness of the forms. None of the requirements of this specification shall relieve the Contractor of his responsibility to place in the Works only sound well-compacted concrete free from voids and cracks.

B The Contractor's staff approved to supervise concrete work shall be on site whenever such work is executed.

C Before placing concrete, the Contractor shall remove from the surface of the foundations or previously placed concrete all oil, Latinate, loose fragments of rock, earth, mud, timber and other debris, and standing water to the satisfaction of the Engineer. Unless otherwise specified or directed by the Engineer, all excavated surfaces are to be covered with blinding

concrete Grade 20 not less than 75 mm thick.

D A vapour barrier separation layer shall be installed on the underside of blinding concrete and ground slabs on grade as specified. Lap joints shall be minimum 100 mm on sides and ends and the barrier shall not be disturbed while placing reinforcement.

E Concrete dropped into place in the Work shall be dropped vertically. It shall not strike the formwork between the point of its discharge and its final place in the Work. Except by prior approval of the Engineer, concrete shall not be dropped freely through a height greater than 1.5 m. Chutes and conveyor belts shall be also designed so that there is no segregation or loss of mortar. They shall be provided with a vertical tapered down pipe, or other device, to ensure that concrete is discharged vertically into place. When pumps are used, the end of the supply pipe shall be kept immersed in the concrete during placing to assist compaction. Concrete shall be carefully placed in horizontal layers which shall be kept at an even height throughout the Work. Concrete shall not be allowed to slide or flow down sloping surfaces directly into its final position but shall be placed in its final position from skips, trucks, barrows, down pipes or other placing machines or devices. If this is impossible, it shall be shovelled into position, care being taken to avoid separation of the constituent materials. Concrete placed in horizontal slabs from barrows or other tipping vehicles shall be tipped into the face of the previously placed concrete.

F Mortar or water used at the beginning or end of a run shall be discharged outside the formwork.

G Where concrete abuts against earth or any other material liable to become loose or to slip, care shall be taken to avoid falls of materials on to the surface of the wet concrete by suitable means.

H Concrete toppings shall be placed on top of structural slabs where indicated using a max. size aggregate of l0 mm, applied over an epoxy bonding agent. All toppings to be steel trowelled finished as specified in Section 03320 hereof.

I During the placing of all reinforced concrete, a competent steel fixer shall be in attendance on each concreting gang. He shall ensure that the reinforcement and embedded fittings are kept in position as work proceeds.

J Whenever instructed by the Engineer, the Contractor shall carry out the work in such a manner that the placing of the concrete in any particular section of the structure shall be executed without any interruption whatsoever from the beginning to the end of the operation. Concrete floor and inverts shall be cast in one layer unless where specified otherwise, or when written approval has been obtained to use an alternative construction method.

K Care shall be taken to prevent men engaged in placing concrete from introducing foreign matter into the concrete from their boots or in any other way. Where concrete, is placed directly against the surface of excavations any softened material shall first be removed. Disturbance of freshly finished concrete shall be prohibited.

L The Contractor shall take precautions to prevent the temperature of concrete rising above 32°C. The concrete temperature shall be maintained at, or below 32°C, until it has hardened, and shall be shaded from direct sunlight to the satisfaction of the Engineer. Concrete shall not be mixed or placed when the ambient shade temperature exceeds 40°C and rising or 43°C on a falling thermometer. The times at which concreting will be allowed to take place will be agreed with the Engineer. The Contractor shall take the following precautions in hot weather:

1 Cool water to between 5°C and 8°C.
2 If ice is used take account in computing water/cement ratios and ensure that ice is melted before the concrete leaves the mixer.
3 Cool aggregate with draughts and protect from sunlight with heat reflecting covers.
4 Cool formwork and reinforcement:
5 Use mixed concrete without delay.
6 Do not expose wet concrete, or concrete carrying vehicles to the hot sun for more than the minimum practicable time.
7 Insulate the rotating mixer drum externally to prevent overheating of the metal and excessive heat transfer.
8 Any additional recommendations of ACI-305, BS 5328 and Cement and Concrete Association advisory note on "Hot Weather Concreting".
9 Concrete shall be placed and compacted before initial set has occurred and in any event not later than sixty minutes from the time of mixing unless otherwise approved by the Engineer.

C Placing Concrete in Water

1 No concrete shall be placed in flowing water.
2 Underwater concrete shall be placed in position by tremis, or by pipeline from the mixer.
3 Full details of the method proposed shall be submitted in advance to the Engineer and his approval obtained before placing begins.
4 Where the concrete is placed by the tremis, its size and method of operation shall be in accordance with BS 8004.
5 During, and after, concreting under water, pumping or dewatering operations in the immediate vicinity shall be suspended until the Engineer permits them to be continued.

3.07 Compacting Concrete

A Except for slabs less than 100 mm thick, all concrete placed in-situ shall be compacted with power-driven internal type vibrators supplemented by hand spading and tamping. Unless otherwise agreed by the Engineer slabs less than 100 mm thick shall be compacted by approved vibrating screeds. Vibrators shall at all times be adequate in numbers, amplitude and power to compact the concrete properly and quickly throughout the whole of the volume being compacted to the satisfaction of the Engineer. Spare vibrators shall be readily on hand in case of breakdown.

B Internal type vibrators shall be inserted into the uncompacted concrete vertically and at regular intervals. Where the uncompacted concrete is in a layer above freshly compacted concrete, the vibrator shall penetrate vertically for about 100 mm into the previous layer. Vibrators shall not come into contact with the reinforcement or the formwork and shall be drawn back slowly from the mass concrete so as to leave no voids. Internal type vibrators shall not be placed in the concrete in a random or haphazard manner nor shall concrete be moved from one part of the work to another by means of the vibrators.

C Compaction shall commence as soon as there is sufficient concrete to immerse the vibrator and continued during the placing operations so that at no times shall there be a large volume of uncompacted concrete in the formwork.

D The duration of vibration shall be limited to that required to produce satisfactory compaction without causing segregation. Vibration shall, on no account, be continued after water or excess grout has appeared on the surface.

3.08 Curing of Concrete

A Immediately after compaction, and for a continuous minimum period of 14 days thereafter, concrete shall be protected from the harmful effects of weather, including rain, dry winds rapid temperature changes, premature drying and resulting effects of thermal shrinkage. Curing to be in accordance with ACI 301 chapter 12 and as modified here-under. The Contractor shall obtain approval of curing methods.

B Formed surfaces, including the undersides of girders, beams, supported slabs and the like, shall be cured by moist curing with the forms in place for the full curing period, or until forms are removed. When forms are stripped, curing shall be continued by any applicable specified method.

C Unformed surfaces shall be cured initially by moist curing and finally by any applicable specified method, unless otherwise indicated.

D Moisture curing shall be executed by covering surface with water and keeping continuously wet; fine fog water sprays in continuous operations; covering surface with a saturated absorptive cover and keeping continuously wet. The absorptive covers shall be placed with 100 mm laps, to cover the entire surface and edges.

E Moisture retaining cover curing shall comprise a suitable cover to the concrete surface. The cover shall be in the widest practicable widths and shall have 200 mm side and end laps and shall be sealed with waterproofing tape or adhesive. The Contractor shall immediately repair any holes or tears in the cover with cover material and waterproof tape.

F Liquid membrane curing shall be an approved non-staining, membrane forming curing compound in accordance with the manufacturer's recommendations and shall be applied immediately after any water sheen which may develop after finishing has disappeared from the surface and within two hours of stripping formwork on formed surfaces. Curing compound shall have a minimum 95 percent moisture retention standard. It shall not be used on surfaces against which additional concrete, or other material is to be bonded, unless it is proven that the curing compound will not prevent bond, or that positive measures are taken to remove it completely from those areas which are to receive bonded applications.

G Steam curing shall be carried out in an enclosure around the concrete using tarpaulin or other suitable means. Application of steam shall not commence until at least two hours after final placement of concrete. Steam shall be applied at a maximum temperature between 65°C and 80°C and the maximum steam temperature shall not rise above 82° C. Excessive rates of heating and cooling shall be prevented during steam curing and temperatures in the enclosure shall not increase or decrease by more than 22°C per hour. The maximum steam temperature shall be maintained in the enclosure until concrete has reached its specified strength.

H Backfill shall not be placed over concrete surround to pipes for a minimum of six hours after completion of concreting and dewatering equipment shall continue in operation for at least this period. Compaction of backfill over the pipe surround concrete shall not commence until at least 48 hours after completion of concreting.

3.09 Joints

A Construction joints shall comply with BS 5328 except as modified here-in. Waterstops are not considered necessary in properly formed construction joints. If the contractor wishes to install waterstops in construction joints to satisfy the requirements of these Specifications, then waterstops shall comply with these Specification and Drawings, the cost of which shall be borne by the Contractor. The Contractor shall submit detailed proposals not less than three weeks before the commencement of concreting and the details shall include the sequence of placing concrete; sizes of concrete pours; positions of all vertical and horizontal construction joints; and height of lifts. No concreting shall be started until the Engineer has approved the detailed proposals. Construction joints shall be so located as not to impair the strength of the structure.

Positions of construction joint and size of formwork panels shall be so co-ordinated that, where possible, the line of any construction joints coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series. For all exposed horizontal joints and purposely inclined joints, as uniform joint shall be formed with a pattern of approved dimension to give a straight and neat joint line. Concrete placed to form the face of a construction joint shall have all Latinate removed and the aggregate exposed prior to the placing of fresh concrete. Latinate shall wherever practicable be removed by spraying the concrete surface with water under pressure and brushing whilst it is still green or by the application of surface mortar retarder followed by washing and scrubbing with stiff broom. Where the Latinate cannot be removed whilst the concrete is still green the whole of the concrete surface forming part of the joint shall have the aggregate exposed by means of a proprietary power driven scabbling/bush hammer as approved by the Engineer. Powerful hammers shall not be used and hacking, chipping, chiselling, etc. shall not be permitted. All loose matter shall be removed and the exposed surface thoroughly cleaned by wire brushing, air blasting or washing and the surface to which fresh concrete is applied shall be clean and damp.

Joints shall be located as follows:

1 in the middle third of span in slabs, beams or girders,
2 walls (vertical) away from corners; spaced at maximum 5m; where the concrete wall is monolithic with the floor or footing, the pouring of the wall shall commence within 7 days of placing the floor slab or footing with which it corresponds. Successive lifts in walls shall be placed within 3 days. Circular walls of tanks with a sliding joint between floor and wall are not subject to the 5 m panel limits referred to above if a lift in the wall is concreted as a continuous ring. Concreting shall then be carried out continuously in both directions until the ring is complete,
2 walls (horizontal) are only allowed when wall is continuous with floor slab and shall be keyed on cast kicker 150 mm high or on top of wall meeting soffit of suspended members,
3 a minimum 20 mm above soffit of beams connecting or 15 mm above soffits of slabs for columns,
5 ground slabs bearing on ground shall be cast in panels designed by movement subject to 7.5 m panel limits. Where no movement joints are specified or where the distance between movement joints exceeds 7.5 m in any direction for ground slabs and exceeds 7.5 m in length for wall slabs (except as described above under walls) they shall be sub-divided by properly formed construction joints into panels of dimensions not exceeding 7.5 m. Panels shall be separately concreted and, except as detailed below, no panel shall be concreted until the concrete in adjacent panel is at least 14 days old. These requirements will generally be met by casting in alternate bays in a chequer board fashion. If long and short bays are proposed, the long bays shall be concreted first. It is desirable that reinforcing bars extending across in-fill bays are not continuous (i.e. a

splice is provided within the in-fill bay). If the Contractor adopts the above or other approved method to accommodate shrinkage, the Engineer may agree to a reduction in the 14-day time, but in no case will the approved period be less than four days. The peripheral ring beam in the floor of a circular tank shall not be concreted in advance of its integral floor slab. The periods referred to above do not apply to successive lifts in walls. The proposed sequence of casting panels as called for in this subsection shall be submitted for the Engineer's approval before commencement of concreting.

6 Non-structural ground slabs shall be cast as ACI 302 and shall be aligned with column or grid lines where practicable.

a isolation joints shall be diamond-shaped or circular separations around columns ensuring all edges of slabs are isolated from adjoining construction.

b control joints shall be spaced at 4 to 7m centres in both directions and spacing is dependent upon the type of coarse aggregate in the concrete as follows unless reliable data indicate wider spacings are feasible:

siliceous gravel or slag : 4m;
crushed limestone : 5.5m;
crushed granite : 7m.

c panels formed by joints shall be approximately square and in no case shall be the length/width ratio exceed 1.5:1. They shall be formed by either: sawing a continuous straight line in the top of the slab; grooving fresh concrete with hand grooves; or placing strips of wood, metal or pre-moulded joint material at joint locations. The top edges of strips shall be flush with concrete. Control joints shall extend 1/5 to 1/4 x slab thickness into the slab.

B Expansion joints: reinforcement or other embedded metal items bonded to the concrete (except dowels in floors bonded on only one side of joints) shall not extend continuously through any expansion joint. Joints shall not be sealed until adjacent concrete is at least 28 days old. Joint sealant shall be prepared and installed in accordance with Section 07920 and manufacturer's instructions.

C Waterstops shall be fixed at locations indicated on the Drawings and shall be installed to give a continuous diaphragm in each joint. Pre-moulded waterstop shall be in maximum possible lengths to minimise the number of end joints. Joints at ends and intersections shall be made in the manner most appropriate to the material used and according to manufacturer's recommendations. Joints shall fully develop effective watertightness, equal to that of the continuous waterstops material; permanently develop not less than 50 percent of the mechanical strength of the parent section; and permanently retain their flexibility. Waterstop shall be fixed to formwork or reinforcement in accordance with manufacturer's recommendations. It shall be fitted accurately to formwork to prevent seepage of grout when concreting and shall not be fixed with nails or ties through the web of waterstop. Damaged waterstops shall be repaired before concreting. Waterstop shall be protected whilst protruding from an incomplete joint.

3.10 Concrete Finishing

A Finishes to unformed surfaces of concrete shall be classified as U1, U2, U3, "spaded" or "bonded concrete" or such other special finish as may be particularly specified. Where the class of finish is not indicated on the Drawings the concrete shall be finished to Class U1.

1 Class U1 finish shall be the first stage for Class U2 and U3 finishes and for a bonded concrete surface. It shall be a levelled and screeded, uniform plain or ridged finish, which (unless it is being converted to Class U2, U3 or bonded concrete) shall not be disturbed in any way after the initial set and during the period of curing. Surplus

concrete shall be struck off immediately after compaction. Where a bonded concrete surface is specified, the Latinate shall be removed from the Class U1 finished surface and the aggregate exposed while the concrete is still green. A spaded finish shall be a surface free from voids and brought to a reasonably uniform appearance by the use of shovels as it is placed in the works. Where a broom finish is specified, the surface of the concrete shall first be levelled and screeded and then brushed in one direction with a stiff broom.

2 Class U2 finish shall be a wood float finish. Floating shall be done after the initial set of the concrete has taken place and the surface has hardened sufficiently. Concrete shall be worked no more than is necessary to produce a uniform surface free from screed marks.

3 Class U3 finish shall be a hard smooth steel-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess Latinate from being worked into the surface. Surface shall be trowelled under firm pressure and left free from trowel marks. All surfaces, which are not to be covered with a further finish, will be U3 finish. All surfaces on which further finishing screeds or treatment are to be applied, will be U2 finish.

B Concrete work shall be constructed to an accuracy which shall permit the proper assembly of components and installations and shall be compatible with the finish. The accuracy of the work shall be within the tolerances stated on the Drawings or specified elsewhere. For further information regarding tolerances see BS 5606

3.11 Concrete Inspection

A Concrete work will be subject to detailed inspection and tests at the plant and in the field. The Contractor shall notify the Engineer one day in advance of concrete work for inspections and tests. Sampling of concrete taken from the job will be carried out under the direction of the Engineer. Tests carried out by the Contractor in his site testing laboratory shall be under the direction of the Engineer.

B Concrete shall be produced in accordance with BS 5328 and this requires that tests are made on the constituent materials in accordance with the relevant British Standard. Control tests are made on concrete to ensure compliance with the specified requirements.

C The Contractor shall establish a plan for sampling and testing to the approval of the Engineer. When tested, the concrete shall meet the appropriate requirements specified in BS 5328, i.e.:

1 characteristic compressive strength,
2 specified mix proportions,
3 minimum or maximum cement content,
4 maximum free-water/cement ratio,
5 workability,
6 air content of concrete,
7 temperature of fresh concrete,
8 density of fully compacted concrete.

D The rate of sampling and testing shall be as specified and/or as directed by the Engineer and the cost of sampling and testing shall be borne by the Contractor. The atmospheric conditions, temperature of concrete, concrete constituents, and the state of reinforcement steel and formwork shall be monitored continuously during concrete placement.

E The Contractor shall facilitate sampling procedures and provide labour and material as required. The Engineer shall be notified when reinforcing steel is in place in order to facilitate any inspection he deems necessary. The Contractor shall submit checking sheets before placing concrete. Concrete shall not be placed until these inspections have been completed and all deficiencies reported by the Engineer have been corrected to the Engineer's satisfaction.

F The Contractor shall supply all moulds required for tests as described below. Moulds of the same type and manufacture shall be used for making all test specimens. If field tests show excessive slumps or other violations of the specified requirements, the entire batch of concrete from which the sample in question was taken will be rejected. Rejected concrete shall be removed from the site at the Contractor's expense. The Engineer will inspect all concrete operations in the plant and in the field.

G If ready-mix concrete is used, each load of concrete arriving at the job shall be accompanied by a delivery ticket which shall be subject to checking by the Engineer at the plant and which shall contain the following information:

1 type and strength of the mix of concrete being delivered,
2 exact time the cement and aggregate discharged into the delivery truck,
3 the Engineer will reject the load if, upon reaching the job, the concrete cannot be placed within the time limits stated, or the type of concrete delivered is incorrect.

H The Contractor shall keep records of all specimens taken and tests made in a format approved by the Engineer. These records shall be signed by the Contractor and the Engineer.

I Final acceptance of the concrete works is based on twenty-eight (28) day testing on the work test cubes. The work is considered in compliance if the average of the three cubes equals, or exceeds, the minimum specified for the class of concrete being placed and if no cube strength falls below 85 percent of the specified works test strength. If the results of the twenty-eight (28) day testing are unsatisfactorily, the Contractor, in accordance with the instructions of the Engineer, shall conduct tests in the suspect parts of the structure.

J As and where directed by the Engineer, cylindrical core specimens of 150mm nominal diameter shall be cut perpendicular to the face of the hardened concrete in the Works for the purpose of examination and testing. The procedure for drilling, examination, measurement and testing for compressive strength shall be in accordance with BS 1881: Part 120. Prior to preparation for testing, specimens shall be made available for examination by the Engineer. If the crushing strength of the specimen in accordance with BS 1881: Part 120 is less than the minimum crushing strength given in Table 3.3 or if, in the opinion of the Engineer, the concrete fails to meet the specified requirements in other respects, the concrete in that part of the Work of which it is a sample will be considered defective.

3.12 Defective Concrete

A Defective concrete shall be defined as one or more of the following:

1 not conforming to required levels, lines, details and elevations,
2 defective in required concrete strengths,
3 defective in appearance in ultimate exposed areas due to:
  a improper placement or preparation of formwork resulting in bowed formwork,
  b improper formwork joints,
  c honey combing,

d surface cracks or damaged surfaces,
e exposed reinforcement,
f improperly placed snap on or cone ties,
g unsatisfactory conditions for the performance of sandblasting work etc.

B Defective concrete work must be reported to the Engineer. No remedial work shall be performed without the prior agreement of the Engineer, with respect to timing, method of repair, and final acceptable standard and appearance of completed repair work. Defective concrete members shall be totally removed and replaced if a satisfactory appearance (accepting satisfactory strength requirements) cannot be achieved, even after the completion of remedial work and members with satisfactory strength requirements including any adjacent members so affected.

C. The Engineer's decision shall be final in all aspects related to the correction of defective concrete.

END OF SECTION 03300

Section 03320

Concrete Topping

Part 1 General

1.01 Description

A The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with concrete floor screeds and accessories.

1.02 Quality Assurance

A Only materials of known quality shall be incorporated in the work.

B All materials shall be properly selected, reviewed with the Engineer before use and maintained during shipment, storage and use.

C Regardless of reviews by the Engineer, the Contractor shall be responsible for all materials, methods and the work.

D If any work does not satisfy the Contract Documents, implement removal, replacement or remedial work and revise procedures or materials to prevent recurrence of unacceptable work.

1.03 Submittals

A Samples of concrete accessories of every type to be used.

B Certified mill test reports for cement.

1.04 Delivery, Storage and Handling

A Deliver all packaged materials to the site in original unopened containers, clearly indicating manufacturer's name, brand name and other identifying information.

B Store materials in a dry, well-ventilated location, off the ground and in such manner as to prevent damage or intrusion of foreign matter.

C All materials which, in the opinion of the Engineer, have become damaged or otherwise unfit for use during delivery or storage shall be replaced.

Part 2 Products

2.01 General

A The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, will be considered acceptable.

2.02 Materials

A Portland cement shall be to BS 4027 or ASTM C150, Type V, non-staining. Only one brand of cement from one mill shall be used throughout the work, unless otherwise approved by the Engineer.

B Coarse aggregate shall be to BS 882 or ASTM C33 and shall be evenly graded crushed gravel or stone, or a combination thereof passing a 9.5 mm sieve and retained on a 4.5 mm sieve.

C Fine aggregate shall be natural sand to BS 882 or ASTM C33

D Water shall be clean, fresh and free of harmful matter such as oil, salts, acids, alkali, sewage, deleterious minerals or organic matter and shall conform to BS 3148.

E Curing material shall be:
1 polyethylene sheeting to ASTM C171, 0.10 mm thick, opaque black,
2 reinforced waterproof building paper to ASTM C171 and or BS 1521, Grade A1 opaque,
3 burlap to AASHTO M 182.

F Dustproofer shall be a product of Fosroc International Limited or other equal to the approval of the Engineer.

G Hardener and sealer shall be a product of Fosroc International Limited or other equal to the approval of the Engineer.

H Mixes:
1 Grout shall be one part cement to one part sand, with sufficient water to make a stiff slurry.
2 Bond coat shall be one part cement to 1¼ parts sand to two parts coarse aggregate mixed with bonding agent as approved by the Engineer. The amount of water shall not exceed 19 litres per 50 kg. bag of cement.
3 Top coat shall be same mix as specified for the bond coat.
4. Stair platforms, landings and treads without finish covering shall be made "non-slip" by using 1.2 kg. of a fine abrasive aggregate for each square metre of area. Abrasive aggregate shall consist of a vitreous ceramic grit containing 60 to 70 percent aluminium oxide abrasive.

I Mesh reinforcement shall conform to BS 4483.

J Pigmented concrete shall contain pigments for integrally coloured concrete and which shall be submitted for the Engineer's approval and shall be certified in writing by the manufacturer to be in compliance with ASTM C 979.

Part 3 Execution

3.01 Condition of Surfaces

A The Contractor shall examine the substrate, adjoining construction and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory conditions have been corrected.

3.02 Preparation

A The substrates shall be cleaned to remove grease, laitance and other substances which may adversely affect the adhesion of the work by using a dilute solution of muniatic acid, chipping of the surface, or any other method of cleaning required.

B The surfaces shall be left thoroughly clean and wet with as much water as will be absorbed. The substrates shall be kept wet continuously overnight, but in no case for less than six hours, before work is applied.

3.03 Application

A The wet substrate surfaces shall be completely covered with grout, applied with force and brushed in to ensure full coverage. The bond coat shall be applied not less than 16 mm thick immediately after application of grout and brought to true lines, levels and profiles. The bond coat shall be thoroughly compacted and roughed to form a key for the top coat. Before the bond coat has set, the top coat shall be applied to such thickness that the total of the work measured from substrate to finished surface will be as shown, less only thickness of finish covering.

3.04 Finishing

A General
1 Consolidate concrete with vibrating screeds or roller screeds.
2 Power float and hand float after water sheen has disappeared to push down aggregate, raise mortar and level.
3 Power trowel and hand trowel as soon as surface can be worked without cement base clinging to blades.
4 Tolerances in surfaces for hand trowelled and non-slip finishes shall not exceed 3 mm in 3 metres in any direction. Elsewhere, tolerances shall not exceed 6 mm in 3 metres in any direction.
5 Saw-cut control joints 5 mm wide, 20 mm deep in hardened toping using diamond-bladed power saw at locations approved by the Engineer.

B Finishes
1 Hand trowelled.
a Trowel smooth finish free of trowel marks and other defects until a ringing sound is produced.
b Moist cure with hardener and sealer
2 Non-slip finish.
a Wood float to rough granular finish, and let set.
b Moist cure with hardener and sealer.
3 Trowelled - for all floors to receive carpet or resilient floor finish.
a Float to smooth granular finish.
b Trowel to smooth finish, free of trowel marks, pockets or humps.
c Cure and seal in 2 coats.
d Use self-levelling compound to bring to final true level.
4 Other surfaces to receive subsequent finishes e.g. cement and sand beds for quarry tiles, ceramic tiles, etc.
a Consolidate and level.
b Use stiff broom to roughen surface and expose aggregate.
c Moist cure only.
d Do not use chemicals for curing.

3.05 Curing and Protection

A Work shall be cured by covering with polyethylene sheeting and flooding for at least seven days after finishing. After curing the work shall be kept covered to protect it from damage during the progress of other work.

3.06 Dustproofing

A When the work is cured and dry, two coats of dustproofer shall be applied in accordance with manufacturer's instructions for hand trowelled and non-slip finishes.

END OF SECTION 03320

Section 03350

Linings and Protective Coatings to Concrete

Part 1 - General

1.01 Description

A This section is applied only where lining or protective coating on concrete surface is specified in the drawings or in the Particular Specifications.

B. The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with protection of concrete surfaces.

1.02 Work Not To Be Coated

A Concrete foundation walls and exterior equipment pads.

1.03 Submittals

A Submittals shall be made in accordance with Section 01300 and include the following items:

1 Method statement
2 Liner schedule.
3 Material certifications.
4 Test results.
5 Material samples.
6 Manufacturer of the lining shall submit an affidavit attesting to the successful use of his product as a lining for a minimum period of ten years in sewage conditions recognized and acknowledged as corrosive or otherwise detrimental to concrete.

B Shop drawings shall be submitted for approval showing a minimum of:

1 Details showing the sheet layout of the liner system indicating the location and direction of seams and panel sizes.

2 Details of liner system giving:
a liner anchorage to concrete structures,
b details of sealing the liner material to concrete structures,
c details of sealing the liner materials to pipe conduits,
d other openings into the structure.

3 The Contractor shall submit a schedule detailing the liner fabrication and installation.

C Manufacturer's Data

1 Manufacturers current printed product description, materials safety, and technical datasheets shall be furnished for all coating systems.

2 Detailed mixing, thinning, and application instructions, minimum and maximum application temperature, and curing and drying times between coats shall be furnished for epoxy and all special coatings.
3 For the liquid glaze coatings, the instructions shall also include surface preparation requirements and the number and types of coats required for each surface.
4 Colour charts for each coating system.
5 Certifications from manufacturers verifying that the factory applied prime coats are compatible with specified finish coatings.
6 Detailed maintenance manual including the following information:
a product name and number,
b name, address and telephone number of manufacturer and local distributor,
c detailed procedures for routine maintenance and cleaning,
d detailed procedures for light repairs such as scratches and staining.

D Certificates of Compliance.

E Inspection Reports.

F Test Reports.

1.04 Quality Assurance

A The liner must be continuous and free of pinholes both across the joints and in the liner itself.

B All work for and in connection with the installation of the lining in concrete pipe and structure, and the field sealing and welding of joints, will be done in strict conformity with all applicable specifications, instructions, and recommendations of the lining manufacturer.

C Applicator Qualifications:
1 Submit the name and experience record of the coating applicator.
2 Include list of utility or industrial installations coated, responsible officials, architects, or engineers concerned with the project and the approximate contract price.

D Inspect the surface and correct all deficiencies prior to the application of each coat.

E All coating products, liner material and all accessories as recommended by the manufacturer shall be supplied by the same Manufacturer at no additional cost to the Employer.

F Comply with all Government laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including:
1 ACI 515.1R, A guide to the use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete.
2 WPCF Manual of Practice No. 17, Paints and Protective Coatings for Wastewater Treatment Facilities. Guide and Paint Application Specifications.

1.05 Warranty

A The manufacturer and the Contractor shall jointly guarantee the completed liner installation to be free from defects in workmanship and or materials for a period of ten years from the date of Substantial Completion of the works. Warranties and guarantees by the suppliers of various components in lieu of single-source responsibility by the liner manufacturer will not be accepted. The liner manufacturer shall be solely responsible for the warranty. In the event of a failure in the liner installation or component or if the liner installation or component is

proven defective in service during the warranty period, the Contractor and manufacturer shall provide, replace or repair the liner without any additional cost to the Employer.

B. The Contractor shall furnish Employer with manufacturer's guarantee and warranty certificates for all materials and components duly registered with the manufacturer.

1.07 Delivery, Storage and Handling

A Deliver materials to the job site in original, unopened packages and containers bearing manufacturer's name and label, including the following information:
1 name or title of material,
2 manufacturer's stock number and date of manufacture,
3 manufacturer's name,
4 contents by volume, for major pigment and vehicle constituents,
5 thinning instructions where recommended,
6 application instructions,
7 colour name and number.

B Storage
1 Shall conform to the manufacturer's recommendations.
2 Store only acceptable project materials on site in a suitable location.
3 Keep area clean and accessible.
4 Restrict storage to coating materials and related equipment.
5 Temperature of storage area shall be kept between 20°C and 36°C at all times.
6 Comply with health and fire regulations.
7 Provide approved fire extinguishers in the coating storage area.

1.08 Environmental Conditions

A Unless otherwise recommended by the coating manufacturer, the ambient temperature shall be between 8°C and 39°C when applying coatings other than water-thinned and epoxy.

B Water-thinned coatings shall be applied only when ambient temperature is between 11°C and 36°C.

C Epoxy shall be applied only within the minimum and maximum temperatures recommended by the coating manufacturer.

D Coatings, except water-thinned types, shall be applied only to surfaces that are completely free of moisture as determined by sight or touch.

E Do not apply to surfaces which have visible frost or ice.

Part 2 - Products

2.01 Liner Material

A Sheet liner shall be manufactured from high molecular weight PVC or PE resin and other components necessary to make a material of permanent flexibility suitable for a liner in concrete pipes and structures in sewerage service.

B Weld strips and the joint strips shall be made from like material.

C For PVC and PE sheet liners, the actual resin used in manufacture must constitute not less than 99 percent of the resin used in the formulation.

D Copolymer resins will not be permitted.

E The following are the main properties of PVC and PE sheet:

1 Test Method:		PVC	PE
Elongation at break	ASTM 638/882	300%	Exceeds 600%
Tensile Strength	ASTM 638/412	15 N/mm^2	10-20 N/mm^2
Low Temp/Brittleness	ASTM 746	0°C	-75°C

2 All plastic sheets including locking extensions, all joints and welding strips shall be free of cracks, asperities and other defects that may affect the protective properties of the material.

3 Lining shall have good impact resistance, be flexible and have an elongation sufficient to bridge up to 6 mm wide settling cracks which may occur after installation, without damage to the lining.

4 Lining shall be capable of being repaired at any time during the life of the structure.

F Except at shop welds, all the plastic sheet liner, strips shall have the following properties when tested at 25°C

Property	**Initial**
Tensile Strength	15 N/mm^2
Elongation at Break	200%
Shore Durometer	1 Second 50-60 $\pm$ 5 (With respect to 10 Seconds 35 - 50 $\pm$ or 5 initial test result)
Weight Change	+ or - 1.5 %

G Details and Dimensions of Basic Size Sheets:

1 Minimum thickness of sheet and strip shall be as follows:

Material Thickness	**Structures**	**Concrete Pipe**
Sheet with locking extensions	4.0 mm	1.5 mm
Sheet, plain	2.3 mm	2.3 mm
Joint strip	1.9 mm	1.0 mm
Weld strip	2.4 mm	2.4 mm

2 Locking extensions of the same material as that of the liner to be integrally extruded with the sheet.

3 Locking extensions to be approximately 65 mm apart and shall be at least 10 mm high.

4 Sheets to have a nominal width of 1200 mm and a length of not more than 7.5 m, except that longer lengths may be supplied on special order. Lengths specified shall include a tolerance at a ratio of 1:400.

5 Sheets not used for shop fabrication into larger sheets to be shop tested for pinholes using an electrical spark tester set at 9000 Volts per 1.0 mm thickness of lining minimum. Any holes shall be repaired and retested.

H Pipe linings shall be supplied as pipe-size sheets, fabricated by shop-welding the basic size sheets together. Shop welds shall be made by lapping sheets a minimum of 12 mm and applying heat and pressure to the lap to produce a continuous welded joint. Tensile strength measured across shop-welded joints measured in accordance with ASTM D412 to be at least 15 N/mm^2. Sheets that are strapped on forms shall have transverse strap channels cut in the locking extensions so that strapping can be placed perpendicular to the locking extensions. Channels to be not less than 20 mm wide and not more than 50 mm wide and shall be cut so that a maximum 5 mm of the base of the locking extension remains in the base of the strap channel. Strap channels to be provided at intervals of not less than 400 mm nor more than 500 mm centre-to-centre. Strap channels shall not be cut through the final two locking extensions on each edge of the sheet. Transverse flaps shall be provided at the ends of sheets for pipe. Locking extensions shall be removed from flaps so that a maximum of 0.4 mm of the base of the locking extension is left on the sheet. Weld strips shall be approximately 25 mm wide with a minimum width of 22 mm. Edges of weld strips shall be bevelled in the manufacturing process. Thickness of weld strip shall be a nominal of 3 mm. Joint strips for pipe shall be 100 mm wide with a minimum width of 95 mm. Thickness of joint strips shall be equivalent to that of the liner. Before preparing the sheets for shipment, they shall be tested for pinholes using an electrical spark tester set at 20,000 volts minimum. Any holes shall be repaired and retested.

2.02 GRP Lining

A GRP linings shall be as specified in Section 06610.

2.03 Epoxy Coating

A General

1 No substitutions shall be considered that will decrease film thickness; number of coats; surface preparation; or performance criteria or the generic type of coating specified.
2 All coatings under this Section shall be furnished by a single manufacturer.
3 Compatible materials shall be used as primer and finish coats of systems.
4 Colours shall be as scheduled or selected by the Engineer, except prime and intermediate coats shall be tinted as approved by the Engineer to facilitate inspection of coverage for each coat.
5 All products submitted shall conform to Government laws and ordinances, and regulatory agency requirements limiting the emission of volatile organic compounds.

B Hazardous Materials Restrictions

1 Coatings shall comply with all applicable state and local laws enacted to insure compliance with clean air standards.
2 Lead content shall not exceed the amount permitted by Government and regulatory agency laws and regulations.
3 Mercurial fungicides shall not be used.

C Materials

The epoxy coating shall meet the following properties.
1 Working Life and Setting Time - Test Methods C 308,
2 Tensile Strength - Test Method C 307,
3 Compressive Strength - Test Method C 579,
4 Flexural Strength and Modulus of Elasticity - Test Method C 580,

5 Shrinkage and Coefficient of Thermal Expansion - Test Method C 531,
6 Absorption - Test Method C 413,
7 Chemical Resistance - Test Method C 267.

2.04 Water Proofing Membrane

As specified in Section 07100 hereof.

2.05 Bituminous Damp-Proofing

As specified in Section 07100 hereof.

2.06 HDPE Lining

As specified in Section 02712 hereof.

2.07 Coating System For Exposed Concrete Surfaces

A The systems shall be elastomeric comprising a weather resistant top coat with a penetrating primer. The coating shall have the ability to provide in depth protection for reinforced concrete structures against corrosion associated with the ingress of chloride ions; sulphate irons; carbon dioxide; and air borne acid gases. It shall have the ability to allow water vapour to escape from the structure; shall be UV stable; and shall be easily maintainable.

B The primer shall be a low viscosity reactive silane-siloxane/acrylic blend with the capacity to penetrate and produce a chemically bound hydro-phobic barrier to prevent the passage of chloride and sulphate ions.

C The top coat shall be: pure aliphatic acrylic resin; decorative high-performance water based, pigmented; resistance to water carbon dioxide and other air borne acids; have the ability to allow the passage of water vapour from the structure; and shall have elastomeric and flexural capabilities.

D The system shall, during trials, display the following properties when applied in accordance with the manufacturer's specification to samples obtained from concrete made without additives:

1 Reduction in water absorption (measured against a control concrete sample in accordance with ASTM C 642)	82% minimum at 28 days.
2 Reduction in chloride ion penetration	90% minimum at 28 days.
3 Water vapour transmission resistance	0.98m @ 150 microns DFT
4 Carbon dioxide diffusion resistance	Equivalent to 500 mm of 30 N/mm^2 concrete
5 Fire Testing	Spread of flame Class 1.

Part 3 - Execution

3.01 Installation of Liner

A Installation of the lining and all accessories shall be as recommended by the manufacturer including backing material, if any, preheating of sheets in cold weather and the welding of all joints, to be done strictly in accordance with the recommendations of the manufacturer. Coverage of the lining shall not be less than the minimum detailed in the schedule. The lining

shall be held snugly in place against inner forms by means of steel banding straps or other means recommended by the manufacturer. Banding straps must be located in the precut strap channels to prevent crushing or tilting of the cloaking extensions. If banding straps are used, a steel channel, angle, or bar may be inserted along the edge locking extension of each liner sheet for concrete pipe or cast-in-place structures. Banding straps must be located in the precut strap channels to prevent crushing or tilting of the locking extensions. Locking extensions shall terminate not more than 40 mm in from the end of the inside surface of the pipe section. Joint flaps, when used, shall extend approximately 100 mm beyond the end of the inside surface. Concrete poured against lining shall be vibrated, spaded, or compacted in a careful manner to protect the lining and produce a dense, homogenous concrete, securely anchoring the locking extensions into the concrete. When removing forms, care should be taken to protect the lining from damage. Sharp instruments shall not be used to pry forms from lined surfaces. Any nails that remain in the lining shall be pulled, without tearing the lining, and the resulting holes clearly marked. Form tie holes shall be marked before ties are broken off and all areas of serious abrasion or damage shall be marked. All nail and tie holes and all cut, torn, and seriously abraded areas in the lining shall be patched. Patches shall be made entirely with welding strip and shall be fused to the liner over the entire patch area. Larger patches may consist of smooth liner sheet applied over the damaged area with adhesive. All edges must be covered with welding strip fused to the patch and the sound lining adjoining the damaged area. Hot joint compounds, such as coal tar, shall not be poured or applied to the lining. The Contractor shall take all necessary measures to prevent damage to installed lining from equipment and materials used in or taken through the work.

B Testing Requirements

1 Samples taken from sheets, joints or weld strips shall be tested to determine material properties.

2 Determination of tensile strength and elongation shall be in accordance with ASTM D 412 using Die ‘B’.

3 Determination of indentation hardness shall be in accordance with ASTM D 2240 using a Type D Durometer, except that a single thickness of material and indentation hardness shall be made on 25 x 75 mm specimens.

4 Thickness of specimens shall be the thickness of the sheet or strip.

5 The initial values for tensile strength, weight, elongation and indentation hardness shall be determined prior to chemical resistance tests.

6 The physical properties of the specimens shall be determined after exposure to chemical solutions.

7 Test specimens shall be conditioned to constant weight at 43°C before and after submersion in the following solutions for a period of 112 days at 25°C $\pm$ 3°C.

Chemical Solution	**Concentration**
sulphuric acid	20%
sodium hydroxide	5%
ammonium hydroxide	5%
nitric acid	1%
ferric chloride	1%
soap	0.1%

detergent (linear aklyl benzyl sulfonate or LAS)	0.1%
bacteriological	BOD not less than 700 mg/l
phosphoric acid*	50%

Volumetric percentages are of concentrated reagents of C.P. grade. At 28-day intervals, specimens shall be removed from each chemical solution and tested. If any specimen fails to meet the 112-day exposure, the material will be subject to rejection.
* Phosphoric acid test for U.V. cleaning basin and U.V. module washdown tray only.

8 Liner locking extensions embedded in concrete shall withstand a test pull of at least 18 kN/m, applied perpendicularly to the concrete surface for a period of one minute, without rupture of the locking extensions or withdrawal from embedment. Tests shall be made at a temperature between 21°C to 27°C inclusive.

9 Shop-welded joints, used to fuse individual sections of liner together, shall be at least equal to the minimum requirements of the liner for thickness, corrosion resistance and impermeablility. Welds shall show no cracks or separations and shall be tested for tensile strength. Tensile strength measured across the welded joint in accordance with ASTM D 412 using Die 'B' shall be at least 15 N/mm^2. Test temperature shall be 25°C $\pm$ 3°C. Measured minimum width and thickness of the reduced section shall be used.

10 All liner shall be shop tested for holes with a spark tester set to provide from 15 000 to 20 000 volts. Sheets having holes shall be satisfactorily repaired in the shop prior to shipment from the manufacturer's plant.

11 Provide certified copies of test reports prior to shipment of product to jobsite.

C Application to Concrete Pipe: linings shall be set flush with the inner edge of the bell or spigot end of a pipe section and shall extend to the opposite end, or to approximately 100 mm beyond the opposite end, depending upon the type of lining joint to be made with the adjoining concrete pipe. Whenever concrete pipe or cast-in-place structures protected with lining join structures not so lined (such as brick structures, concrete pipe, or cast-in-place structures with clay lining or clay pipe), the lining shall extend over and around the end of the pipe and back into the structure for not less than 100 mm. This protecting cap may be moulded or fabricated from the lining material but need not be locked into the pipe. Where a pipe lateral (not of plastic lined concrete) is installed through lined concrete pipe, the seal between the lined portion and the lateral shall be made by the method prescribed for cast-in-place structures. Lined concrete pipe may be cured by standard curing methods. Care shall be exercised in handling, transporting, and placing lined pipe to prevent damage to the lining. No interior hooks or slings shall be used in lifting pipe. All handling operations shall be done with an exterior sling or with a suitable fork lift. On pipes having a 360^o liner coverage, the longitudinal edges of the sheet shall be butt welded. When pipe tubes are furnished, these shall be shop-welded joints. No pipe with damaged lining will be accepted until the damage has been repaired to the satisfaction of the engineer.

D Joint between sections of lined pipe shall be prepared in the following manner. If required, the inside joint shall be filled and carefully pointed with cement mortar in such a manner that the mortar shall not, at any point, extend into the pipe beyond a straight line connecting the surfaces of the adjacent pipe sections. No lining joint shall be made until after the trench has been back-filled and consolidated. Pipe joints must be dry before lining joints are made. All mortar and other foreign material shall be removed from lining surfaces adjacent to the pipe joint, leaving them clean and dry. Field joints in the lining at pipe joints may be either of the following described types:

1 Type P-1: Joint to be made with a separate 100 mm joint strip and two welding strips. The 100 mm joint strip to be centered over the joint, heat-sealed to the lining, then welded along each edge to adjacent liner sheets with a 100 mm joint strip. Width of the space between adjacent sheets shall not exceed 25 mm. The 100 mm joint strip to lap over each sheet a minimum of 25 mm.

2 Type P-2: Joint to be made with a joint flap with locking extensions removed and extending approximately 150 mm beyond the pipe end. Joint flap to overlap the lining in the adjacent pipe section a minimum of 25 mm and be heat-sealed in place prior to welding. Field joint to be completed by welding the flap to the lining of the adjacent pipe using 25 mm weld strip.

The joint flap or strip on bevelled pipe shall be trimmed to a width (measured from the end of the spigot) of approximately 100 mm for the entire circumferential length of the lining. All welding of joints is to be in strict conformance with the specifications and instructions of the lining manufacturer. Welds shall fuse both sheets and weld strip together to provide a continuous joint equal in corrosion resistance and impermeability to the liner plate. The following special requirements shall apply when the liner coverage is 360 degrees. When groundwater is encountered the lining joint will not be made until pumping of groundwater has been discontinued for at least three days and no visible leakage is evident at the joint. When welding downstream side of joint strip or flap, do not weld 150 to 200 mm at the pipe invert to provide relief of potential future groundwater buildup. Hot-air welding guns shall provide effluent air to the sheets to be joined at a temperature between 260°C and 315°C. Welding guns shall be held approximately 12 mm from, and moved back and forth over, the junction of the two materials to be joined. Guns shall be moved slowly enough as the weld progresses to cause a small bead of molten material to be visible along both edges and in front of the weld strip.

E Application to Cast-In-Place Concrete Structures. Liner sheets shall be closely fitted and properly secured to the inner forms. Sheets shall be cut to fit curved and warped surfaces using a minimum number of separate pieces. If liner joints are to be Type C-3 joints, the adjacent sheets to be butted with not more than 3 mm in opening between the sheets. A 50 mm side water-resistant tape or welding strip shall be welded on the back of butt joints to prevent wet concrete from flowing around edges. Unless otherwise shown on the drawings, the lining shall be returned at least 100 mm at the surfaces of contact between the concrete structure and items not of concrete (including manhole frames, gate guides, clay pipe, or brick manholes, and clay or cast iron pipes). The same procedure will be followed at joints where the type of protective lining is changed or the new work is built to join existing unlined concrete. At each return, the returner liner will be sealed to the item in contact with the plastic-lined concrete with an approved adhesive system. If the liner cannot be sealed with this adhesive because of the joint at the return being too wide or rough or because of safety regulations, the joint space will be densely caulked with lead wool or other approved caulking material to a depth of 50 mm and finish with a minimum of 25 mm of an approved corrosion resistant material.

F Joints in Lining for Cast-In-Place Concrete Structures. Lining at joints will be free of all mortar and other foreign material and will be clean and dry before joints are made.

1 Type C-1: Joint will be made with a separate 100 mm joint strip and two welding strips. The 100 mm joint strip will be centred over the joint, heat-sealed to the liner then welded along each edge to adjacent sheets with 25 mm wide welding strip. The width of the space between adjacent sheets will not exceed 50 mm. The 100 mm joint strip will lap over each

sheet a minimum of 25 mm. Joint strip shall be used at any transverse or longitudinal joint.

2 Type C-2: Joint will be made by lapping sheets not less than 25 mm. One 50 mm welding strip is required. Upstream sheet will overlap the one downstream. Lap will be heat-sealed into place prior to welding.

3 Type C-3: Joint will be made by applying 50 mm wide waterproof tape or 25 mm wide welding strip on the back of the butt joint or by some other method approved by the engineer to prevent wet concrete from getting under the sheet. After the forms have been stripped, 25 mm welding strip will be applied over the face of the sheet.

4 All welding is to be in strict conformance with the specifications of the lining manufacturer.

G. Testing and Repairing Damaged Surfaces. After the pipe is installed in the trench, and the formwork removed and patching completed for structures, all surfaces covered with lining, including welds, shall be tested with an approved electrical holiday detector (Tinker & Rasor Model NO. AP-W or equal with power pack) with the instrument set at 9000 volts per 1.0 mm of lining minimum. All welds and all patches over holes, or repairs to the liner wherever damage has occurred shall be physically tested by a non-destructive probing method. Each transverse welding strip which extends to a lower edge of the liner will be tested by an approved testing agency at the cost of the contractor. Welding strips will extend 50 mm below the liner to provide a tab. A 5 kg pull will be applied to each tab and the force will be applied normal to the face of the structure by means of a spring balance. The liner adjoining the welding strip will be held against the concrete during application of the force. The 5 kg pull will be maintained if a weld failure develops, until no further separation occurs. Defective welds will be retested after repairs have been made. Tabs shall be trimmed away neatly by the installer of the liner after the welding strip has passed inspection. Inspection will be made within two days after joints have been completed in order to prevent tearing the projecting weld strip and consequent damage to the liner from equipment and materials used in or taken through the work.

3.02 Application of Epoxy Coating

A Coatings shall be applied so as to produce an even film of specified thickness. Edges, corners, crevices, and joints shall receive special attention to ensure that they have been thoroughly cleaned and that they receive an adequate thickness of paint. Finished surfaces shall be free from runs, drips, ridges, waves, laps, brush marks, and variations in colour, texture, and finish. Coverage shall be complete so that the addition of another coat of paint would not increase the coverage. Adjacent surfaces shall be protected by the use of drop cloths or other approved precautionary measures.

B Surfaces to receive paint and protective coatings shall be cleaned as specified prior to application of coating materials. Surfaces to be finished shall be examined, and surface defects corrected before application of any coating material. Preparation of the concrete shall be in accordance with ACI 515.1R, paragraph 3.4 and ASTM C811.

C Items not to be coated. Hardware, hardware accessories, UL and FM labels, nameplate data tags, machined surfaces, and similar items shall not be coated, but when in contact with coated surfaces, shall be removed or masked prior to surface preparation and painting operations. Following completion of coating of each piece, removed items shall be reinstalled. Removal and installation shall be done by workmen skilled in the trades involved.

D Application. Except where in conflict with the manufacturer's printed instructions, or where otherwise specified herein, brush, roller, air spray, or so-called airless spray application shall be used. Any spray painting must first have the approval of the Engineer. Areas inaccessible to spray coating or rolling shall be coated by brushing or other suitable means. Give Special attention shall be given to ensure that edges, corners, crevices, welds, bolts, and other areas, as determined by the Engineer, receive a film thickness at least equivalent to that of adjacent coated surfaces. Protective coating materials shall be applied in strict accordance with the manufacturer's printed instructions. Prime coat shall be applied to clean surfaces within a four-hour period of the cleaning; prior to deterioration or oxidation of the surface or in accordance with the manufacturer's recommendations. Coatings shall be applied in dry and dust-free environment. No coating or paint shall be applied when the surrounding air temperature, measured in the shade, is below 17°C; to wet or damp surfaces; in rain, fog or mist, or when the relative humidity exceeds 85 percent; when it is expected that the relative humidity will exceed 85% or that the air temperature will drop below 5°C within 18 hours after the application of the coating or paint; or when dew or moisture condensation shall be anticipated. If any of these conditions are prevalent, painting shall be delayed until surfaces are dry. The day's coating shall be completed in advance of the probable time of day when condensation will occur in order to permit the film a sufficient drying time prior to the formation of moisture. Care shall be exercised to avoid lapping paint on adjacent surfaces. Coatings shall be sharply cut to lines. Finished coated surfaces shall be free from defects or blemishes. Drop cloths shall be used to protect floors, fixtures, and equipment. Care shall be exercised to prevent paint from being spattered onto surfaces from which such paint cannot be removed. Surfaces from which paint cannot be removed shall be painted or repainted as required to produce a finish satisfactory to the Engineer. Whenever two coats of a dark coloured paint are specified, the first coat shall contain sufficient powdered aluminium to act as an indicator of proper coverage, or the second coating shall be of a contrasting colour. Surfaces inaccessible after assembly shall be coated before erection. Touch-up of surfaces shall be performed after installation. Surfaces to be coated shall be clean and dry at the time of application. The manufacturer's recommended recoat time shall be complied with. Sufficient time shall be allowed to elapse between successive coats to permit satisfactory recoating, but, once commenced, the entire coating operation shall be completed without delay. No additional coating of any structure, equipment, or other item designated to be painted shall be undertaken without specific permission of the Engineer until the previous coating has been completed for the entire structure, piece of equipment, or other item. The dry film thickness specified shall be achieved for each coat.

E Concrete surfaces shall be visually inspected to ensure proper and complete coverage has been attained. Upon completion of the work, staging, scaffolding, and containers shall be removed from the site or destroyed in an approved manner. Coating spots, oil, or stains upon adjacent surfaces shall be removed.

F The paint and coating schedule shall indicate the coating system to be used.

System	Component	Film Thickness Minimum
A	Primer: Universal Primer	100 microns
	First Coat: Epoxy Polyamide	125 microns

3.03 Application of Coating System For Exposed Concrete

A Prior to applying the system in the works, trial applications shall be carried out on trial panels. Surface preparation and application shall be carried out with the manufacturer's recommendations. Trials shall demonstrate the method proposed for applying the system, coverage, coating thickness, colour, and final appearance of the coating.

END OF SECTION 03350

Section 03400

Precast Concrete

Part 1 General

1.01. Description

A The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Structural Precast Concrete Work.

1.02 Quality Assurance

A This Specification Section shall govern all structural precast concrete work for the project except where more stringent or specialized requirements are indicated.

B All work shall be performed to secure for the project homogeneous concrete having the required strength, surface finish, materials, durability, and weathering resistance, without planes of weakness or other structural defects, and free of honeycombs, air pockets, voids, projections, offset of plane and other defacements of concrete.

C The Contractor shall be fully responsible for any defects or damage in the structure or building arising from faulty materials or workmanship and the costs of remedial measures in order to ensure that the completed work complies with the Contract Documents.

D No alterations or substitutions of the structural systems shown on the Drawings shall be permitted unless otherwise specified.

E The Contractor shall supervise and co-ordinate all phases of the structural precast concrete construction process and be responsible for the complete manufacturing process. All methods of manufacture and practices of handling raw materials and manufactured concrete shall be reviewed by the Engineer prior to execution of the structural precast concrete work.

F Only materials of known quality shall be incorporated in the work. All materials shall be properly selected, reviewed and approved by the Engineer before use, and maintained during shipment, storage and use. Construction systems and techniques shall be properly selected, reviewed and approved by the Engineer before use, and maintained throughout the complete structural precast concrete construction phase. Adequate spare equipment, parts, additional components and repair facilities shall be available for all tools and equipment.

G Regardless of approvals by the Engineer, the Contractor shall be responsible for all materials and methods of structural precast concrete work. If any work does not satisfy the Contract Documents the Contractor shall at no additional cost to the Employer implement removal, replacement or remedial work and revise procedures or materials to prevent recurrence of unacceptable work.

1.03 Qualifications

A Structural precast work shall be executed by an approved specialist subcontractor.

B The Contractor may execute this work himself if he can satisfy the Engineer that he has

sufficient experience and expertise in this field and can provide satisfactory evidence that his tradesmen and their supervisory personnel engaged in such work have successful experience with work comparable to that shown and specified. Details of organized quality control and testing procedures shall also be provided.

1.04 Testing

A Concrete shall be tested as specified in Section 03300 and load tests shall be conducted in accordance with BS 8110 before erection and also after erection.

B The Engineer will evaluate the adequacy of the Contractor's quality control. In addition to the requirements hereinafter specified under Paragraph "MIX DESIGN", the Contractor shall:
1 furnish labour required to facilitate testing,
2 inform the Engineer with at least one day's advance notice when concrete is to be placed,
3 provide storage facilities for concrete test cubes,
4 provide material samples and access to materials as required for testing.

C The Contractor shall station a qualified technician at the batch plant during the entire time of batching, and shall continuously test, inspect, and report on the following:
1 the batching equipment and procedures,
2 the conformance of the materials (cement, aggregates, water and admixtures) to the approved materials,
3 Correct dosage of admixtures as prescribed by the manufacturer are used,
4 the proportioning of the concrete,
5 mix transport equipment.

D Should the batching plant be located more than 500 m away from the site offices, the Contractor shall provide suitable transport, acceptable to the Engineer, for the sole use of the Engineer's staff.

E The Contractor shall station a qualified technician at the casting site to continuously test, inspect and report. The tests shall comprise, for each thirty cubic metres of each different concrete type or portion thereof cast per day, six strength tests as BS 1881;slump tests; and temperature tests. The Contractor shall check and verify conformance with Contract Documents and approved shop drawings. The Contractor shall check all openings and provisions for full co-ordination with all trades in the Contract as shown on approved shop drawings.

F The Contractor shall provide facilities and equipment for the conducting of all tests specified herein except for the strength test which should be carried out by an approved independent testing agency.

G All welding of steel supports, anchorages, connections and attachments will be visually inspected by the Engineer.

1.05 Quality Control

A The Contractor shall prepare and provide his quality control programme for structural precast concrete work with particular attention to details, pre-checking processes, procedures and close supervision. In order to assure that proper work is performed to prevent later corrective actions, the Contractor shall provide at least one experienced supervisor full time to provide quality control for structural precast concrete work. The assignment will not relieve the Contractor's other quality control personnel of their duties relative to the quality control of

the structural requirements and surface finish of the structural precast concrete work.

B The Contractor shall provide suitable quality control personnel who will be versed in quality control of structural precast concrete work including:
1 materials evaluation,
2 special mix design techniques,
3 mix placement,
4 vibrator selection and use,
5 formwork details formwork protection,
6 release agent use,
7 reinforcing steel,
8 detailing and installation,
9 finishing equipment and techniques,
10 corrective procedures and protection of completed work.

C The Contractor's quality control personnel shall be responsible for verifying all details necessary to produce the final structural design objectives. The Contractor's quality control personnel shall also verify the quality of the structural precast concrete work and guide the production of results which will be within acceptable physical tolerances

1.06 Pre-construction Meeting

A Within a reasonable time prior to commencement of structural precast concrete work, the Contractor shall schedule a pre-construction meeting at a mutually agreeable time with the Engineer and his designated Representatives to discuss design, materials, methods of work and forming systems for structural precast concrete work.

B Prior to this meeting, the Contractor shall submit to the Engineer all pertinent information including:
1 written procedural outlines,
2 description of forming systems,
3 brochures of proposed equipment
4 sources of all materials,
5 characteristics of all materials,
6 the above information shall be received by the Engineer at least 30 days prior to the pre-construction meeting.

C During the pre-construction meeting the Contractor shall present an outline plan for all concrete work to be accomplished and indicating special procedures relative to the structural precast concrete work. The outline shall include:
1 reviews of sources of materials commentary on source,
2 source variations during the course of the work,
3 storage and use of materials,
4 description of all equipment necessary for batching, mixing, conveying, placing, forming, reinforcing, compacting,
5 finishing of structural precast concrete.

1.07 Submittals

A Copies of manufacturer's specifications and installation instructions for each item of proprietary material used, showing compliance with these Specifications.

B Copies of mix designs with support material, as required by Contract Documents.

C Copies of manufacturer's certificates of mill tests of all cement and reinforcing steel.

D Product Design Criteria and Calculations including loadings for design:
1 initial handling and erection stresses,
2 all dead and live loads as specified on the contract drawings or as required,
3 all other loads specified for member where they are applicable.
The Design calculations shall be performed by a Structural Engineer experienced in precast concrete design. Calculations for the design of any precast member shall be supported by a statement explaining the principle of design and type of analysis adopted and the influence of any member in achieving the overall stability of the structure should be considered. Any computer programmes used in the designs shall be fully described and details of input and print out shall be presented in a manner which can be readily understood. Programme manuals and any instruction to programme users shall be made available to the Engineer upon request. Where any such programmes cannot be demonstrated by the Contractor to have been fully checked or where the Engineer considers it necessary, the Contractor shall run such test examples as the Engineer may choose, in order to verify the completeness and accuracy of the programme. Design members exposed to the weather to provide for movement of components without damage, failure of joint seals, undue stress on fasteners or other detrimental effects, when subject to seasonal or cyclic day/night temperature ranges. Design system to accommodate construction tolerances, deflection of other building structural members and clearance of intended openings. Calculate structural properties of framing members in accordance with BS 5328 and BS 8110.

E Shop Drawings
1 Layout plans and detailed fabrication and placement drawings for each structural precast element.
2 Shop drawings are to include the following information:
a size, grade, profile and dimensions of all materials used,
b connection and anchorage details,
c lifting devices, locations and handling limitations,
d steel reinforcement details,
e all openings, sleeves, inserts and other provisions in full co-ordination with all trades in the Contract,
f identification marks.

F Detailed outline of sequence and methods of erection.

G A record shall be kept for every piece of precast element produced showing the following:
1 type and number
2 date of pour
3 concrete test results
4 reference shop drawing number
5 type and duration of curing
6 date of delivery to site
7 date of fixing in position

H Copies of all testing and Inspection Reports.

1.08 Delivery, Storage and Handling

A The structural precast elements shall be removed from the forms without damaging or over stressing and stored or placed for transportation on a stable bed that will not allow further

distortion of the member. Stacked members shall be separated with suitable battens and bracing.

B Each member shall be marked with an identifying reference or piece mark, and the date of casting. All piece marks are to be correlated with test reports and plan layouts or erection drawings.

C The structural precast element shall be transported with sufficient battens, bracing, and supports so as not to over-stress by vibration or impact loadings.

D Structural precast units shall be transported, stored and handled in a manner to avoid undue strains, hair cracks, staining, or other damage.

E Units from casting site shall be delivered to the project site in accordance with schedule and proper setting sequence.

F Structural precast units shall be stored free of the ground and protected from wind or rain splashes. Units shall be covered and protected from dust, dirt or other staining materials.

G During fabrication, construction and after erection, the castings shall be protected to avoid possibility of any damage.

1.09 Design Loadings, Actions & Structural Members Selection

A Precast elements shall be designed to withstand all loading conditions against which strength and serviceability must be measured.

B Vertical loads shall include own weight of precast elements, floor covering and live loads indicated on the Drawings.

C Wind pressure shall be calculated in accordance with the provisions of BS CP3 chapter V, Part 2:1972 “Basic data for the design of buildings - Wind Loads” using basic wind speed of not less than 160 km/hr.

D Account must be taken of the loads and deformation caused by temperature and time dependent deformations. For such purpose 55°C temperature variation and 90 percent relative humidity should be considered for all members, except exterior elements and facade elements where 85^{o}C shall be consider.

E Floor systems are assumed to function as rigid diaphragms with respect to in plane forces. Forces due to lateral loads should be considered to achieve this assumed condition when designing peripheral beams and continuity ties etc.

F Precast elements shall be designed in accordance with BS 8110. Design tensile stresses should not exceed the design flexure tensile stress of concrete.

G Nominal cover to steel including links must meet the durability requirement of severe condition of exposure and to meet requirements for two hour period of fire resistance.

H Total deflection of any precast element should be limited to 1/350 of the span of this element.

I Plans & designs for openings for building services shall be accommodated, where required or necessary.

1.10 Co-ordination

The work of this Section shall be completely co-ordinated with the work of other sections and the Contractor shall verify dimensions and Work of other trades which adjoin or pass through materials of this Section before the installation of items herein.

Part 2 Products

2.01 Materials

A The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality. Products equivalent to, or better, than those specified will be considered acceptable. The decision of acceptability will rest with the Engineer.

B All materials shall be provided in accordance with, and meet all applicable requirements of, Section 03300. All cement, aggregates and water shall be provided from single sources, sufficient to complete the entire structural precast concrete work to assure regularity of appearance and uniformity of colour.

C Reinforcing bars shall conform to BS 4449 high strength deformed bars with a minimum yield strength of 460 N/mm^2. Reinforcement shall be epoxy coated in accordance with ASTM A 775 M-91 B where shown on the Drawings.

2.02 Mix Design

The mix shall be designed to obtain the strength specified. The compressive strength of the structural precast concrete shall be 50 N/mm^2 characteristic cube strength minimum at 28 days and 40N/mm^2 at the time of transfer. The slump shall be 100 mm. Air entertainment shall be 5 percent minimum and 7 percent maximum.

2.03 Formwork

A The formwork shall be as required to constantly maintain dimensional and surface finish controls specified in BS 5975. Formed surfaces of the structural precast elements are to be at least as smooth, flat and joint free as 19 mm plywood formed finished.

B Forms shall be constructed of non-staining metal, fibre-glass reinforced polyester, or other approved material. Forms shall be fabricated and reinforced for close control of dimensions, shapes, profiles, curvatures, smooth and perfect edges, and corner finishes and details. Forms shall be sufficiently rigid so that precast units will meet the casting tolerances and shall be constructed tightly to prevent leakage of water or mortar. Form joints will not be permitted on faces exposed to view in the finished work.

2.04 Form Release Agent

The agent shall be a quick drying, non-staining type and the manufacturer's supplied solvents shall be used for cleaning re-bars and embedded items.

2.05 Bearing Pads

Bearing pads shall be elastomeric neoprene, conforming to Standard Specifications for Highway Bridges (Section 25) adopted by the American Association of State Highway Transportation Officials with maximum compressive stress of 70 kg/sq. cm; maximum shear stress of 7 kg/sq.

cm; maximum shear deformation of one half thickness; and maximum compressive strain of15 percent. Unfactored loads shall be used for design.

2.06 Grout

A Non-shrink grout shall be non-shrink, non-metallic grout as specified in Section 03600.

B Epoxy grout shall be "Expocrete GP" (Expandite Ltd); "Hypol Epoxy Grout" (HBM Polymer Products Ltd); "Sikadur 42" (Sika Ltd) or other equal and approved.

2.07 Embedded Steel

All embedded items shall be of stainless steel Grade 316L.

Part 3 Execution

3.01 Forming

A Forms and casting beds are to be firmly seated so as not to deflect or be displaced under concreting or tensioning loads. For member penetrations larger than 150 mm coring or field cutting is not permitted unless prearranged with and approved by the Engineer. Clean and coat forms with release agent prior to installation or reinforcing or embedments.

B Refer to Section 03100 for materials and other requirements of formwork.

C Permissible deviations of formed surfaces are not to exceed tolerances outlined in PCI Manual 116, summarized and /or modified as follows:

1	length:	+/- 5 mm.
2	width:	+/- 3 mm
3	thickness:	Stem +/- 3 mm; Flange +/- 2.0 mm.
4	embedment or penetration location:	+/- 0.2%
5	straightness:	+/- 3 mm. for 300 cm
6	end squareness:	+/- 3 mm.

3.02 Reinforcing Steel Placement

A Reinforcing steel shall be placed in accordance with properly executed placement drawings. Embedments, inserts and lifting devices are to be firmly anchored to resist misplacement during concreting. Maximum permissible deviation from detailed placement.

1	in plane:	+/- 1/200
2	in position:	+/- 6 mm

3.03 Concrete Placement and Finishing

A Concrete shall be batched, transported, deposited, consolidated and struck off to produce dense homogeneous concrete elements.

B Surface finishes shall be broomed perpendicular to axis with stiff brush just sufficient to remove the outer mortar skin and expose the larger aggregate without disturbing the aggregate when a topping is to be applied; hand trowelled if exposed and floated if concealed.

C Curing shall be effected to retain moisture to ensure complete hydration of the cement. Membrane forming curing compounds shall not be used on surfaces to which topping is

eventually to be bonded. Steam curing shall not be applied until concrete undergoes initial set (2 to 4 hours) and the heat gain in the enclosure shall be maximum 4°C per hour with a maximum heat in the enclosure of 65°C.

3.04 Surface Treatment and Repair

Minor cracks and spalls not affecting the structural integrity of the element can be patched with epoxy type bonding agents and patching compounds. Cracks and honeycomb, in anchorages, bearings or otherwise critical zones will be unacceptable unless repair can be effected and substantiating testing performed. Structural repairs shall not be undertaken without the Engineer's knowledge and approval.

3.05 Installation

A Erection responsibilities include the safe and proper placing, aligning, and levelling of the structural precast elements on the accepted bearing surfaces and affecting their proper securement.

B Before placement of structural precast elements all temporary supports shown or required to control alignment and deflection shall be provided. Temporary supports shall be retained until framing elements braced thereby have attained integral stability in accordance with the design.

C All temporary supports shown or required to control alignment, deflection and stress levels shall be installed in proper sequence and maintained. They shall be retained until framing elements braced thereby have attained integral stability in accordance with the design.

D Any mis-alignment affect of temperature, draw from welding, bolting or erection sequence or grouting shall be compensated and corrected.

E Erection tolerances shall be:

1 variations from plumb : 6 mm in any 6m run; 12 mm total in any 12m or longer run.
2 variation from level or elevation : 6 mm in any run; 12 mm in any 12m run; total 12 mm at any location.
3 variation from position in plan : +/- 12 mm maximum at any location.
4 offsets in alignment of adjacent members at any joint : 1.5 mm in any 3m run; 6 mm maximum.

F Welding shall be in accordance with AWS recommendations. No welding shall be carried out until all adjacent elements to be connected have been aligned, firmly seated and braced. The heat build-up shall be controlled by limiting voltage, electrode size, and rate. Spalled or heat damaged concrete around weldments is not acceptable.

G Joints, gaps and connections shall be completed by filling with grout as shown on the Drawings and as approved by the Engineer.

3.06 Field Cutting

Field cutting of holes may be done only with the Engineer's concurrence, and only with power saws or core drills. The maximum hole size is 150 mm diameter or as limited by member size or strand location. Cracks, spalls and sharp corners created by field cutting are to be ground, eased, and patched with epoxy type bonding and patching compounds.

END OF SECTION 03400

Section 03600

Grout

Part 1 General

1.01 Description

Furnish all plant, labour, equipment appliances and materials and performing all operations in connection with pre-mixed and packaged non-shrinking grout and site mixed grout/concrete containing an expanding additive.

1.02 Quality Assurance

Complete samples of the premixed and site mixed work in an approved location and obtain Engineer's approval before proceeding. The additive manufacturer's representative shall be present to supervise control sample.

1.03 Submittals

A Samples of any proposed additives and of any proposed premixed grout shall be submitted and product data from the proposed suppliers shall be provided.

B Prior to commencing work details of methods and techniques proposed for the design and execution of the work shall be submitted.

1.04 Delivery, Storage and Handling

Delivery of cement shall be as specified in Section 03300 hereof. Premixed grout and additives shall be delivered to site in manufacturer's unopened containers, the labels of which shall bear the date of manufacture. The shelf life shall not exceed one year. Storage of cement and aggregates shall be as specified in Section 03300 hereof. Premixed grout and additives shall be stored in accordance with manufacturer's recommendations.

Part 2 Products

2.01 Premixed Grout

A Non shrink grout shall be non-metallic, chloride free, epoxy grout formulated to comply with U.S. Corps of Engineers Specification CRD-C-621-81. When tested under conditions of ASTM-C827 it shall indicate non-decrease in volume change.

B Curing compound (for application to exposed surfaces of grout) shall conform to ASTM C-309.

2.02 Cement

Cement shall be Portland cement as specified in Section 03300 hereof.

2.03 Aggregates

A Aggregates shall be as specified in Section 03300 hereof and selected to reduce bleeding to a minimum.

B Fine aggregate shall be washed dry sand. The use of beach sand is not permitted

C Coarse aggregates shall be rounded and evenly graded; 10 mm nominal size except where pumping is employed when 6 mm nominal size shall be used. The percentage passing No. 16 sieve shall not exceed 5 percent.

D Additives shall be to the approval of the Engineer.

E Water shall be as specified in Section 03300 hereof.

2.04 Mixes

A The mix proportions and workability for each type of grout shall be selected to produce the required performance. The minimum characteristic strength of the grout shall be at least equivalent to the requirements for Grade 35 concrete as specified in Section 03300.

B Grout for filling uncongested areas over 50 mm wide shall have mix proportions of 1:1.25:1.75 (cement/fine aggregate/coarse aggregate 10 mm nominal size) by weight and with a slump of 100 - 200 mm. Grout for filling narrow areas less than 50 mm wide shall have mix proportions of 1:2 (cement/fine aggregate) by weight and with the slump to be kept to a minimum to allow placing.

C Dry packing for areas over 75 mm wide shall have mix proportions of 1:1:2 (cement/fine aggregate/coarse aggregate 10 mm nominal size) by weight and the slump shall not exceed 5 mm. Dry packing for areas less than 75 mm wide shall have mix proportions of 1:2 (cement/fine aggregate) by weight and the slump shall not exceed 5 mm.

D Alternative mixes incorporating additives shall only be used with the Engineer's prior approval.

E Premixed grout shall only be used to voids of small widths and apertures of limited accessibility.

Part 3 Execution

3.01 Mixing of Grout

A Grout shall normally be mixed in a batcher mixer of a type approved by the Engineer and shall not be mixed by hand unless specifically approved by the Engineer.

3.02 Preparation of Foundation Surfaces

Surfaces of structural concrete foundation shall be thoroughly scabbled to remove all laitance to provide a clean rough surface. Bolt pockets and surfaces of concrete foundations shall be cleaned immediately before base plates are placed in position. Immediately before grouting, the spaces

between the concrete and base plates shall be cleaned and thoroughly wetted. All excess water shall be blown away by means of a compressed air jet.

3.03 Transporting and Placing of Grout

Grout shall be transported from the mixer to the placing point quickly and in such a way that the materials do not segregate. Grout shall be placed within 45 minutes of being mixed. Grout shall be worked into position with chains, bolts, rods or other suitable instruments until the whole of the space is completely filled with the grout. Mechanical vibrators shall not be used. The main grouting and the grouting of bolt sleeves and pockets shall normally be carried out at the same time. If separate operations are advisable, bolt sleeves and pockets shall be grouted up to approximately 50 mm of the level of the concrete foundation before the main grouting.

END OF SECTION 03600

Section 03800

Architectural Concrete Finishes

Part 1 General

1.01 Description

A The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Architectural Concrete Finishes.

B The intent of this Specification is to secure for the job, materials and workmanship of such quality that only nominal finishing will be required to produce concrete surfaces equal to the best obtainable with the concrete and forming materials specified.

C Surfaces which reveal, upon removal of forms, imperfections of such magnitude as to seriously impair the appearance of the structure, in the opinion of the Engineer, shall be deemed to be a cause for rejection.

D Concrete members containing such imperfections shall be entirely removed and replaced without damage to adjacent materials or extra expense to the Employer.

E Lesser imperfections of concrete surface shall be patched and finished in accordance with the following procedures and with the approval of the Engineer.

1.02 Submittals

A Samples as requested by the Engineer shall be provided of each finish specified herein. Samples shall be 500 x 500 x 100 mm thick; cast from concrete made in accordance with the approved mix design, using the approved materials, and shall be cured using the methods proposed for the Works. Each panel shall show treatment of typical tie-rod hole, rustication joint and corner as well as typical patch of void. One panel for each finish shall be sandblasted each side with slightly different degree of blasting for selection and approval by the Engineer.

B Prior to construction of any work above grade, a mock-up shall be constructed on the site, at a place selected by the Engineer. The mock-up shall include typical portions of exterior column, beam and flat wall panel all connected together. All materials, formwork, reinforcing and accessories used for the mock-up shall be those approved for use in the actual construction. The mock-up panel shall be used for sampling and approving patching materials and techniques.

C The Contractor shall remove rejected panels and mock-ups from the site when directed by the Engineer.

1.03 Safety During Sandblasting Operations

Sandblasting shall comply with all local and national anti-pollution laws and shall be carried out in suitable enclosures for collecting grit and dust from the blasting operation. The Contractor shall be responsible for safety of the workmen engaged during sandblasting and shall equip each man with an air-fed helmet.

1.04 Delivery, Storage and Handling

A Work under this Subdivision shall be delivered and stored in a manner to prevent wracking or stress components, and to prevent mechanical damage or damage by the elements. Work under this Subdivision shall be delivered to site in ample time to avoid delay in job progress and at such times as to permit coordination of the various parts.

Part 2 Products

2.01 Materials

A Cement, sand, colour pigments and water for surface preparation shall be as specified in Section 03300 hereof. Work to receive exposed aggregate finish shall be cast from a gap-graded mix to match precast architectural concrete.

B Sandblasting grit shall be a fine abrasive grit of uniform grain size which shall not adversely affect the colour of the finished surfaces as approved by the Engineer. The grit used shall be uniform throughout the work.

2.02 Patching Mortar Mix

A Patching mortar shall be of the same material and proportions as used for the concrete without coarse aggregate. A sufficient quantity of white cement shall be substituted for part of the grey cement so that the patching mortar, when dry, will match the surrounding concrete.

B Rubbing grout shall be a paste of one part Portland Cement and 1½ parts sand, mixed with clean clear water to a consistency which will not be too stiff to allow application with a stiff bristle brush.

C Patching mortars shall conform to approved samples.

Part 3 Execution

3.01 Surface Preparation

A Each surface to be finished shall be patched as further specified below for each type of finish, in addition to patching completed under the requirements of Section 03300 hereof.

B Water in patching mortar mix shall be kept to a minimum. Mortar shall be re-tempered without adding water and shall be allowed to stand for one hour prior to use, during which time it shall be mixed to prevent setting.

C The perimeter of the hole to be repaired shall be chipped to produce sharp edges perpendicular to the face and to produce a hole not less than 30 mm deep and loose and weak material at the bottom of the hole shall be removed.

D Just prior to placing the mortar, the hole and an area 150 mm wide entirely around it shall be wetted using clean clear water. Mortar shall be thoroughly compacted into place and screeded so as to leave the patch slightly higher than surrounding surfaces. Where the depth of patch exceeds 25 mm, the hole shall be filled to 25 mm from face and after mortar has completed 90

percent of its shrinkage, the filling of the hole shall be completed to slightly higher than surrounding surfaces.

E The mortar shall be left undisturbed for one to two hours to permit initial shrinkage, and finished to match the adjoining work.

F Holes left by the withdrawals of cone-ties, and/or associated tie-rods shall be filled solid with mortar. For holes passing entirely through the wall, a plunger-type grease gun or other device to force mortar through the wall, starting at the back face shall be used. Voids left by cone-tie ends shall be filled solid up to a distance of 15 mm from the face of the concrete and tamped smooth with approved tool.

G Plain rod-tie holes shall be filled as specified above for cone-tie holes except that mortar shall be struck flush with the face of the concrete wall. Mortar smearing onto the concrete face shall then be wiped off clean with clean wet clothes or sponges.

3.02 Sandblasting Concrete

A Immediately after removal of forms, all fins and other projections shall be removed including those with adjacent surfaces. All voids, honeycombs, and air pockets greater than 17 mm in any dimension shall be patched. In areas where concentration of voids 13 mm and less occur, patch appearance across the entire surface.

B Sandblasting shall be done after all concrete to be blasted has attained its full strength as determined by field control cubes, or after a minimum of seven days, whichever is first. Rounding edges shall be avoided. Abrasive blasting shall be carried out to the same depth and produce the same texture as the accepted sample panel, throughout, which shall conform to the medium degree of finish defined by ACI-303. As far as is practicable all concrete surfaces to be sandblasted shall have been cast for the same period, thus ensuring uniformity of finish. Voids greater than 10 mm in any dimension exposed by sandblasting shall be patched as specified above. After patches have cured and attained full strength, they shall be re-blasted until the patched areas match adjacent areas.

3.03 Finishes

A All voids and honeycombs over 10 mm in largest dimension and all tie rod holes and depressions shall be thoroughly patched. In areas where concentrations of small voids occur, a sufficient number of them shall be patched to produce a uniform appearance across the entire panel. Projections and fins shall be smoothed out with wet carborundum stones or power grinders to extent as directed by the Engineer. All surfaces indicated to produce a "light abrasive blast finish" shall be sandblasted. Blasting shall remove the surface skin sufficiently to expose the coarse particles of the fine aggregate as well as a few particles of the coarse aggregate in accordance with approved samples. The surface shall be flat with little texture. Light sand blasting shall be done a minimum of seven days after casting, and prior to 50 days after casting.

3.04 Clean-up

A Grit remaining from sandblasting shall be collected and removed frequently to an approved waste storage facility as the work progresses.

END OF SECTION 03800

Section 03900

Testing of Water Retaining Structures

Part 1 General

1.01 Description

The Contractor shall test leakage of structures that are required to be watertight.

1.02 Submittals

The Contractor shall record and submit to the Engineer within 24 hours the results of the leakage tests carried out.

Part 2 Products

2.01 Water

All water used for testing shall be potable water.

Part 3 Execution

3.01 Cleaning

All water retaining structures shall, on completion, be carefully cleaned, to the complete satisfaction of the Engineer. The structure shall be cleaned of all debris and shall be brushed down on all internal faces with a stiff broom while still dry. All resulting debris shall be removed. All associated pipework shall be cleaned in accordance with the Specification requirements. The structure shall then be flooded with approximately 75 mm of clean water. The whole of the internal faces shall be carefully brushed down with stiff brooms using the water continuously until all faces are clean. The water shall then be drained off and walls and floors hosed and flushed with clean water until perfectly clean.

3.02 Testing

A. Concrete tanks, conduits and channels shall be tested for leakage. Tests shall be done before the structure is backfilled and before any water proofing material, if required, is applied.

B. No leakage from the concrete tanks, conduits and channels will be allowed.

C. Concrete tanks, conduits and channels shall be tested individually. These shall be kept filled with water for at least three (3) days for the concrete to absorb water thoroughly. Then, water level shall be brought to the normal operation level, and left undisturbed for seven (7) days. The leakage shall then be assessed based on any diminution of water level, accounting for any evaporation losses.

D. The roof slabs of water tanks shall be tested for leakage by impounding the slab by water to a depth not less than 25mm, and keeping it for a period of not less than 24 hours, and with visual

inspection of the underside of the slab for any dampness or leakages. This impounding may be in small sections, if required.

E. If any test shows that there is a leakage of any tank, conduit or channel, the structure shall be emptied and examined and all defects shall be repaired by grouting, cutting out or remaking joints, as directed, or by any other approved method. Such tests shall be repeated until there is no leakage any more.

F. Non-potable water may be used for testing, provided that discharge of water after the testing should not cause any environmental problem.

3.03 Disposal of Water Used for Testing

The Contractor shall provide suitable means for disposal of water used for testing, such that no damage results to facilities, structures or property. These means shall be subject to the approval of the Engineer and local authorities. The Contractor shall be responsible for any damage caused by his filling, testing, flushing, and waste disposal operations.

END OF SECTION 03900

DIVISION 4.

MOSONRY

Section 04220

Concrete Masonry

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with concrete masonry walls.

1.02 Quality Assurance

A Work shall to be carried out by persons skilled in laying concrete masonry units.

B Requirements for fire-rated or lateral support conditions are to be regulated in compliance with local building codes and are not necessarily fully defined on the Drawings. Whenever a fire-rating is shown for a wall, use masonry units in that wall complying with the requirements established by the local governing authorities.

C Mixer drums are to be painted white on the outside and kept white. All equipment, used for mixing transporting and laying mortar, shall be kept cool. Recording thermometers shall be placed at each location of concrete masonry work during its construction.

D Brands or sources of supply for masonry materials shall not be changed during the course of the work.

1.03 Mock-up

Prior to the installation of concrete masonry work the Contractor shall provide a sample wall mock-up for all types of masonry units. Each sample wall panel shall use materials, together with bond and joint tooling, shown or specified for final work and special features as directed for caulking and contiguous work. Each sample wall panel mock-up shall be built at the site, as directed, of full thickness and approximately 1 m high x 1.5 m long, unless otherwise shown, indicating the proposed range of colour, texture and workmanship to be expected in the completed work. The Engineer’s acceptance of visual qualities of each sample panel shall be obtained before proceeding with the final work. Each sample panel mock-up shall be retained during the construction period as a standard for judging completed masonry work and it shall not be altered, moved or destroyed until work is completed.

1.04 Submittals

A The manufacturer's printed literature indicating product specification and installation instructions for each product required by this Section shall be submitted.

B Manufacturer's certification that the following comply with the requirements specified shall be submitted:
1 Portland cement
2 masonry cement
3 hydrated lime
4 mortar aggregates
5 concrete masonry units (all types specified)

6 reinforcing bars, etc.

C Three samples of each type, and size, of hollow and solid concrete blocks shall be provided. These will be reviewed for colour and/or texture only and compliance with all other requirements, is the exclusive responsibility of the Contractor.

D Shop drawings shall be provided as follows:
1 shop drawing indicating details of anchors, inserts, joints, connections to adjoining work or materials, including elevations indicating setting out and placement of all joints, openings, cut-outs, etc.
2 shop drawings for fabrication, bending and placement of reinforcing bars for unit masonry work complying with ACI 315. "Manual of Standard Practice for Detailing Reinforced Concrete Structures" unless more stringent requirements are specified. Show bar schedules, diagrams of bent bars, stirrup spacing, lateral ties and other arrangements and assemblies as required for fabrication and placement of reinforcement for unit masonry work.

1.05 Pre-installation Co-ordination

A Prior to the start of each major type of masonry work, a meeting shall be held at the site to review the installation procedures and co-ordination with other work. The meetings shall include Contractor, Engineer and major material manufacturers as well as others whose work must be co-ordinated with the masonry work.

B The Contractor shall ensure co-ordination between masonry work and concrete work such that all inserts and flashing reglets required for the proper installation of masonry work are correctly pre-installed.

C A pre-installation inspection shall examine all parts of the supporting structure and the conditions under which the masonry work is to be installed. The Engineer shall be notified, in writing, of any conditions detrimental to the proper and timely completion of the work and installation of masonry work shall not proceed until satisfactory conditions have been corrected in a manner acceptable to the Engineer.

1.06 Delivery, Storage and Handling

A Concrete masonry materials, other than bulk materials, shall be delivered to site in manufacturer's unopened containers, bundles, pallets or other standard packaging devices, fully identified with name, type, grade, colour and size.

B All concrete masonry material shall be protected during shipment, storage and construction against wetting and soilage or intermixture with earth or other types of materials. Outside storage of masonry units and reinforcement shall be on plank platforms, off the ground, in dry locations. All necessary precautions shall be taken to prevent all masonry items from chipping, cracking or other damage during transportation, unloading and storage on site. Damaged units shall not be installed.

C Metal reinforcing or ties having loose rust or other coatings that will reduce or destroy bond shall not be used.

1.07 Protection

A In hot weather all necessary precautions shall be taken to keep mortar and blocks and

other materials cool and in particular mortar shall not be mixed or units laid while shade temperature is above $40^{O}C$ on a rising thermometer or above $43^{O}C$ on a falling thermometer. The temperature of fresh mixed mortar shall not exceed $32^{O}C$ and suitable measures shall be taken to ensure this. Masonry units shall not be laid with a film of water on their surfaces.

B When the ambient air temperature is more than $30^{O}C$ in the shade and the relative humidity is less than 50 percent, the masonry shall be protected from direct exposure to the wind and sun for 48 hours after installation. When work is not in progress partially completed unit masonry walls shall be protected against weather by covering top of walls with strong, waterproof, non-staining membrane which shall extend, at least 600 mm, down both sides of walls and be anchored securely in place, ensuring that there is free air flow sufficient to prevent heat build-up.

C Completed walls shall be kept clean and protected from staining. Suitable corner guards shall be used to protect the corners of exposed masonry walls.

1.08 Co-ordination

A The Work of this Section shall be completely co-ordinated with the work of other sections and dimensions and work of other trades, which adjoin materials of this Section, shall be verified before the installation of items herein.

Part 2 Products

2.01 Materials - Mortars

A Portland cement for mortar shall comply with ASTM C 150, Type I, or BS 12, ordinary, non-staining, without air entrainment, natural colour or white as required to produce the required colour of mortar or grout. The cement content in the concrete mix used for the manufacture of blocks shall be less that 200 kg/m^3 of concrete.

B Hydrated lime shall comply with ASTM C 207, Type S or BS 890.

C Aggregates shall comply with ASTM C 144, or BS 1200. The coarse aggregate used shall be 10 mm nominal size for standard blocks. For joints less than 6 mm aggregate graded with 100 percent passing the No: 16 sieve (1.18 mm) shall be used. Deleterious salt contents in aggregate shall not exceed the following limits depending upon the cement type used in the concrete mix:

	% wt of aggregate	
	Fine	Coarse
Acid soluble chlorides (Cl) % Max.		
If Concrete made with SRPC	0.03	0.02
If Concrete made with OPC MSRPC cement	0.05	0.04
Acid soluble sulphates ($S0_3$) % Max.	0.30	0.30

White aggregates shall be natural white sand or ground white stone. Coloured aggregates shall be ground granite, marble or other stone as required to match Engineer's sample.

D The acceptable levels of equivalent acid soluble chlorides and sulphates as specified above for aggregates are indicative and subject to the over-riding limits for the mixes as given below:

	By weight of cement in the mix
Acid soluble chlorides (Cl) % Max.	
If concrete made with OPC / MSRPC	0.40
If concrete made with SRPC	0.12
Acid soluble sulphates (SO_3) % Max.	3.7

E Water shall be clear and free of deleterious materials, salts etc. which would impair the work. The pH value shall be in the basic range of 7 to 9 and inorganic impurities shall not exceed the following limits:

	Limits m(g/l)
Chlorides as Cl	250
Sulphates as SO_3	250
Alkali carbonate and bicarbonates	500
Total dissolved ions, including above	2500

F Water retaining/reducing admixtures shall conform to BS 5075 Part I or ASTM C 499 Type B, free from chlorides and compatible with the cement.

G Plasticisers shall conform to BS 4887, and be free from chlorides and compatible with the cement.

2.02 Mortar Mixes, Non Load-bearing Masonry

A Concrete masonry mortar shall conform to ASTM C 270, except limited to the mix materials specified above and the following cement/lime ratios by volume; wherein sand (in damp condition) equals 2 $^1/_4$ to 3 times the sum of the volumes of cement and lime:

1 type M: not more than 1/4 part lime per part Portland cement.
2 type S: not more than 1/2 part lime per part Portland cement.
3 type N: not more than 1 part lime per part Portland cement.

2.03 Concrete Masonry Units (Blocks)

A Blocks shall be provided as shown, complying with type classifications, weights, grades and curing requirements as hereinafter specified and the following general requirements:

1 blocks for external and load bearing walls shall be solid blocks
2 blocks for internal partition, non-load-bearing walls shall be lightweight hollow blocks
3 solid blocks are to be provided and placed in position where fixings or supports are required
4 blocks shall have a textured surface to provide a good mechanical key for rendering but low suction qualities to prevent premature drying out
5 do not use blocks which have chips, cracks, voids, streaks, iron spots or other substances which might stain exposed finished surfaces
6 obtain blocks from one manufacturer, cured by one process and of uniform texture and colour, for each type required, for each continuous area and visually related areas
7 work sizes of all blocks shall be in accordance with BS 6073: Part 2
8 provide special shapes wherever shown and wherever required to build corners, lintels, jambs, control joints and expansion joints, and for other uses where necessary to provide a complete installation in accordance with the highest standard of workmanship.

B Non-load bearing solid hollow concrete blocks shall conform to BS 6073: Part 1 using machine-expanded slag and the following:
1 Shale aggregate complying with ASTM C 331
2 Dry net concrete weight of not more than 1680 kg/cu.m
3 Grade N or the equivalent grade of BS 6073: Parts 1 and 2
4 Average Compressive Strength of ten blocks shall be more than 7.5 N/mm^2 with minimum individual strength not less than 7 N/mm^2 when tested in accordance with Appendix 'B' of BS 6073: Part 1
5 Blocks of thickness 75 mm or greater shall be tested for compressive strength and of thickness less than 75 mm tested for transverse strength. The average transverse strength of five samples shall not be less than 0.65 N/mm^2 when tested in accordance with Appendix 'C' of BS 6073: Part 1
6 Average drying shrinkage of four samples should not exceed 0.05 percent when tested in accordance with Appendix 'D' of BS 6073: Part 1
7 Average absorption of 3 samples shall not exceed 15 percent of its dry weight when tested in accordance with ASTM C140

C Blocks shall be cured by low-pressure steam at a pressure of 0.7 kg/cm^2. The curing temperature shall be raised uniformly, at not more than 0.56^oC per minute, from 30^oC to 66^oC. The masonry units shall be cured for approximately 3 1/2 hours from initial set period, and thereafter kept moist for a period of 7 days by means of a fine spray of water, and then allow to air dry for 14 days. An interval of not less than 3 hours shall be allowed between the forming of the units and the curing process, and blocks shall be cured in a moisture-controlled atmosphere at normal temperature and pressure. Moisture absorption shall be limited to 35 percent of saturation at time of delivery and until time of installation. Curing shall comply with ASTM Type I classification.

D Concrete block shall be units with exposed faces of the manufacturer's standard colour and texture, unless otherwise shown or specified.

2.04 Metal Ties, Anchors and Joint Reinforcement

A Horizontal joint reinforcing:
1 truss type welded wire units of 3 m lengths with prefabricated corner and tee units
2 fabricate from ASTM A 82 or BS 4482 cold drawn steel wire with deformed side rods
3 plain 9 gauge truss rods, crimped if used in cavity wall construction
4 provide width of between 37 and 50 mm less than wall thickness
a fabricate with 9 gauge (3.7 mm) side rods, unless otherwise shown
b provide units with a single pair of side rods, unless otherwise shown
c for use in interior partition walls, fabricate from mill galvanised wire
d for use in exterior walls, hot dip galvanise after fabrication, with 458 g/m^2 zinc coating to ASTM A 153, Class B-2 or BS 729, Table 1.

B Steel reinforcing bars for vertical reinforcement shall comply with BS 4449, size as shown or specified herein, free from mill scale and excess or loose rust deposits. Two 12 mm diameter bars shall be provided in each block.

C Concrete inserts shall be of unit-type inserts of the type and size shown, of cast iron or malleable iron, or fabricated from not less than 2.6 mm steel with 458 g/m^2 hot-dip zinc coating to ASTM A 153, Class B-2 or BS 729 Table 1 after fabrication.

D Dovetail strap type shall comprise dovetail slots with 22 mm wide flat bar anchors formed from 1.5 mm galvanized steel, with 6 mm upturned end or 12 mm diameter hole located

within 12 mm of end. The anchor shall extend to within 37 mm of face of masonry units. At the Contractor's option, 3.7 mm galvanized wire triangular tie-backs with metal tabs for insertion into dovetail slots may be provided in lieu of flat bar anchors.

E Provide bolt, strap, bar and rod anchoring devices of the type and size shown, but fabricated from not less than 1.5 mm sheet metal or 9 mm diameter rod stock unless otherwise shown. Devices shall be fabricated from steel with mill galvanized or hot-dip zinc coating.

F Lateral supports for wall heads shall comprise continuous 50 x 50 x 3 mm thick metal angle on both sides.

G Blockwork shall be restrained at vertical abutments with concrete with stainless steel wall starters with integral ties for building in.

2.05 Miscellaneous Metals

A Wall Control Joint Filler:
1 provide compressible control joint filler of closed cell PVC, SBR or Neoprene, either solid or tube type, of proper dimension to serve as back-up for joint sealant at face of masonry
2 do not use control joint filler at building expansion joints
3 provide solid rubber "key section" in control joint filler (60 to 80 Shore A durometer hardness) designed to maintain lateral stability in masonry wall.

B For wood nailers and similar items to be set into the masonry work and for masonry reglets and flashings see other relevant sections of these specifications

C Materials and sealants shall meet the required fire rating specified in Section 07910 hereof.

D Damp-proof course shall conform to BS 743.

Part 3 Execution

3.01 Inspection

The Contractor shall inspect existing surfaces and ensure that they are satisfactory for work to proceed as specified, and shall report unsatisfactory conditions to the Engineer. Work shall not proceed until rectified to the satisfaction of the Engineer.

3.02 Workmanship - General

A Work shall comply with the manufacturer's printed instructions and recommendations for the installation of each type of masonry product, unless otherwise shown or specified.

B Masonry construction shall be built to the full thickness shown, except for single ‘Wythe’ walls masonry walls which may be built to the actual thickness of the masonry units, using blocks of nominal thickness shown.

C Chases and recesses shall be formed as shown, and as may be required, for the work of other trades. Hollow blocks shall not be chased nor horizontal or diagonal chases cut in

load bearing work. Not less than 200 mm of masonry shall be provided between chase or recess and jamb of openings and between adjacent chases and recesses.

D Openings for equipment shall be left as shown or required to be installed at later date. Masonry work shall be completed after equipment is in place using materials identical with those immediately adjacent to the opening.

E Unfinished work for joining with new work shall be stepped back. Toothing will not be permitted. Before new work is started the exposed surfaces of set masonry shall be cleaned and units lightly wetted (if specified to be wetted). Loose blocks and mortar shall be removed prior to laying fresh masonry.

F Motor driven saws designed to cut blocks with clean sharp corners shall be used to cut blocks as required to provide pattern shown and to fit adjoining work neatly. Full blocks shall be used without cutting wherever possible and the use of less than half size blocks shall e avoided at corners, jambs and wherever possible at other locations. Chipped or broken blocks shall not be used.

G Concrete blocks shall not be built in until at least 28 days after manufacture and until they are fully cured.

3.03 Laying Masonry Walls and Partitions

A Except as otherwise shown or specified Type S mortar shall be used for exterior masonry work, Type N mortar for interior masonry work and Type M mortar for special structural requirements where shown, and for grouting reinforcing steel in masonry lintels unless concrete is shown.

B Running bond for all single-wythe masonry walls shall be used unless otherwise shown. In multiple-wythe walls, bond wythes together with header blocks wherever possible, unless otherwise shown. Where wythes cannot be masonry bonded, ties of the type and spacing shown, shall be used unless horizontal joint reinforcing provides the tie between wythes. Where type and spacing of wire ties is not shown provide either continuous or individual type ties, installed so that double wires will be spaced not more than 600 mm centres both horizontally and vertically.

C Solid hollow blocks shall be laid with completely filled bed head and collar joints and butter ends with sufficient mortar to fill head joints and push into place. Head joints shall not be slush jointed. Walls shall be laid up plumb and true with courses level and accurately spaced and co-ordinated with other work. Variations from plumb, true or level of more than 1/800 in any direction are unacceptable. Bearing plates, masonry anchors, flashings, sleeves, door frames and other miscellaneous items shall be built into masonry as work progresses and hollow metal frames adjoining masonry work shall be filled solidly with mortar. Anchoring devices shall be provided of the type shown, or of standard type if none are shown. Masonry work shall be anchored to all abutting structural members and space anchors 600 mm centres at vertical and overhead support locations, and 600 mm centres both ways behind masonry veneer work, unless otherwise shown. Uniform joint widths shall be maintained except for minor variations to maintain bond alignment. Except for cavity wall construction no voids shall be left between blocks and slush and grout back joints against other work as blocks are pushed into place. Masonry walls which are concealed or to be covered with other materials shall be finished with flush joints, unless otherwise shown. Exposed wall joints shall be tooled slightly concave, unless otherwise shown. Horizontal joint reinforcement and vertical reinforcement shall be provided in all

masonry walls, unless specifically noted or specified to be omitted. Horizontal reinforcement shall be spaced at 600 mm centres for interior walls and 400 mm centres for exterior walls unless otherwise shown or specified. Reinforcement shall be lapped a minimum of 150 mm at ends. Control and expansion joints shall not be bridged with reinforcement except at wall openings. Matching prefabricated "T" and "L" sections of reinforcement shall be used at corners and wall intersections to provide continuity. Reinforcement shall be centered in wall to provide a minimum mortar cover of 15 mm at side rods.

D Damp-proof course shall be protected with 12 mm thick cement mortar mix 1:3, shall be continuous throughout and stepped down where floor level changes and shall be laid full width of the wall with laps at corners and intersections not less than 75 mm.

EControl joints shall be installed in masonry walls where shown and mortar shall be raked out in preparation for application of sealant.

F If control joint locations are not shown, place joints vertically, spaced at each structural column or joint between bays of the building, but in no case spaced more than 9 m. Place vertical joints at points of natural weakness in the masonry work, including at locations where masonry wall height changes by more than 20 percent, above expansion or control joints in the supporting structure and where end of masonry wall butts against supporting structure.

G Continuous control joints, 10 mm wide, shall be formed across structures where shown with build-in 40 mm wide x 200 mm long galvanized mild steel flats minimum 1.6 mm thick at each alternate course. Vertical joints shall be filled with mortar, except where wall is a fire compartment wall, when it shall be filled as described in other relevant Section of the Specifications.

H Fine grout shall be used for filling spaces less than 100 mm in both horizontal directions and coarse grout for filling spaces 100 mm or larger in both horizontal directions. At the Contractor's option, use either low-lift or high-lift grouting techniques subject to the following requirements:

1 place vertical reinforcing before grouting and either before, or after, laying blocks, as required by job conditions. Support vertical reinforcing at intervals shown. Where individual bars are placed after laying masonry, place wire loops extending into cells as masonry is laid and loosen before mortar sets. After insertion of reinforcing bar, pull loops and bar to proper position and tie free ends.

2 prior to grouting, clean and inspect grout spaces and close cleanout holes. Remove dust, dirt, mortar droppings, loose pieces of masonry and other foreign materials from grout spaces. Clean reinforcing and adjust to proper position as required. Clean top surface of structural members supporting masonry to ensure bond. After final cleaning and inspection, close cleanout holes and brace closures as required to resist grout pressures.

3 do not place grout until entire height of masonry to be grouted has attained sufficient strength to resist displacement of masonry units and breaking of mortar bond. Install shores and bracing, if required, before starting grouting operations.

4 limit grout pours to sections which can be completed in one working day with not more than one hour interruption of pouring operation. Place pour in lifts which do not exceed 1.2 m. Allow not less than 30 minutes, and not more than one hour, between lifts of a given pour. Rod or vibrate each grout lift during pouring operation.

5 when more than one pour is required to complete a given section of masonry, extend reinforcing beyond masonry as required for splicing. Pour grout to within 37 mm of top course of first pour. After grouted masonry is cured, lay masonry units and place

reinforcing for second pour section before grouting. Repeat sequence if more pours are required.

6 for low-lift grouting the vertical reinforcing shall be placed prior to laying of masonry, shall extend above elevation of maximum pour height as required to allow for splicing and shall be supported in position. The masonry shall be laid to a maximum pour height not exceeding 1.2 m. Grout shall be poured using container with spout or chute. Rod or vibrate grout during placing. Place grout continuously; does not interrupt pouring of grout for more than one hour. Terminate grout pours within 37 mm of top course of pour.

7 for high-lift grouting cleanout holes shall be provided in first course at all vertical cells which are to be filled with grout. Units with one face shell removed shall be used and temporary supports provided for units above, or use header units with concrete brick supports, or cut openings in one face shell. Masonry shall be constructed to full height of maximum grout pour specified, prior to placing grout. Grout pours shall be limited to heights recommended by the National Concrete Masonry Association (NCMA) for the type of blocks, reinforcing and grout used in the work, but in no case exceed 3 m height.

3.04 Lintels

A Masonry lintels shall be used wherever shown, and wherever openings in the masonry of more than 300 mm are shown without structural steel or other supporting lintels. Unless otherwise shown one reinforcing bar shall be provided for each 100 mm thickness of wall, and bars of adequate size shall be used in relation to opening width. A minimum lintel bearing at each jamb of 100 mm shall be provided for openings which do not exceed 1.8 m width. Lintels shall be precast and shall be cured thoroughly before handling and installing. In walls of concrete masonry units specially formed U-shaped lintel units shall be provided, with reinforcing bars placed as shown and filled with Type M mortar or concrete grout.

B Steel lintels may be used with the approval of the Engineer and the Contractor shall provide sizes as recommended by the manufacturer.

3.05 Laying Exterior Walls

A In addition to requirements specified above the following shall apply to the installation of exterior masonry walls:

1 space horizontal joint reinforcing bars at 400 mm centres in exterior walls, unless otherwise shown.

2 install reglets and nailers for flashings and other related work where shown to be built into masonry work.

3 provide flashings in masonry work as shown and extend details to corners and intersections to provide complete waterproofing.

4 keep cavity clean of mortar droppings in cavity wall construction and strike mortar joints flush as the work progresses.

5 place wall ties in cavity work as the work proceeds and set with slope to outer wythe. Do not raise one wythe more than 1350 mm above the other where wire ties are used or 450 mm above the other where any other type of tie is used. Close cavities at openings and top.

6 provide ties 150 mm long for cavities up to 50 mm wide and 200 mm long for cavities 51 - 100 mm wide.

7 space ties in cavity as follows:

) Wythes of thickness (one or both	Cavity Width	Spacing of Ties

	Horizontal (mm)	Vertical (mm)	(mm)
90 mm or more both Wythes	50-75	900	450
90 mm or more both Wythes	75-100	750	450
90 mm or more both Wythes	100-150	450	450

3.06 Repair, Pointing and Cleaning

A Blocks which are chipped, broken stained or do not match adjoining units as intended, or are otherwise damaged shall be replaced and new blocks provided promptly to match adjoining blocks. Mortar or grout joints shall be pointed up to eliminate evidence of replacement.

B During the completion of masonry installation and the tooling of joints, any voids or holes shall be enlarged and completely filled with mortar. All joints shall be pointed up at corners, openings and adjoining work to provide a uniform, neat appearance, properly prepared for the application of sealant compounds and other work to follow. The exposed masonry surfaces shall be cleaned as follows:

1 all exposed work shall be cleaned without the use of acid. Cleaning shall not be done until mortar is thoroughly set and hard. Before wetting wall, remove large particles of mortar by means of wood scraper, chisel or wire brush.

2 the wall shall be pre-soaked, saturating the masonry with clean water and flushing off all loose mortar and dirt. Using a stiff fibre brush only, the wall shall be scrubbed down with a solution of 0.25 l household detergent and 0.25 l of trisodium phosphate dissolved in 4 l of clean water. All cleaning solution, dirt and mortar crumbs shall be thoroughly washed of using clean pressurised water.

3 If after this cleaning procedure is completed, the wall or portion of the wall is not clean, in the judgement of the Engineer, the Contractor shall clean with an acid solution by methods acceptable to the Engineer. If cleaned with an acid solution, all sashes, metal lintels and other material shall be thoroughly protected.

4 Particular care shall be taken to prevent smearing mortar on surfaces of concrete masonry units. If mortar smearing occurs, it shall be removed while soft, when possible; if dry and hard, it shall be removed by rubbing with a small piece of concrete masonry. All mortar smears, drippings, etc., on expanded faces of concrete masonry units shall be removed.

END OF SECTION 04220

Section 04400

Stone

Part 1 - General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations for:

1 Marble/granite wall cladding
2 Marble/granite flooring
3 Marble/granite in staircases, skirtings, vanity units etc.

1.02 Qualifications

A The work in this Section shall be executed by an approved specialist subcontractor.

B The fabricator shall be a firm with a minimum of five years successful experience in the fabrication of stonework units of similar sizes, shapes and finishes to the units required for this Project. The fabricator shall have ample production facilities to produce, furnish and supply the units as required for installation without delay to the Works.

C The erector shall be a firm with a minimum of five years experience in the successful erection of stonework units of similar sizes and shapes and of similar quantities to the units required for the Works.

1.03 Submittals

A Shop Drawings:
1 shop drawings of stonework showing in detail the layout, jointing, anchors and dowels, dimensions, sizes and locations of cut-outs, adjoining work, etc.
2 each piece on the shop drawings shall correspond to the identification number on the back of each stone
3 co-ordinate all components which are specified elsewhere (flashing, insulation, sealants) which comprise the system into this submittal
4 co-ordinate shop drawings with all related trades.

B Samples:
1 600 x 600 mm samples of each type and finish of marble and granite required, showing the full range of colour and texture expected in the finished work,
2 in addition submit one full size sample of each type and finish, falling in the average colour and texture range,
3 Engineer's review and approval of samples shall be for colour, texture and pattern only,
4 compliance with all other requirements is the exclusive responsibility of the Contractor,
5 sample review and approval shall precede mock-up installations as hereinafter specified,
6 provide also 400 x 400 mm stone sample panels with central cross joint to show sealant materials for the Engineer's review and selection of jointing materials.

C Manufacturer's data sheet or equivalent printed literature indicating product information correlated to specified requirements.
D Test Reports and Calculations:
1 reports of testing and inspection of anchor plugs and fasteners.

a provide manufacturer's test data for concrete inserts showing that the proposed inserts meet or exceed specified performance criteria.
b provide manufacturer's certification stating that these inserts are appropriate for the intended purpose.

2 calculations, certified by a licensed professional engineer for structural adequacy of stones and anchorage system, including support of window wall in areas where stonework supports the window wall.

3 reports of stone panel testing.

E Certification. After review of samples by Engineer and prior to fabrication certify in writing and submit any additional evidence required indicating that a sufficient quantity of materials within the range of approved mock-up materials is available from a single quarry, for each specified or approved stone to satisfy the total requirements of the project.

F Maintenance Instructions. Submit to the Engineer recommended cleaning and maintenance instructions for the marble materials being provided.

1.04 Performance Criteria

Design, fabricate and install the stonework and anchorage systems to support the gravity loads and to withstand the specified inward and outward pressures normal to the wall plane. Stone breakage, anchorage failure or displacement, either from the stone or from the support system, shall not occur under loading equal to 2.5 times the design load pressures, positive and negative.

1.05 Testing

A Stone Testing Programme:

1. The initial testing of stone will be performed prior to all other testing programmes. Samples of sizes and shapes of stone shall be provided as required for the following tests:

Physical Property	Test Method	No. of Tests
a. Compressive Strength	ASTM C 170	4
b. Modulus of Rupture	ASTM C 99	
Tested Dry		30
Tested Wet		30
c. Flexural Bending	ASTM C 880	
Tested Dry		30
Tested Wet		30
d. Density	ASTM C 97	2
e. Absorption (% by weight)	ASTM C 97	2
f. Petrographic Analysis	ASTM C 295	1

2 Above samples shall be taken at random locations from areas which will be quarried for the project.
a do not take all the samples from a single block.
b identify and transmit a record of the samples and quarry locations from which they were taken.

3 Based on the properties of stone as determined by the above test programme, the Engineer may revise the design safety factor as specified.

B Stone Panel Tests:

1 in a certified testing laboratory acceptable to the Engineer, test three, full sized stone

panels and their anchors under gravity loads and uniform loads in 50 kg/m^2 increments, alternately inward and outward to simulate wind loads,

2 stone panels and anchors shall be representative of the sizes and shapes as proposed for the installation and the assembly shall be tested to failure and the test pressure recorded at failure. The type of failure shall be recorded i.e. anchor pull-out or stone breakage, whether pressure was positive or negative and any other pertinent information Prior to testing, the Contractor shall submit for acceptance a description of the test assembly (including pertinent data on materials), test apparatus and procedures.

C Welding. Provide visual inspection for 100 percent of welds, reporting on defects and measures taken to correct those defects.

1.06 Mock-Ups

A Following approval of sample slabs construct mock ups as follows:

1 wall cladding: assemble to simulate final condition, direction of graining and indicating joint conditions, use of spacers, shims, anchorage, relieving angles, supports and all other features of the final work. Erect wall mock-up adequately reinforced and braced to sustain the imposed loads. Build in all items of anchorage and support.

2 flooring: provide in place sample installations of flooring/skirting, etc., at locations shown or directed by the Engineer, of each type of marble work shown and specified. Each sample installation shall consist of a full pattern and shall be complete with all anchors, bedding, jointing, sealers, etc., as shown and in accordance with final shop drawings. Sample installations shall be reviewed by the Engineer for acceptance of marble and granite colour, finish, jointing, pointing and general workmanship. Replace unsatisfactory work as directed for final acceptance. Maintain sample installations during construction as a standard for judging acceptability of marble work. Properly finished and maintained sample installations may be retained as a portion of the completed work.

3 provide mock-up for any other stone work as shown on the drawings and as required by the Engineer.

1.07 Pre-Installation Co-Ordination

A Pre-Installation Conference: prior to the start of marble and granite installations meet at the Site and review the installation procedures and co-ordination with other Work. The meeting shall include Contractor, Sub-Contractor, and Engineer as well as others whose work must be co-ordinated with the marble work.

B Pre-Installation Inspection:

1 examine all parts of the supporting Structure and the conditions under which the marble and granite work is to be installed,

2 notify the Engineer in writing of any conditions detrimental to the proper and timely completion of the work,

3 do not proceed with marble installation work until all unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

1.08 Delivery, Storage And Handling

A Carefully pack and load marble and granite for shipment and take necessary precautions against damage in transit. Deliver marble and granite to project site using protection and

handling equipment which will ensure that there will be no leakage, chipping, soiling, staining, discoloration, warpage, or other damage. Store above grade on wood dunnage or other suitable surfaces using polyethylene film to separate marble from wood or other supporting or protecting members. Protect from weather, soiling and damage of every kind.

B Deliver other materials, except bulk materials, to project site in manufacturer's unopened containers with name, brand, type, grade and colour fully indicated thereon. Store bulk materials as required to avoid any deleterious effects of weather, soiling or contamination.

Part 2 - Products

2.01 Materials

A Stonework:
1 General:
a Stone shall be sound and free from defects which would impair strength, durability or appearance.
b Each species of stone shall be provided from a single quarry.
c Quarries and fabrication plants shall be available for inspection by the Engineer.
2 Stone Types:
a all stone shall be of soundness (hardness and density),texture, graining colour tone and range matching the approved sample available for inspection in the office of the Engineer's Representative,
b stone flooring shall be 3 mm thick of either Verde Issoire or Chan Gree with polished finish,
c wall linings shall be 20 mm thick, mechanically fixed,
d staircase finishes shall be marble, as shown, unless it is terrazzo or other finish,
e vanity units shall be marble, as shown on the Drawings,
f facing to fountains shall be granite, generally with etched finish but polished where in contact with water, all as shown on the Drawings.

B White Portland Cement: ASTM C 150, Type I or BS 12 non-staining in accordance with the definition and test requirements of ASTM C 91.

C Hydrated lime: ASTM C 207, Type S.

D Sand: pure silica sand.

E Shrinkage reducing accelerator: "Sika Set" (Sika Corp.), or equal.

F Mineral colouring admixture: finely ground, synthetic, lime-proof, non-fading mineral oxides having purity of 98 percent; maximum 5 percent of cement by weight.
G Water: clear and free of deleterious material.

H Anchorage Devices:
1 anchors, dowels, cramps, plug anchors, angles, relieving anchors:
a fabricated of stainless steel complying with ASTM A 167, Type 304.
b thickness as required to sustain imposed loads but not less than 5 mm.
2 Devices embedded in concrete or masonry:
a wedge inserts with tee-shaped wedge-action slot, with askew head bolt, washer and nut;
b dovetail anchor slots of size to receive specified anchor, filled with waterproof filler

and open face sealed;
c adjustable insert with square nut sliding in integral track;
d malleable iron castings or steel fabrications, thickness as required to sustain imposed loads but not less than 5 mm.
e all products galvanized after fabrication.

I Galvanising:
1 ASTM A 153 for galvanising iron and steel hardware.
2 ASTM A 123 for galvanising rolled, pressed and forged steel shapes, plates, bars and strip 3 mm thick and heavier.
3 ASTM A 386 for galvanising assembled steel products.

J Dielectric separator: bituminous paint, "Bitumastic 50" (Koppers Co., Inc.) or "Jennite J-16" (Maintenance Coatings Co.)

K Cushions: clear plastic and 50 Durometer neoprene 25 x 50 mm by thickness required.

L Reinforcing mesh: chicken wire.
M Sealant: as specified in Section 07920 - "Sealants".

N Joint Filler: compressible joint filler as shown and as specified in Section 07910.

O Waterproofing additive to setting bed: liquid latex additive No. 3701 (Laticrete International).

P Tile Adhesive: epoxy adhesive complying with ANSI A136.1 and as recommended by the stone supplier.

Q Divider Strips: complying with ASTM A 167-82 size as shown and finish as approved by the Engineer.

R Structural Steel Shapes: complying with ASTM A 36, hot dip galvanised after fabrication where shown.

S Non-Slip Inserts: as shown and finish as approved by the Engineer.

2.02 Mixes

A Mix mortar in small batches, to a stiff plastic mass, until thoroughly homogeneous.
1 do not use mortar until it has set for one hour.
2 mortar may be used only up to two hours after mixing.
3 do not reuse mortar or use partially set mortar.

B Mortar for Setting Stone:
1 one part white Portland cement, one part hydrated lime, five parts sand.
2 provide waterproof additive for wet areas and exterior stone.
3 prepare mortar with a shrinkage reducing accelerator diluted with water in the ratio as recommended by the manufacturer.

C Mortar for Setting Stone Flooring Steps and Treads:
1 one part white Portland cement, four parts sand,
2 mix as dry as can be worked,
3 provide waterproofing additive for wet area flooring.

D Pointing Mortar:
1 one part white Portland cement, two parts sand, mineral colouring admixture as required to match stone,
2 mixed as dry as can be worked,
3 provide waterproof admixture for exterior and wet area pointing.

2.03 Fabrication

A Accurately cut, dress, drill, fit and finish stonework to shapes and dimensions shown on drawings and approved shop-drawings. Make exposed plane surfaces true in line and exposed curved surfaces true in radius. Thicknesses of stone shown are minimum. Any deviation below the minimum thicknesses will cause rejection and replacement of those stone panels.

B Wall Facings:
1 Cut exposed external corners of stone as shown and ease expose external edges where shown. Cut all other joints and edges square and at right angles to face, and with backs parallel to face. Make arises straight, sharp, true, and continuous at joints. Cut and drill stones in shop as required for supports, anchors, ties and other inserts.
2 Allow for expansion and contraction within the limits of the joint material when cutting for anchorage devices.
3 Provide greater stone thickness than indicated where thicknesses indicated are insufficient for the sizes; extent of cutouts show decreased effective strength of the remaining material; for proper and sufficient anchorage; or to provide suitable and adequate bearing areas or surfaces.

C Jambs, Heads, etc.:
1 **f**abricate units designated for one piece installations like heads, jambs, etc., accurately to shape and sizes established by actual site measurements,
2 fabricate units neatly for proper installation.

D Steps, etc.:
1 Cut steps, etc. to shapes and profiles shown,
2 make arises straight and true and ease edges slightly,
3 cut and trim stone in the shop as required for supports, anchors and other inserts.

E Flooring:
1 cut stones into sizes and shapes as shown,
2 cut with right angle edges normal to the face plane to provide for even jointing and with back of stone roughly parallel with face plane.

Part 3 - Execution

3.01 Condition of Surfaces

A Prior to installation examine surfaces to receive stone and do not proceed until any defects detrimental to the finished work are corrected and moisture protection, structural supports, provisions for expansion, or any other condition which might affect the finished work in appearance, water tightness or integrity of the completed installation are finalised.

B Verify all measurements and dimensions, co-ordinate the installation of inserts for this work and co-ordinate and schedule this work with the work of other trades. Give particular attention to the location and size of cutouts required to accommodate mechanical, electrical, and other work or adjoining construction, in accordance with the reviewed shop drawings for such trade.

C Co-ordinate shop drawings of items or assemblies related to the support or anchorage of stonework, including requirements for clearances for proper installation.

3.02 Installation

A furnish dovetail anchor slots, wedge type inserts and other items requiring building in to concrete or masonry work, along with location drawings, in sufficient time so as not to delay job progress. Inserts shall be tied with wire into reinforcing to prevent displacement. No forced entry type anchorage devices will be allowed.

B Stone setting, anchoring, and pointing shall be in accordance with applicable requirements of specifications of the Marble Institute of America unless otherwise specified or shown.

C Set stone in accordance with approved shop drawings, level, plumb, square, and true with uniform joints, accurately aligned with grain running in the direction shown and match work to mock-up.

D After all adjustments have been made to stonework anchorage devices, weld adjustable supports so as to prevent future displacement or movement. All welds will be subject to visual inspection.

E The quality of field cutting shall be the same as for shop cutting.

F Provide dowels, anchors and ties in sufficient quantity to eliminate "rattle" or loose pieces and to ensure a rigid installation. Extent of anchorage and installation details shown are intended to indicate minimum requirements. In general, a minimum of one anchor per 0.18 sq. meter of area is required, with additional anchorage provided where necessitated by size, thickness, setting or shape.

G Provide steel back-up support for stone work where shown on the Drawings and wherever required, particularly at lintel soffits etc., to provide rigid installation. Anchor steel support framing securely to building structure.

H Wall Cladding:

1 set relieving angles as required for proper support of stone, before setting, clean stone and backing and before setting in mortar saturate with water,

2 set stone with two fixations per stone in every horizontal joint, extending full depth of stone and to within the dimension from the face as shown. Secure with anchors, dowels, cramps etc., as required for rigid and secure installation and fill anchorage holes with accelerated setting mortar. Rigidly secure strap anchors to the backing,

3 repair flashing materials to their original condition where they have been punctured by anchorage or damaged during setting,

4 fill the cavities behind facing with 1:4 cement sand mortar, unless full mechanical installations are called for on the drawings.

5 fill and seal joints as shown.

J Paving and Flooring:

1 provide reinforcing mesh in setting bed,
   a tamp stone into setting bed with mallet until firmly bedded to the proper level,
   b remove stone and back parge with wet cement or sprinkle the bed with water and cement after wetting the back of the stone,
   c return to position on setting bed,
   d use cushions and spacers to maintain uniform jointing and setting.
2 grout with water and neat cement by buttering the edges of the stone as they are laid. Immediately clean surplus joint cement from face of the stone,
3 where grinding is required to completely align and level joints, permit a minimum of six days of setting time to elapse before commencing. Perform grinding by wet abrasion, in a manner as to retain the finish, to match the balance of stone paving, and to be free of depressions and grind marks. Exercise care to avoid damage or soiling of adjacent work.

K Erection shall comply with the following maximum non-cumulative tolerances:

1	variation from plumb	:	+/- 3 mm in storey height
2	variation from level	:	+/- 3 mm in any bay
3	variation in location :	:	+/- 6 mm in any bay
4	edge alignment	:	1.5 mm

L. Joint Widths. Provide stone work joint widths as shown.

3.03 Protection

A After initial cleaning, provide non-staining temporary wood guards at corners and other surfaces subject to damage. Rope off flooring to permit curing of setting bed and protect work from damage due to subsequent building operations. Immediately prior to completion of the Work clean stone by washing with water and bristle brushes. Remove all stains, dirt and other discolorations but do not use acids, cleaning compounds or wire brushes. On completion of construction, remove all temporary protection.

3.04 Engineer's Approval

A Installed units which are chipped, cracked, or otherwise damaged or which, in the opinion of the Engineer, do not conform to the Specification requirements shall be removed and replaced such that the completed work meets the entire satisfaction of the Engineer.

End of Section 04400

DIVISION 5.

METALS

Section 05120

Structural Steel

Part 1 General

1.01 Description

The work covered by this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Structural Steelwork.

1.02 Qualifications

Structural steel fabrication and erection shall be performed by an organization experienced in structural steel work of equivalent magnitude with minimum five years documented experience. The Contractor shall verify all measurements and shall take all field measurements necessary before fabrication. The Contractor shall be responsible for correctness of detailing, fabrication, and for the correct fitting of structural members. Substitution of sections, or modification of connection details, or both, will not be accepted by the Engineer. Connections, fully designed and detailed on the Drawings, shall be furnished as shown. Members and connections, for any part of the structure, not shown on the Drawings shall be the Contractor's responsibility. Such connections shall be considered standard and designed and detailed in accordance with AISC M016. AISC S335 shall govern the work, high-strength bolting shall be in accordance with the AISC S329 and welding shall be in accordance with AWS D1.1.

1.03 Submittals

A Shop Drawings

1 Shop drawings shall include structural calculations for all structural steel components and their connections, all in accordance with the requirements of the Contract Documents and show the following:

a fabrication drawings which show type of material, size and weight of members, information for shop assembly of members of the structure and other information necessary for the fabrication of each member,

b drawings shall include the type, size, location and extent of all welds and bolts,

c drawings shall clearly distinguish between shop and field, bolts and welds,

d field assembly and erection drawings which show all field assembly prior to erection and after erection,

e drawings shall indicate all details, schedules, procedures and diagrams showing field assembly and sequence of erection,

f information shall indicate locations of bracing and shoring and how shoring is stabilized and controlled,

g drawings shall indicate elevations of shored points and splice locations,

h procedures shall indicate step by step erection sequences including intermediate surveys and allowances for temperature,

i diagrams shall indicate erection equipment, size and weight and additional elements which may be required to support or stabilize elements during erection.

2 Written procedures for fabrication of the steel work shall describe the complete welding process including machine, current, voltage, preheat, filler metal, welding system (manual, semi-automatic or automatic), positions of welding, number of passes for each weld size, preparation of surfaces prior to welding, etc. These procedures shall indicate the Contractor's quality control measures, monitoring and repair procedures.

3 The Contractor shall be responsible for all details along with calculations to the Engineer prior to fabrication and the arrangement of all joints and their load carrying capacities. Connections may, or may not, be shown on the Drawings.

B Manufacturer's Literature
Manufacturer's specifications and installation instructions for the following products shall include laboratory test reports and such other data to show compliance with these Specifications (including specified standards):
- a structural steel, (each type) including certified copies of mill reports covering: chemical and physical properties; country and rolling mill of origin; statement indicating that the steel is new billet steel; and that testing has been performed in accordance with ASTM standards,
- b high strength bolts (each type) including nuts and washers,
- c welding electrodes (each type),
- d shop coat primer paint, field touch-up paint, and colour samples of all paint to be used,
- e epoxy paint,
- f bearing materials or assemblies.

C Testing Reports. The following reports shall be submitted in triplicate directly to the Engineer by the testing laboratory, with copy to the Contractor.
1 shop welders certification.
2 field welders certification.
3 magnetic particle tests: shop welds and field welds.
4 ultra-sonic tests: shop welds and field welds.
5 high strength bolted connection tests: shop and field.

1.04 Testing

A The Contractor shall engage, at his own expense, an independent certified testing laboratory approved by the Engineer to inspect high strength bolted connections and welds and to perform all tests and submit test reports to Engineer as herein specified. The Contractor shall submit evidence regarding qualification of the proposed Testing Laboratory.

B The Contractor shall provide the testing laboratory with a complete set of shop, fabrication and erection drawings and cutting lists, order sheets, material bills, shipping bills and mill test reports. Certified copies of mill test reports shall be provided for bolts, nuts and washers including names and locations of mills and shops and analyses of chemical and physical properties, and information as to time and place of all rolling and shipment of material to shops. The Contractor shall provide representative sample pieces requested for testing, full and ample means and assistance for testing all material and proper facilities, including scaffolding, temporary work platforms, hoisting facilities, etc., for inspection of the work in the mills, shop and field.

C Bolted connections shall be inspected by the testing laboratory in accordance with AISC Specifications for "Structural Joints Using ASTM A325-83C, ASTM A325M-83 and ASTM A490-83A or ASTM A490-82.

D Welding shall be inspected and tested by the testing laboratory during fabrication and erection of structural steel as follows:
1 certify all welders in accordance with AWS and make inspections and tests as required. Record types and locations of all defects found in the work, and measures required and performed to correct such defects,

2 in addition to visual inspection of all welds, magnetic particle and ultra-sonic inspection shall be made of all welds indicated on the Drawings. Magnetic particle inspection shall be made on the root pass and finished weld,
3 the method of magnetic particle inspection shall be in accordance with ASTM E109. Any type of crack or zone of incomplete fusion or penetration will not be acceptable,
4 ultra-sonic inspection shall be performed in accordance with AWS D1.1.

F Each bolting crew and welder shall be assigned an identifying symbol or mark. All shop and field connections shall be so identified so that the inspector can refer back to the crew or person making the connection.

G The testing laboratory shall be responsible for conducting and interpreting the tests, shall state in each report whether, or not, the test specimens conform to all requirements of the Contract Documents and any deviations therefrom.

H Access to places where material for the Works is being fabricated or produced shall be provided to Engineer and the testing laboratory for the purpose of inspection and testing. The Engineer and the testing laboratory may inspect structural steel at the plant before shipment. The Engineer reserves the right to reject any material, at any time before final acceptance, which does not conform to all of the requirements of the Drawings and Specifications. The testing laboratory shall perform specified tests and submit reports to the Engineer. Any corrective measures, including additional and more complete testing, which may result from these tests shall be the Contractor's responsibility. The Contractor shall pay for all costs of above.

I The Contractor shall coordinate and allow for necessary time for the testing laboratory to complete all testing and inspections prior to shop painting.

J The testing laboratory shall prepare test specimens from steel samples cut from delivered material and shall conduct tension tests in accordance with ASTM. To provide the steel for testing the Contractor shall order one metre extra length for the members noted on the Drawings.

1.05 Substitutions

A The Contractor shall fabricate and erect the structural steelwork as shown on the Drawings and Specifications. Details of all fabrication and construction shall be submitted to Engineer for approval.

B All changes and modifications require that the Contractor shall guarantee, in writing, signed by a principal officer of the company, that the equipment offered will provide comparable or superior features to the equipment specified including performance; quality; materials of construction.

C Costs of any changes incidental to the installation of the alternate equipment such as electrical wiring, relocation of piping, engineering supervision, ductwork, building configuration and design, shall be at the expense of the Contractor with no additional expense to the Employer.

D If, after installation, the alternate installation does not perform in accordance with the specifications, or other deficiencies are noted, the Employer will require the modification or replacement of such equipment to meet the specifications at no additional expense to the Employer.

1.06 Delivery, Storage and Handling

A Care shall be exercised to avoid abrasions and other damage and structural steel shall not be handled until paint has thoroughly dried.

B Storage of fabricated steel at the job site shall be the responsibility of the Contractor. Material shall be stacked above ground out of mud and dirt and provided for proper drainage and protected from damage or soiling by adjacent construction operations. Material stored at the job site shall not exceed design loads on existing or newly-constructed structures so that members will not be distorted or otherwise damaged and shall be protected against corrosion or deterioration.

C Material shall not be delivered to the project site until the proposed method and sequence of erection has been reviewed by the Engineer. The method and sequence shall be planned so as to avoid delay or damage to the work of other trades.

Part 2 Products

2.01 Structural Steelwork

All structural steel shall conform to ASTM A43 Grade 36 (min. yield strength 300 N/mm^2 unless noted otherwise). All bolts, nuts and washers shall conform to the requirements of ASTM A490 and A325. All bolts shall be cold forged with rolled threads. All structural testing shall conform to ASTM A 500, Grade B, Seamless, yield stress 317 N/mm^2.

2.02 Welding Electrodes

All welding electrodes shall be E70XX and shall comply with the provisions of AWS Specifications A5.1, A5.5, A5.17, A5.18, A5.20. All welds not specified shall be continuous fillet welds using not less than the minimum size based on thickness of the thicker part jointed.

Thickness	Min. Weld Size
12 mm	4 mm
Over 12 mm to 20 mm	6 mm
Over 20 mm to 40 mm	8 mm
Over 40 mm to 50 mm	10 mm

2.03 Grout

Grout shall be in accordance with Section 03600, and manufacturer's recommendations.

2.04 Paint

A Primers: steel surfaces, which are not embedded in concrete, shall be painted with anti-corrosive primer complying with BS 5493. Minimum dry film thickness 50 microns for all members that will receive finishing coat. All other members/surfaces will receive three coats of total thickness 150 microns.

B Finishing Coat: all steel members exposed to view shall be coated in accordance with Section 09870.

C Use spray application for painting and minimum thicknesses shall be maintained on all corners, edges and ends of pieces. Surface to be painted shall be dry and above 2°C and

temperature of the air shall be over 5°C. No painting shall be undertaken outdoors in rainy and dusty weather and at least 24 hours drying time in good weather shall be allowed before re-coating.

2.05 Source Quality Control

A Testing and inspection of structural steel will be performed by an independent structural steel testing agency engaged by the Contractor, at his own expense and approved by the Engineer. The testing agency shall be provided with the following:

1 a complete set of accepted documents required under "Submittals",
2. cutting lists, order sheets, materials bills and shipping bills,
3 information as to time and place of all rollings and shipments of materials to shops,
4 representative sample pieces as requested by the testing agency,
5 full and ample means and assistance for testing all material,
6 proper facilities, including scaffolding, temporary work platforms, etc., for inspection of the work in the mills, shop and field.

B The Inspector will perform his duties in such a way that fabrication and erection are not unnecessarily delayed or impeded, and as follows:

1 the Inspector will make all tests and inspections as required by "Structural Welding Code",
2 the edges of material to be welded will be ultrasonically examined for evidence of laminations, inclusions or other discontinuities. The extent to which such defects will be permitted and the extent of repair permitted shall be determined by the Inspector and made in accordance with ASTM A6, Paragraph 9. Repairs made by welding shall be done in compliance with the requirements of AWS D1.1 and the accepted welding procedures,
3 the root layer of all multiple pass welds and the backside of groove welds made from both sides, after back gouging or chipping, will be examined by magnetic particle inspection (or dye penetration if magnetic particle inspection is not feasible).
4 all shop and field welds shall be listed as stated on Drawings,
5 the technique of radiographic inspection will be in accordance with the requirements of AWS D1.1. A double film technique will be used. One copy of each film will be sent to the Engineer, the other will be retained by the Inspector,
6 where inspection reveals defects, the extent of inspection will be increased as much as necessary to ensure that full extent of the defects in a joint has been found and that the same defects are not present in welds made on similar parts or under similar circumstances,
7 work that is not acceptable will be designated by "Repair" or "Reject", as applicable,
8 shop welds will be inspected in the shop before the work painted or approved for shipment,
9 the Inspector will maintain a daily record of the work he has inspected and its disposition. Reports of tests will be made in form prescribed in AWS D1.1. One copy of each of the reports will be submitted to the Engineer on a weekly basis,
10 the Inspector will make all tests and inspections of high strength bolt connections as required by AISC S314.

Part 3 Execution

3.01 Bench Marks

The Contractor shall employ the services of a registered professional engineer who shall establish permanent bench marks, field check all elevations of concrete on which structural steel is to be placed, locate anchor bolts, report discrepancies to the Engineer, and obtain the Engineer's approval before the work proceeds.

3.02 Erection

A The Contractor shall be responsible for the accurate setting and levelling of all bearing plates or setting plates. Bearing plates or setting plates shall be levelled on steel wedges or shims, or as otherwise detailed, and shall be grouted as specified. Templates shall be furnished for accurate setting of all anchor bolts. Shim plates or fills shall be provided where required to obtain proper fit and alignment.

B Oxygen cutting of structural steel in excess of 3mm for "fitting-up" purposes shall not be done except with the prior approval of to the Engineer. The use of an oxygen cutting torch for correcting fabrication errors will be permitted only when the member is not under load, and only after prior written approval of the Engineer to the procedures to be followed in the event corrective work is necessary.

3.03 Erection Tolerance

A The Contractor shall be responsible for the correct fitting of all structural members and for the elevation and alignment of the finished structure. Any adjustments necessary in the steel work because of discrepancies in elevations and alignment shall be the responsibility of the Contractor.

B Unless otherwise noted, the structure shall be levelled and plumbed to an accuracy of 1 to 1000, but not to exceed 12 mm. The actual centrelines of truss chords shall not vary from theoretical centrelines by more than 12 mm at any point. The difference between offsets to the actual centrelines of truss chords at adjacent panel points shall not exceed 3mm. All levelling and plumbing shall be done based on the mean operating temperature of the structure. Allowances shall be made for the difference in temperature at time of erection and the mean temperature at which the structure will be when completed and in service.

C All measurements relating to the above shall be on the theoretical centrelines of the members.

3.04 Connections

A Welding or bolting shall not be performed until all stiffening components of the structure have been properly aligned.

B Drift pins shall not be used to enlarge holes in primary members. Holes that must be enlarged to admit bolts shall be reamed. Burning and drifting may be used to align holes only in secondary bracing members, and only when approved by the Engineer.

C When high strength bolts, or high strength bearing bolts, are used, the AISC specifications shall apply, including values as noted therein, and installation shall be with torque wrenches. In using manual torque wrenches, the required torque can be read from the wrench dial but

care should be taken that the wrench is properly calibrated. Nuts shall be in motion when torque is measured. In using power wrenches, the recommendations of the wrench manufacturer shall be followed. Hardened washers shall be used under bolt head or nut whichever is turned in tightening, unless the specified standards require hardened washer under both head and nut.

D All bolts shall be kept in dry storage until needed for installation. A325 bolts 28mm and 32 mm diameter and A490 bolts 25 mm diameter and over shall have Johnson's Stick Wax No. 140 applied to their threads before being assembled in the work. If bolts have been left out and have become rusty before use, they shall be rejected and shall not be used until they have been cleaned and waxed with Johnson's Stick Wax No. 140.

E Welded and bolted connections shall be tested in accordance with the requirements of 1.06, Testing, and as indicated on the Drawings.

3.05 Setting Bases and Bearing Plates

A The Contractor shall clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. The bottom surfaces of base and bearing plates shall also be cleaned.

B Loose and attached baseplates and bearing plates for structural members shall be set on wedges or other adjusting devices.

C The anchor bolts shall be tightened after the supported members have been positioned and plumbed. Wedges or shims shall not be removed, but, if protruding, shall be cut off flush with edge of the base or bearing plate prior to packing with grout.

D Grout shall be packed solidly between bearing surfaces and bases or plates to ensure that no voids remain. Exposed surfaces and installed materials shall be protected and allowed to cure in strict compliance with the manufacturer's instructions, or as otherwise required.

3.06 Weld Test Schedule

Weld Location	Length of Weld to be Tested Specification	Type of Weld	Test	ASTM Test
Other stress Carrying Welds	300 mm in 3 m	Fillet	M.P. *	E709 (magnetic particle)
	300 mm (min. test)	Groove	U.T.	E164 (ultrasonic)
Flange Splice (Full Penetration) (Weld only)	100%	Groove	U.T.	E94 (Radio graphic)-Shop E164 (ultrasonic)-Field
Web Splice	Top - 100% Bottom - 33% Middle - 34%	Groove	U.T.	E94 (radiographic) - Shop E164 (ultrasonic)-Field
Bearing Stiffener to Web	300 mm in 1.2 m 300 mm (min. test)	Fillet	M.P. *	E709 (magnetic particle)
Misc. Secondary Members Tension Zones	300 mm in 3 m (min. test)	Fillet	M.P. *	E709 (Magnetic Particle)

Compression Zones	Visual only			

* Only for field welds E165, liquid penetrant test may be substituted.

3.07 Survey

The Contractor shall make an accurate survey of actual locations of steel members immediately upon the completion of erection of steel but before removal of shoring and shall promptly submit same to the Engineer. Should locations vary beyond the allowable tolerances, the necessary corrective measures and procedures shall be performed with approval of the Engineer. The Contractor shall survey the finally erected structural steel after release of shoring, but prior to final removal of shoring elements and prior to the start of any other work. Any discrepancies from Contract requirements shall be reported to the Engineer.

END OF SECTION 05120

Section 05500

Miscellaneous Metals

Part 1 General

1.01 Description

A The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with metal fabrication work.

B Metal fabrication work is defined as including any items shown on the Drawings and/or specified herein, fabricated from steel and iron shapes, plates, bars, pipes, tubes, casting and roll-formed shapes which are not a part of an overall system specified in any other Section of these Specifications.

1.02 QUALITY ASSURANCE

A Reference Standards:
AISC S326, Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings (referred to herein as AISC specification).
ANSI A14.3, Ladders-Fixed-Safety Requirements.
ASTM A36, Standard Specification for Structural Steel.
ASTM A48, Standard Specification for Gray Iron Castings.
ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
ASTM A108, Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality.
ASTM A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
ASTM A197, Standard Specification for Cupola Malleable Iron.
ASTM A307, Standard Specification Carbon Steel Bolts and Studs, 60.000 psi Tensile Strength.
ASTM A325, Standard Specification for High-Strength Bolts for Structural Steel Joints.
ASTM A496, Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
ASTM A500, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
ASTM A525, Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
ASTM A536, Standard Specification for Ductile Iron Castings.
ASTM A563, Standard Specification for Carbon and Alloy Steel Nuts.
ASTM A582, Standard Specification for Free-Machining Stainless and Heat-Resisting Steel Bars, Hot-Rolled or Cold-Finished.
ASTM A666, Standard Specification for Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar.
ASTM A668, Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial use.
ASTM A780, Standard Practice for Repair of Damaged Hot-Dipped Galvanized Coatings.
ASTM A786, Standard Specification for Rolled Steel Floor Plate.

ASTM B26, Standard Specification for Aluminium-Alloy Sand Castings.
ASTM B36, Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar.
ASTM B221, Standard Specification for Aluminium and Aluminium-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes.
ASTM B308, Standard Specification for Aluminium-Alloy 6061-T6 Standard Structural Shapes.
ASTM B632, Standard Specification for Aluminium-Alloy Rolled Tread Plate.
ASTM F467, Standard Specification for Non-Ferrous Nuts for General use.
ASTM F468, Standard Specification for Non-Ferrous Bolts, Hex Cap Screws, and Studs for General Use.
ASTM F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
Aluminium Association (AA):
a 30-86, Specifications for Aluminium Structures.
b Standard Specifications for Highway Bridges.

1.03 Qualifications

The Contractor shall employ only experienced tradesmen for both fabrication and installation, who are capable of producing work of the highest standards of quality in the industry.

1.04 Submittals

A Manufacturer's Literature shall include specifications, load tables, dimension diagrams, anchor details and installation instructions for products to be used in the manufacture of metal fabrications, including paint products.

B Shop Drawings shall include:
1 shop drawings for the fabrication and erection of all assemblies of metal fabrication work which are not completely shown by manufacturers' data sheets.
2 include plans and elevations at not less than 1:10 scale, and include details of sections and connections at not less than 1:5 scale.
3 show anchorage and accessory items.
4 give location, type, size and extent of welding and bolted connections and clearly distinguish between shop and field connections.
5 prior to submittal, coordinate shop drawings with related trades to ensure proper mating of assemblies.
6 detailed drawings shall show material type, thickness, grade/class, dimensions, and construction scheme.
7 the submittal shall include catalogue pages, erection description, manufacturers data/instructions and templates.

C Test Reports. The Contractor shall furnish certified physical and chemical mill test reports for materials used for major structural members.

D Samples shall include:
1 handrail assembly to show joints, bends, toeplate, posts and anchorage,
2 stair treads and safety nosings, 200 mm long,
3 gratings and plates, 200 x 200 mm,
4 fasteners and anchoring devices.

1.05 Delivery, Storage and Handling

Store on blocking so that no metal touches the ground and water cannot collect on the miscellaneous fabrications and protect from bending under their own weight or superimposed loads.

Part 2 Products

2.01 General

A Products and manufacturers specified herein are specified for the purpose of establishing minimum quality standards.

B Structural steel fabrication and erection shall be performed by an organization experienced in work of equivalent magnitude.

C The Contractor shall verify all measurements, shall take all field measurements necessary before fabrication and shall be responsible for correctness of detailing, fabrication, and for the correct fitting of structural members.

D Substitution of sections or modification of connection details, or both, will not be accepted by the Engineer.

E Connections fully designed and detailed on the Contract Drawings shall be furnished as shown. Members and connections, for any part of the structure, not shown on the Contract Drawings shall be the Contractor's responsibility. Such connections shall be considered standard and designed and detailed in accordance with AISC M016.

F AISC S335 shall govern the work, high-strength bolting shall be in accordance with AISC S329 and welding shall be in accordance with AWS D1.1.

2.02 Materials

A Steel
1 structural steel: ASTM A36, Grade 43,
2 steel pipe: ASTM A53, Types E or S, Grade B,
3 structural Tubing: ASTM A500, Grade B,
4 bolts, nuts and washers, high strength: ASTM A325, and unfinished: ASTM A307, Grade A. Provide two washers for each nut and bolt,
5 anchor bolts: ASTM A36,
6 electrodes for welding steel: AWS A5.1, E70 Series,
7 steel forgings: ASTM A668.

B Iron
1 ductile iron: ASTM A536,
2 gray cast iron: ASTM A48,
3 malleable iron: ASTM A47, A197.

C Stainless steel shall conform to ASTM A167 and ASTM A276 and the alloy types shall be minimum type 316 unless otherwise stated.

D Aluminium

1 rolled shapes and extrusions: ASTM B308 or B221.
2 castings: ASTM B26.
3 alloys 6061-T6 or 6063-T6 unless specified otherwise in this Section.
4 aluminium angles, beams, pipes, plates and channels: Alloy 6061-T6.
5 aluminium weir plates and baffles: Alloy 6061-T6.
6 aluminium bolts: ASTM F468, alloy 2024 T4.
7 aluminium nuts: ASTM F467, alloy 2024 T4.
8 electrodes for welding aluminium: AWS D1.2, filler alloy 4043 or 5356.

E Washers: same materials and alloy as found in accompanying bolts and nuts.

F Galvanizing
1 iron and steel: galvanizing shall be done in accordance with ASTM A123 with an average coating weight of 600 g/m^2 and not less than 560 g/m^2,
2 ferrous Metal Hardware Items. These shall be galvanized in accordance with ASTM A153 with an average coating weight of 400 g/m^2,
3 touch-up material for galvanized coatings: galvanized coatings marred or damaged during erection or fabrication shall be repaired in accordance with the coating manufacturer's instructions.

G Expansion anchors shall be Kwik-Bolt II by Hilti, Red Head by Phillips Drill Co., or approved equal and shall meet or exceed ICBO requirements.

H Adhesive anchors shall be HVA anchors by Hilti or approved equal and shall meet or exceed ICBO requirements.

I Headed studs shall be to ASTM A108 with a minimum yield strength of 345N/mm^2 and minimum tensile strength of 414N/mm^2.

J Deformed bar anchors shall be to ASTM A496 with a minimum tensile strength of 552 N/mm^2 and a minimum yield strength of 483 N/mm^2.

2.03 Manufactured Units

A Ladders
1 material: stainless steel ASTM, type 316, Grade A or galvanized steel as scheduled, or aluminium, Grade 6082 (HE - 30) to BS 1472 as indicated,
2 rails: minimum sizes as detailed on Drawings,
3 minimum distance from centreline of rungs to wall: 200 mm,
4 rung spacing: uniform, maximum 300 mm and top rung level with top platform,
5 design to support minimum 140 kg concentrated vertical load with 70 kg concentrated horizontal load. Maximum allowable stresses as per AISC Specification of AA specification. Maximum lateral deflection: side rail span/300,
6 provide ladder cage where shown on the Drawings. Cage construction shall be as follows:
a hoops: minimum 6 mm x 50 mm bar,
b vertical bars: minimum 4 mm x 40 mm bars,
c all connections shall be constructed from same material as ladder,
7 designed in accordance with OSHA standards and applicable codes,
8 construction: fully welded type and all welds to be full penetration welds,
9 ladder accessories:
a telescoping tubular steel section that automatically locks into place when fully extended,

b accessories shall be constructed from same material as ladder,
c corrosion-resistant spring,
d factory assembled with all hardware necessary for mounting to ladder where indicated on the Drawings.

B Abrasive Stair Nosings
1 two component consisting of an embedded sub-channel, installed with concrete pour, and an abrasive tread plate to be installed later,
2 6063-T5 extruded aluminium, mill finished and heat-treated,
3 complete with concrete anchors and tread plate securing screws,
4 units: 100 mm less in length than stair width.

C Stairs - Grating: Fabricated as indicated
1 grating treads as specified with exception that nosing shall have integral corrugated non-slip edge,
2 landings: Grating as specified,
3 fabricate and design stair, landing assembly and connections to support a 450 kg concentrated, moving load or 5 kN/m^2 uniform live load, whichever requires the stronger component,
4 fabricate and design stair components in accordance with NAAMM Metal Stairs Manual,
5 design, fabricate, and install in compliance with applicable codes,
6 material: aluminium alloy 6061-T6.

D Steel Checkered Plate
1 conform to ASTM A786 with diamond pattern no. 3 (large) or no. 4 (medium) but only use one pattern throughout the project. The material shall have $165N/mm^2$ minimum yield strength,
2 design live load capacity unless noted otherwise, 5 kN/m^2 with maximum deflection of 1/300 of span under a superimposed live load of 2.5 kN/m^2,
3 reinforce as necessary with steel angles,
4 plate sections: maximum 1000 mm wide and minimum 6 mm thick,
5 provide joints at centre of all openings unless shown otherwise. Reinforce joints and openings with additional angles to provide required load carrying capacity,
6 unless shown otherwise, frame for opening for steel checkered plate:
a steel angles 40 x 40 x 6 mm minimum size having 8 mm dia x 150 mm long steel anchor bolts spaced at maximum of 600 mm OC along each side with not less than two anchor bolts per side,
b Drill and tap frame to receive 8 mm dia steel cap screws at not more than 600 dmm OC with not less than two screws per side,
7 provide galvanized checkered plate and edge supports unless noted otherwise.

E Aluminium Checkered Plate:
1 conform to ASTM B632: Diamond pattern: Use one pattern throughout project and material type 6061-T6,
2 design live load capacity unless noted otherwise, 5 kN/m^2 with maximum deflection of 1/300 of span under a superimposed live load of 2.5 kN/m^2,
3 reinforce as necessary with aluminium angles,
4 plate sections. maximum 1000 mm wide and minimum 6 mm thick,
5 provide joints at centre of all openings unless shown otherwise. Reinforce joints and openings with additional angles to provide required load carrying capacity,
6 unless shown otherwise, frame for openings for aluminium checkered plate:

a aluminium angles 40 x 40 x 6 mm minimum size having 8 mm dia x 150 mm long steel anchor bolts spaced at maximum of 600 mm along each side with not less than two anchor bolts per side,
b drill and tap frame to receive 8 mm dia aluminium cap screws at not more than 600 mm OC with not less than two screws per side.

F Aluminium Grating: Fabricate in accordance with NAAMM Metal Bar Grating Manual.
1 minimum depth: 38 mm,
2 minimum rectangular bar size: 5 mm thick,
3 minimum I-bar flange width: 6 mm,
4 allowable superimposed live load: Not less than 10 kN/m^2 with a maximum deflection of 6 mm under a superimposed live load of 5 kN/m^2,
5 cross bars: welded, swaged or pressure locked to bearing bars,
6 top edges of bars: serrated,
7 grating sections: not wider than,
8 standard mill finish,
9 ends and perimeter edges: banded,
10 openings through grating: reinforced to provide required load carrying capacity and banded with 100 mm high toe plate,
11 provide openings at joints between individual grating sections,
12 clips and bolts: stainless steel.

G Manhole and Valve Covers and Frames
1 Covers and frames shall be manufactured from ductile iron complying with BS 2789 and seatings shall be designed to be non-rocking.
2 Castings shall be smooth, true to pattern and free from projections, sandholes, blow holes or other distortions.
3 They shall meet or exceed minimum wheel loading requirements as defined for the specified grade test load in accordance with BS EN 124: 1994. “Heavy duty cover” means the cover is capable of a Grade A (BS EN 124: 1994) test load. “ Medium duty cover” means the cover is capable of Grade B, Class 2 (BS EN124: 1994) test load. “Light weight cover” means the cover is capable of a Grade C (BS EN 124: 1994) test load. In general, all covers and frames used in the Works shall be heavy duty unless otherwise detailed and or directed by the Engineer and shall be single sealed with two vent holes of 5 mm. Key holes shall be of the closed type.
4 The frame shall be square with a minimum clear opening of 600 mm diameter or, as sized on the Drawings, and shall be fixed to the manhole shaft by four 16 mm diameter stainless steel nuts on a threaded rod in a regular pattern. The frame shall be notched to accommodate the bolts. Contact surface between cover and frame shall be greased with heavy duty grease prior to the fitting of the cover.
5 Covers shall have marked clearly on them the BS no./ the grade/ manufacturer’s name and name of service "WATER", "SEWER" or "STORMWATER". Covers and frames shall be grit blasted and coated with a suitable heavy duty abrasion resistant epoxy paint to a minimum Dry Film Thickness (DFT) of 400 microns.
6 The Contractor shall supply one prying and lifting bar with each 20 covers (minimum of one tool for every type cover). Prying and lifting bars shall be of approved appropriate design to match the different cover configurations.
7 The Contractor shall furnish to the Engineer, manufacturer’s certificates certifying compliance of the cover and frames to the specification.

H Miscellaneous Products
1 Grates and frames for horizontal stormwater gullies shall be made of cast iron in accordance with the requirements of BS EN124:1994 and the dimensions given on the

Drawings. Castings shall be of sound manufacture, free from voids or projections and treated with two coats of an approved rust proofing compound such as Inertol thick L or approved equal.

I Heavy-duty Castings, Trench Covers, and Accessories:
1 prefabricated, ASTM A48 or A536,
2 design load: AASHTO HS-20 wheel loading for indicated span,
3 machine horizontal mating surfaces.

J Step irons
1 material: galvanized malleable cast iron to BS 1247 or stainless steel to BS 1247.
2 shall be staggered 250 mm long and 150 mm wide and shall be spaced 300 mm horizontally and 225 m vertically,
3 shall not be used for moving or lifting any precast rings or segments to which they are fixed.

2.04 Shop Primers

A Primers selected shall be compatible with finish paints and in accordance with Sections 09900 and 09870.

B Aluminium shall have mill finished unless scheduled or otherwise specified or, if approved, finished in manufacturer's standard. Coat surfaces in contact with dissimilar materials as specified in Sections 09900 and 09870.

2.05 Fabrication- General

A For the manufacture of metal fabrications which will be exposed to view, use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness. Remove such blemishes by grinding, or by welding and grinding, prior to cleaning, treating and application of finishes including zinc coatings.

B Use materials of the size and thickness shown, of the required size and thickness to produce adequate strength, close and durability in the finished product for the intended use. Work to the dimensions shown or approved on shop drawings, using proven details of fabrication and support. Use the type of materials specified for the various components of work.

C Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 1 mm unless otherwise shown. Form bent metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.

D Verify dimensions by accurate field measurement before fabrication wherever work adjoins other work that precedes it in construction. Allow for trimming and fitting of metal fabrication work wherever the taking of field measurements before fabrication might delay the work. On shop drawings, note which dimensions have been verified by field measurement.

E Weld corners and seams continuously and in accordance with the recommendations of AWS. Grind exposed welds smooth and flush, to match and blend with adjoining surfaces.

F Form exposed connections with hairline joints which are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type shown, or if not shown, use Phillips flat-head (countersunk) screws or bolts.

G Pre-drill bolt and/or screw holes as shown and as required for attachment of metal fabrication work and for the attachment of adjacent materials prior to galvanising.

H Furnish inserts and anchoring devices which must be set in concrete or built into masonry for the installation of metal fabrication work. Co-ordinate delivery of such devices with other work so as to avoid any delay.

I Provide for anchorage of the type shown, co-ordinated with the supporting structure and the construction program. Fabricate and space anchoring devices as required to provide adequate support.

J Cut, reinforce, drill and tap metal fabrication work as may be required to receive finish hardware and similar items of work.

K Use hot-rolled steel bar for work fabricated from bar stock, except where shown or specified to be fabricated from cold-finished or cold-rolled stock.

L Pre-assemble work at shop to the greatest extent possible, so as to minimize field splicing and assembly of units at the project site. Disassemble units only to the extent necessary to comply with shipping limitations. Mark units clearly for reassembly and proper installation.

M Where shown as galvanized, complete the shop fabrication prior to application of the coating. Remove mill scale and rust, clean and pickle the units as required for coating. Apply hot-dip zinc coating of 0.6 kg/m^2 in accordance with ASTM A 123.

2.06 Fabrication - Specific Items

A Miscellaneous Trim:
1 provide shapes and sizes as required for the profiles shown,
2 except as otherwise noted, fabricate units from structural steel shapes, plates and steel bars, with continuously welded joints and smooth exposed edges,
3 use concealed field splices wherever possible,
4 provide cutouts, fittings and anchorages as required for co-ordination of assembly and installation with other work.

B Railings and Handrails:
1 provide railings and handrails of designs and dimensions shown, with smooth bends and welded joints ground smooth and flush,
2 comply with ANSI A12.1 and ANSI A58.1 for railings around floor openings and exposed edges of floors, stairs, ramps, etc. and similar locations,
3 provide handrails on walls at stairs and similar locations as required by ANSI A12.1,
4 installed railings, and supports, shall withstand a 110 Kg. load applied at any point, downward or horizontally or 75 Kg/m along the top rail, whichever is greater,
5 complete with all sleeves, brackets, bolts and fastening devices as required for a complete installation.

C Edge Angles and Seating Angles:
1 provide edge angles or seating angles of size as shown on the Drawings with welded-on strap anchors 600 mm on centres,

2 install angles in as long lengths as possible. Mitre and weld corners and provide splice plates for alignment between sections,
3 trench covers:
a provide removable galvanized steel, medium duty checkered plate covers minimum of 6 mm thick with sunken handles over HT and LT trenches complete with angles, junctions, etc.,
b provide angle frames and anchors as required to support plate covers.

D Duct Covers
1 covers shall be manufactured by Glynwed Brick House or other equal and approved.,
2 covers shall be of cast iron with concrete grade 35 in-filling unless otherwise specified,
3 cover and frame manufactured in 2 mm stainless steel,
4 shall be capable of supporting a 3000 kg wheel load,
5 covers shall, preferably, be single span but multi-span with intermediate beams are acceptable on larger openings,
6 covers and frames shall have edging strips and keyhole extensions of brass for floor finishes when provided in floors inside buildings.

E Roof and Floor Access Hatches
1 roof and floor access hatches shall be of approved manufacturer and shall be suitable for mounting on a concrete slab with exterior aluminium panels over the insulation,
2 access hatches shall be furnished and installed as shown on the Drawings and shall be aluminium,
3 locks, where required, shall be suited with the door locks,
4 drains shall be installed as required.

F Car Park Shade Canopies
1 fabricate canopies from structural steel cantilevered frames and hollow steel box section rails and purlins as indicated on the Drawings,
2 fix steel framework to concrete substrate with requisite fixing devices,
3 provide all trim as required,
4 shop prime the complete assembly prior to erection.

2.07 Shop Painting

A Clean, treat and paint metal fabrications work in the shop prior to delivery to the project site, except for work which has been hot-dip galvanized after fabrication. Include all surfaces, inside and out, whether exposed or concealed in the construction.

2.08 Fully Concealed Items

A Clean steel and wrought iron work by "Solvent Cleaning" method specified in SSPC-SP 1-63, followed by "Hand Tool Cleaning" to remove loose mill scale and rust by methods specified in SSPC-SP 2-63. Apply paint as per system A section 09870.

2.09 Exposed Interior Items

A Clean and paint work which is not accessible to foot traffic, floor cleaning operations or hand contact, as specified for "Fully Concealed Work", except that mill scale and rust which would result in visible roughness must be removed and the surfaces must be made smooth before painting.

B Apply the following cleaning, treatment and painting to interior work which is exposed (or partially exposed), and is subject to foot traffic, floor cleaning operations or hand contact by the building occupants.

1 clean by "solvent cleaning" method specified in SSPC-SP 1-63, followed by "hand tool cleaning" by method specified in SSPC-SP 2-63 or "power tool cleaning" by method specified in SSPC-SP 3-63 to remove loose mill scale and rust. "Pickle" by methods specified in SSPC-SP 8-63 to remove all remaining mill scale and rust. Grind rough surfaces as may be necessary to provide smooth metal surfaces. Tool cleaning and pickling may be omitted from work fabricated from cold-rolled or cold-finished stock and from castings, provided the surfaces are not heavily rusted.

2 Apply pre-treatment to inhibit corrosion and improve paint adhesion, by methods specified in SSPC-PT 2-64 for "cold phosphate" treatment.

3 Apply prime coat of metal primer paint as soon as possible after pre-treatment. Provide a smooth coat, with uniform dry film thickness of 0.05 mm.

Part 3 Execution

3.01 Condition of Surfaces

Examine the substrate and conditions under which the work is to be installed. Do not proceed with the installation until satisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.02 Installation

A Set metal fabrication work accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels.

B Anchor securely as shown or as required for the intended use, using concealed anchors wherever possible. Fastenings to wooden plugs will not be permitted. Drill holes for bolts to the exact diameter of the bolt, using a rotary drill for concrete and a percussion drill for masonry.

C Where pipe sleeves are used to support miscellaneous iron work, anchor sleeve securely to supporting concrete or structure to provide rigid support. Pipe sleeves shall be of galvanized steel of size shown and adequate to meet the requirements.

D Fit exposed connections accurately together to form tight hairline joints.

1 weld connections which are not to be left as exposed joints, but cannot be shop welded because of shipping size limitations,

2 grind joints smooth and touch up shop paint coat,

3 do not weld, cut or abrade the surfaces of exterior units which have been hot-dip galvanized after fabrication, and are intended for bolted or screwed field connections.

E Deliver items which are to be built into the work of other sections in time so as not to delay the progress of work.

F Leave work exposed to view clean, smooth and neatly finished.

END OF SECTION 05500

DIVISION 6.

WOODS AND PLASTIC

Section 06100

Carpentry

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with rough and finished carpentry work.

1.02 Requirements of Regulatory Agencies

Treat those items required by applicable codes to be treated and those items shown or specified as "Fire Retardant Treated Wood".

1.03 Submittals

A Certification of Wood Preservative Treatment shall state:
1 name of preservative used,
2 retention in kg/m^3 of lumber treated,
3 treated material conforms to drying time and surface deposit requirements of FS TT-W-572, and
4 for water borne preservative treated materials, the moisture content after treatment does not exceed 15 percent.

B Certification of Fire Retardant Treatment shall include:
1 name of fire retarding materials used,
2 compliance with local building code requirements and with AWPA Specification. C1 and C20 for lumber and C27 for plywood, and
3 fire retarding materials will not bleed through painted surfaces.

C Shop Drawings shall include: large scale details, dimensioned plans, elevations, and adjacent work of other trades; details of anchorages, fixing methods, grain direction, joints, shims, trim, etc.; extent of detailing and scales required shall be approved by the Engineer prior to commencing the shop drawings.

D Samples of each type of finished carpentry items shall be provided

1.04 Quality Assurance

A Lumber shall be new, sound, kiln-dried and seasoned, well manufactured and free from bows, twists, crooks and waves that cannot be corrected during bridging or milling. All stock shall be dressed all four sides allowing true surface for attachment of finished work.

B The grade and trademark shall be provided on each piece of lumber (or bundled stock) and only the recognised official marks of association under whose rules it is graded shall be used.

C Except for blocking in adjacent to finish mill-work, moisture content shall not exceed 19 percent for lumber, 12 percent for plywood and 5 percent for blocking adjacent to finish mill-work.

D The American Lumber Standard (PS-20-70) of the US. Department of Commerce shall govern finished lumber sizes. Cross-sectional sizes of lumber expressed herein are nominal unless accompanied by a fraction or noted otherwise. Other dimensions expressed herein are to be regarded as actual.

1.05 Qualifications

The work of this Section shall be executed by an approved specialist Sub-Contractor having a minimum of five years experience on projects of similar size and quality to that specified and shown.

1.06 Delivery, Storage and Handling

Where sequences of operations permit, no interior lumber material shall be delivered until work containing excessive water has been completed at least ten calendar days. Materials shall be stacked to ensure ventilation and drainage. Lumber shall be protected from the elements and against dampness during and after delivery. It shall be stored under cover in a well-ventilated area of the building. Finished carpentry work shall be stored in a dry, well ventilated and air-conditioned space, matching the conditions of the finished installation.

1.07 Protection

Finished carpentry work shall be protected during transit, delivery, storage and handling to prevent damage and shall be kept covered with protective wrapping.

1.08 Environmental Conditions

Do not install finish carpentry work in any space until wet work in such space is dry to the satisfaction of the installer.

Part 2 Products

2.01 Rough Carpentry - Materials

A General:

1 lumber grading shall comply with “Simplified Practice Recommendations PS-20, American Softwood Lumber Standards " by U.S. Department of Commerce, and with the applicable lumbermen association rules,
2 plywood grading shall comply with ANSI A199.1,
3 Each piece of lumber shall be factory marked with the official grade mark of the appropriate association or authorised inspection service,
4 dimensions on the Drawings designate the nominal undressed size of the item and lumber shall be provided which is dressed S4S and worked to such patterns as shown or specified,
5 Lumber shall be provided which has been seasoned by drying to a moisture content not to exceed 19 percent.

B Lumber for general use shall be 200f grade of any species. For grounds lumber shall be no. 2 grade Douglas Fir, nailers and Southern Pine blocking, cants.

C Plywood shall be Backer-Structural I, Douglas Fir boards, etc. with C-D Veneers.

D Anchors and Fasteners:
1 bolts, nuts, studs. FS FF-B-571 and FF-B-575,
2 expansion shields. FS FF-S-325; group, type, class and style best suited for the purpose,
3 lag screws and bolts. FS FF-B-561, type and grade best suited for the purpose.
4 nails. FS-FF-N-105, type and size best suited for the purpose Hot dipped galvanized for exterior,
5 toggle Bolts. FS FF-B-588, type and class best suited for the purpose,
6 wood screws. FS FF-S-111; style best suited for the purpose and hot dipped galvanized for exterior,
7 power-driven fasteners may be used if permitted by the Engineer.

E Steel Plates and Shapes. ASTM A36, galvanized for exterior use.

F Shop primer for metals shall be zinc chromate primer with a synthetic resin carrier.

G Preservative Treated Wood.
1 wood to be treated shall be wood embedded in, or in contact with, either concrete, masonry or plaster; wood plates, cants, curbs, cleats and nailing strips in connection with waterproofing, roofing and flashing,
2 preservative material shall be: water-borne complying with AWPB LP-2 for use above ground and AWPB LP-22 for ground contact use or oil-borne complying with AWPB-LP-4 for use above ground and AWPB-LP-44 for ground contact use,
3 pressure treat in a closed retort by vacuum-pressure process in compliance with AWPA C-2 and AWPA C-9 for plywood,
4 do not use creosote preservative.

H Fire Retarding Treated Wood:
1 fire-retarding chemicals shall be provided as required to suit the relative humidity and to achieve a flame spread rating not higher than 25. They shall comply with AL Test 723 and shall not contain halogens or sulphates,
2 wood shall be treated to meet Building Code requirements and AWPA Specification C1 and C20 for lumber and C27 for plywood as a minimum. Fire retarding materials shall be guaranteed not to bleed through painted finish,
3 wood shall be sized before treatment so that minimum cutting will be required after treatment.

2.02 Finish Carpentry - Materials

A General:
1 in addition to requirements shown as specified, materials shall comply with applicable provisions for grading and workmanship of AWI “Quality Standards”,
2 provide lumber surfaced 4 sides (S4S) and worked to profiles shown,
3 kiln-dry lumber to moisture content recommended by the AWI Section 100-G-3.

B Lumber shall comply with AWI Section 100 with the following requirements:
1 hardwood for opaque finish: any hardwood which, when finished, will not show any grain, imperfection of other surfaces defects when used with the opaque finish specified,
2 hardwood for concealed framing and blocking: economy grade, any species,

3 hardwood for natural finish: premium grade or select Burma Teak (Tectona Gradis) as shown.

C Plywood shall comply with AWI Section 200 veneer core or lumber core unless otherwise specified and with the following requirements:
1 premium grade hardwood, Section 200-3, face veneers as shown or specified,
2 premium grade softwood, Section 200-2, face veneers as shown or specified,
3 plywood edges shall be banded with hardwood in accordance with Premium Grade, Section 1440-8,
4 provide special banding where shown.

D Face veneers for opaque finish shall comprise any hardwood veneer that, when finished, will not show any grain, imperfection or other surface defects when used with the opaque finish. Face veneers for natural finish shall be of teak.

E For natural finish provide natural finish (clear finish) for items designated to receive clear finish and for opaque finish provide painted finish for items designated to receive painted finish as specified in Section 09900. For unexposed wood finish use alkyd type primer-sealer.

F Fasteners
1 wood screws shall be FF-S-111, type, size, material and finish as required for the condition of use,
2 nails shall be FS FF-N-105, type, size, material and finish as required for the condition of use,
3 anchors shall be of type, size, material and finish suitable for the condition of use.

G Sealants for joint sealing as specified in Section 07920.

2.03 Fabrication - General

A Lumber framing and fastening devices shall be provided as required for a rigid installation. All fabrications shall be made from field measurements with provision for scribing as required to meet built-in conditions and shall be coordinated with the work of other trades.

B Details indicate the required type and quality of construction and modifications to conform to manufacturer's standards will be considered providing they comply with the Contract Documents. Profiles shall be maintained as shown and are subject to acceptance by the Engineer.

C The work shall comply with AWI Section 1500, Premium Grade for sanding, filling countersunk fasteners, back priming and similar preparations for the finishing of architectural woodwork.

Part 3 Execution

3.01 Conditions of Surfaces

The Contractor shall examine substrata, adjoining construction, and conditions under which the Work is to be installed and the work shall not proceed until unsatisfactory conditions have been corrected.

3.02 Installation

The Contractor shall:

1 whenever rough carpentry is fitted to other work obtain measurement of such other work,
2 coordinate installation with the work of other trades to ensure exact fit and perfect alignment,
3 verify dimensions before proceeding and obtain measurements at job site for work required to be accurately fitted to other construction,
4 install work plumb, level, true and straight with no distortions,
5 provide shims as required,
6 cutting, trimming, fitting and matching of pre-finished work will not be permitted,
7 where cutting is required, scribe to fit adjoining work so as not to damage finished surfaces,
8 securely fasten finish carpentry work items to blocking with concealed fasteners only. Where surface nailing is required, countersink and fill flush with the woodwork so that the finished heads are undetectable.

B Rough framing shall:

1 fit closely, and be set accurately to required lines and levels,
2 be secured rigidly in place in accordance with details and good practice,
3 use shims of slate or galvanized steel for levelling wood members on concrete or masonry.
4 be cut and fit to accommodate other work as required and in a neat workmanlike manner,
5 be nailed in accordance with Housing and Home Finance Agency, publication "Technique of House Nailing".

C Grounds shall be provided for securing wood trim and other items in plaster work and be installed rigidly, true to line and dimension. The size shall be 38 mm by thickness required to finish flush with surface of plaster or as shown or required.

D Cant strips shall be continuous, cut with square ends, in as long lengths as possible and be secured by nailing to previously installed blocking or nailers.

E For repair of treated wood surfaces two heavy brush coats of the same wood preservative material shall be applied to surfaces exposed by sawing, cutting or drilling complying with AWPA-M-4. Any surfaces, which are cut after treatment, shall have an application of heavy brush coat of same fire retarding chemicals.

F Rough hardware and ferrous metal shall be primed with the specified paint. Fire retarding treated wood shall be painted with one coat of alkyd type paint or a moisture transmission resistant coating immediately.

3.03 Protection

Protect finished carpentry work so that it will be without damage at the time of completion of the Works. Damaged or soiled surfaces, panels, etc. shall be removed and replaced to the satisfaction of the Engineer.

END OF SECTION 06100

Section 06400

Architectural Woodwork

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Architectural Woodwork.

1.02 Requirements of Regulatory Agencies

The Contractor shall treat those items required by applicable codes and those items shown, or specified, as "Fire Retardant Treated Wood".

1.03 Submittals

A Shop drawings shall include large scale details, dimensioned plans, reflected ceiling plans and elevations, adjacent work of other trades, details of anchorages, fixing methods, grain direction, joints, shims, trim etc. and shall be submitted as specified in Section 013000 hereof.

B Samples of each of the following items shall be provided:
1 plastic laminate, 300 mm square, including outside corner of various colours for selection by the Engineer,
2 opaque finish (lacquer) wood veneer laminated to plywood, 300 mm square for each colour, gloss and finish specified (for alternative finish if opted for use),
3 metal trim, 200 mm long, type and finish as specified,
4 timber used for clear finish: 300 x 300 mm size,
5 hardware exposed in the finished work (stainless steel),
6 samples of any other materials specified and as required by the Engineer.

C Certification of fire retardant treatment shall include:
1 name of fire retardant materials used,
2 compliance with local building codes and with AWPA Specification C1 and C20 for lumber and C27 for plywood,
3 fire retardant materials will not bleed through painted or natural finish surfaces.

1.04 Qualifications

The work of this Section shall be executed by an approved specialist subcontractor having a minimum of five years experience on projects of similar size and quality to that specified and shown. The Engineer shall have the right to inspect the fabricator's workshop prior to approval of the proposed subcontractor.

1.05 Mock-ups

Following approval of samples, a full size visual mock-up of the decorative screens and ceilings, simulating final conditions, shall be constructed and located where directed. Full size mock-ups of balustrade handrail and wall handrail including brass/chromium plated trims and methods of fixation shall be constructed. The mock-ups, when approved, may be used in the final work.

1.06 Environmental Conditions

Architectural woodwork shall not be installed in any space until wet work in such space is dry to the satisfaction of the installer and building mechanical system can maintain the relative humidity and temperature so that the woodwork will not be damaged by excessive changes.

1.07 Protection

Architectural woodwork shall be protected during transit, delivery, storage and handling to prevent damage and shall be kept covered with protective wrapping. Architectural woodwork shall be stored in a dry, well-ventilated and air-conditioned space, matching the conditions of the finished installation.

Part 2 Products

2.01 Wood

A General
1 in addition to requirements shown and specified, material shall comply with applicable provisions for grading and workmanship of AWI "Quality Standards",
2 provide lumber surfaced four sides (S4S) and worked to profiles shown,
3 kiln-dry lumber to moisture content recommended by the AWI Section 100-G-3.

B Lumber shall comply with AWI Section 100 and with the following requirements:
1 hardwood for opaque finish: any hardwood which, when finished, will not show any grain, imperfection or other surface defects when used with the opaque finish specified,
2 hardwood for concealed framing and blocking: economy grade, and species,
3 Hardwood for natural finish: premium grade, select Burma teak (Tectona Grandis) and oak as shown.

C Plywood shall comply with AWI Section 200; veneer core, or lumber core unless otherwise specified and with the following requirements:
1 premium grade hardwood, Section 200-3, face veneers as shown or specified,
2 premium grade softwood, Section 200-2, face veneers as shown or specified,
3 plywood edges shall be banded with hardwood in accordance with premium grade, Section 400-8. Where natural finish is specified provide oak edges,
4 provide special banding where shown.

D Hardwood shall be teak, selected by the Engineer, for lacquered finish.

E Face Veneers for opaque finish shall comprise any hardwood veneer that, when finished, will not show any grain, imperfection or other surface defects when used with the opaque finish specified. Face Veneers for natural finish shall be teak veneers.

F For natural finish provide natural finish (clear finish) for items designated to receive clear finish, as specified in Section 09900. For opaque finish for alternative works (lacquer) polish finished substrates to eliminate marks and sander scratches and wipe clean prior to application of coats as follows. The total dry film thickness shall be between 75-125 microns:

1 first coat shall be alkyd resin, nitrocellulose lacquer base, 65 percent solids, opaque undercoat with colour best suited to achieve final colour appearance of subsequent coats, with a cold cycle of 16,
2 second coat shall be opaque lacquer, nitrocellulose plasticizer base, 45 percent solids with colour and specular gloss selected by the Engineer with a cold check of 20,
3 third coat shall be clear catalysed lacquer, alkyd urea base modified nitrocellulose resin, 26 percent solids and specular gloss as selected by Engineer with a cold check of 15,
4 unexposed wood finishes shall be alkyd type primer-sealer.

G Fire Retardant Treated Wood
1 fire retardant materials shall meet the requirements of AWPA P10,
2 wood shall be treated to meet requirements of AWPCA C1 and C20 for lumber and C27 for plywood as a minimum. Fire retardant materials shall be guaranteed not to bleed through painted finish or natural finish,
3 after fire retardant treatment, kiln dry to the moisture content specified herein,
4 wood shall be fabricated before treatment, wherever possible, and disassembled for treatment, so that cutting and jointing will not be required after treatment. A heavy brush coat of the same fire retardant chemicals shall be applied to any surfaces which are cut after treatment.

2.02 Plastic Laminate

Face sheets shall be to NEMA Publication LD3, Grade GP50, Type 1; 1.6 mm thick; satin finish unless otherwise shown; and colour as selected. Backing sheets shall be non-decorative; high pressure plastic laminate; NEMA LD3, Grade BK20; and 0.8 mm thick. Edges shall be finished with plastic laminate to match face and which shall be fixed before face sheets are applied, unless otherwise shown or specified.

2.03 Metal

A Structural steel shapes and plates shall be to ASTM A36 and shall be galvanised where shown or required in accordance with ASTM A386 or other approved standards.

B Stainless steel shall conform to A1S1 Type 317.

C Brass shall be polished brass sheet, alloy 230 complying with ASTM B36.

2.04 Miscellaneous Products

A Fasteners
1 wood screws shall be FF-S-111, type, size, material and finish as required for the condition of use,
2 nails shall be FS FF-N-105, type, size, material and finish as required for the condition of use,
3 anchors shall be of type, size, material and finish as required for the condition of use.

B For laminating plastic laminate surfaces, adhesives shall be melamine; phenol-resin, or resorcinol-resin complying with FS MMM-A-81 of a type, grade and class best suited for the purpose. For all other uses, adhesives shall be moisture resistant; comply with FS MMM-A125 type II, or MMA-A-188, type I, II or III, type best suited for the purpose.
C Joint Fillers shall have back up rods for sealants as specified in Section 07910 hereof.
D Sealants for joint sealing as specified in Section 07920 hereof.

2.05 Fabrication - General

A Provide lumber framing for architectural woodwork, complete with all bracing and fastening devices as required for a rigid installation and as required to sustain the imposed loads. All fabrication shall be done from field measurement with provision for scribing as required to meet built-in conditions.

B The work of this Section shall be coordinated with the work of other trades.

C Units shall be fabricated in the largest practicable sections, assembled in the shop for trial fit and disassembled for shipment and reassembled with concealed fasteners.

D The relative humidity and temperature shall be maintained during fabrication, storage and finishing operations, matching that of the areas of installation.

E Details shall indicate the required type and quality of construction. Modifications to conform to manufacturer's standards will be considered providing they comply with the Contract Documents, and, at no additional cost to the Employer. The profiles shown shall be maintained and be subject to acceptance by the Engineer.

F Reinforcing shown is a minimum and additional reinforcing shall be provided as required to ensure a rigid assembly. Exposed surfaces shall be free from dents, tool marks, warpage, buckle, glue and open joints, or other defects affecting serviceability or appearance. All joints, corners and mitres shall accurately fit. All fasteners shall be concealed and threaded connections shall be made up tight so that threads are entirely concealed.

G Welding and brazing shall be of adequate strength and durability with joints tight and flush, smooth and clean. All exposed surfaces shall be ground and finished flush, free of weld marks. Welds or brazes on finished surfaces shall be indistinguishable from parent metal.

H Factory finishes all items where possible and defers finish touch-up, cleaning and polishing until after delivery and installation. Provide finishes as shown or specified.

J Work shall comply with AWI Section 1500 with premium grade for sanding, filling countersunk fasteners and back priming and similar preparations for the finishing of architectural woodwork.

2.06 Fabrication - Specific Items

A Skirtings shall be fabricated in as long pieces as practicable with minimum joints and joints shall be neatly and accurately made in the running length and with mitre corners.

B Decorative screens shall be fabricated to the details and patterns shown on the Drawings.

C Decorative ceilings shall be fabricated to the details and patterns shown on the Drawings.

D Wall handrails and balustrade handrails shall be fabricated to the details shown on the Drawing.

Part 3 Execution

3.01 Installation

A The Contractor shall:
1 coordinate installation with the work of other trades to ensure exact fit and perfect alignment, especially for items to be set in the vanity tops,
2 verify dimensions before proceeding and obtain measurements at job site for work required to be accurately fitted to other construction,
3 install work plumb, level, true and straight with no distortions providing shims as required,
4 cutting, trimming, fitting and matching of pre-finished work will not be permitted,
5 where cutting is required, scribe to fit adjoining work so as not to damage finished surfaces,
6 securely fasten architectural woodwork items to blocking with concealed fasteners only. Where surface nailing is required, countersink and fill flush with the woodwork so that the finished heads are undetectable.

B Decorative screens and ceilings shall be installed as shown, with adequate concealed supports from building structure. Install units inline, co-ordinating with other components and with all related trades. Install miscellaneous trim as shown.

C Balustrade handrails shall be installed to steel supports cast into concrete as detailed. Wall handrails shall be installed to steel brackets bolted to walls as detailed. Units shall be installed in line, co-ordinating with other components and all related trades.
D Finishings shall be applied to items as indicated and as specified in Section 09900.

3.02 Protection

A Protect architectural woodwork so that it will be without damage at the time of completion of the Works. Damaged or soiled surfaces shall be removed and replaced to the satisfaction of the Engineer.

END OF SECTION 06400

Section 06610

Fibreglass Reinforced Plastic Fabrications

Part 1 General

1.01 Description

The work included in this section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with fibre reinforced plastic fabrications.

1.02 Submittals

A Product data shall include manufacturer's catalogue data showing dimensions, spacings, and construction details; design tables showing limits for span length and deflection under various uniform and concentrated loads; materials of construction.

B Shop drawings shall detail fabrication and erection of each FRP fabrication including plans, elevations, sections, and details of FRP fabrications and their connections, anchorages and accessory items.

C Samples of each type of FRP product proposed shall be submitted for approval.

1.03 Quality Assurance

A Material covered by these specifications shall be furnished by a reputable and qualified manufacturer of proven ability who has regularly engaged in the manufacture and installation of FRP systems and shall be approved by the Engineer.

B Fabricator shall be a firm experienced in successfully producing FRP fabrications similar to that indicated for this project, with sufficient production capacity to produce required units without causing delay in the work.

C Substitution of any component or modification of system shall be made only when approved by the Engineer and at no additional cost to the Employer.

D In addition to requirements of these specifications, the Contractor shall comply with manufacturer's instructions and recommendations for work.

1.04 Delivery Storage And Handling

A All systems, sub-systems and structures shall be shop fabricated and assembled into the largest practical size suitable for transporting.

B All materials and equipment necessary for the fabrication and installation of the grating, stair treads, handrails, ladders, weir plates, linings and structural shapes shall be stored in a manner to prevent cracking, twisting, bending, breaking, chipping or damage of any kind to the materials or equipment, including damage due to over exposure to the sun.

C Any material which, in the opinion of the Engineer, has become damaged as to be unfit for use shall be promptly removed from the site of work and the Contractor shall receive no compensation for the damaged material, or its removal.

D All materials, items and fabrications for installation and field assembly shall be identified and match-marked

Part 2 - Products

2.01 General

A The Contractor shall design, engineer, fabricate, and install the FRP fabrications to withstand the specified structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections. Each load shall be applied to produce the maximum stress in each respective component of each FRP fabrication.

B Materials used in the manufacture of the FRP products shall be new stock of the best quality, free from all defects and imperfections that might affect the performance of the finished product.

C All materials shall be of the kind and quality specified, and where the quality is not specified, it shall be the best of the respective kinds and suitable for the purpose intended.

D All FRP products shall be manufactured by a pultruded process using a vinyl ester resin with flame retardant and ultra-violet (UV) inhibitor additives. A synthetic surface veil shall be the outermost layer covering the exterior surface and FRP shapes shall achieve a flame spread of 25 or less in accordance with ASTM test method E84.

E All FRP items shall be corrosion resistant to a 5 percent concentration of either sulphur dioxide or hydrogen sulphide.

F After fabrication, all cut ends, holes and abrasions of FRP shapes shall be sealed with a compatible resin coating to prevent intrusion of moisture.

G FRP products exposed to weather shall contain an ultraviolet inhibitor and shall additionally receive 25 microns thick U.V. coating to shield from ultra-violet light.

H All exposed surfaces shall be smooth and true to form.

I Colour shall be OSHA safety yellow or grey as instructed by the Engineer.

2.02 FRP Gratings And Stair Treads

A Material
1 the material shall have a glass reinforcement content of 40 to 65 percent,
2 the glass fibre “E” type continuous strand glass mat shall comply with BS 3749,
3 fabrication shall be from bearing bars and cross rods manufactured by the pultrusion process. Bearing bars shall be minimum 25 - 40 mm deep, 15 mm wide top and bottom flanges and 4 mm web thickness.

B Design factor of safety shall be two. The maximum deflection in any direction shall not be more than span/180 and at the centre of simple spans shall not exceed 6 mm. The fabrication shall be capable of withstanding a uniform load of 4.5 kN/m^2.

C The top surface of all panels shall have non-skid grit affixed to the surface by a baked epoxy resin followed by a top coat of baked epoxy resin.

D Hold down clamps shall be stainless steel inset hold down with a minimum of four each per panel.

2.03 FRP Handrails

A Material
1 the material shall have a glass reinforcement content of 50 percent,
2 the glass fibre 'E' type continuous strand glass mat or continuous glass strand rovings shall comply with BS 3749,
3 rails and posts shall be 50 x 50 x 4 mm thick fibre glass pultruded square tube,
4 kickplates shall be 100 x 12.5 (corrugated) x 3 mm thick pultruded fibre glass shape.

B Pultruded parts shall meet the following minimum mechanical properties:

Properties	**Test Method**	**Values**
Tensile Stress	ASTM D638	207 MPa
Tensile Modulus	ASTM D638	17 GPa
Compressive Stress	ASTM D695	207 MPa
Compressive Modulus	ASTM D695	17 GPa
Flexural Stress	ASTM D790	207 MPa
Flexural Modulus	ASTM D790	11 GPa
Shear Stress	ASTM D2344	31 MPa
Density	ASTM D792	1.66 to 1.94 g/cm^3
24 hr. Water Absorption	ASTM D570	max 0.6%
Coef. of Thermal Expansion	ASTM D696	8 x 10^{-6} /°C
Flexural Stress	Full Section	248 MPa
Flexural Modulus	Full Section	25 GPa

C Design shall conform to loading requirements of OSMA 1910.23, with a minimum factor of safety of 2. Fabrications shall be capable of withstanding a concentrated load of 90 kg applied at any point non-concurrently, vertically downward or horizontally. Horizontal hand rails shall be 1000 mm high with an intermediate rail at 500 mm high.

2.04 FRP Ladders

A Material
1 the material shall have a glass reinforcement content of 50 percent.
2 the glass fibre 'E' type continuous strand glass mat or continuous glass strand rovings shall comply with BS 3749.
3 side rails shall be 50 mm x minimum 4 mm thick square tube.
4 rungs shall be 24 mm dia solid rod; at spacing of maximum 250 mm with minimum 400 mm between stringers and minimum 200 mm from adjacent walls. The top surface shall be provided with a non-slip grit surface and the rungs shall be capable of withstanding a point load of 5000 N applied at the centre.
5 safety cages shall be provided where indicated or where the distance between landings exceeds 3500 mm. Cage hoops shall conform to the following:
   a top or bottom hoop : 75 mm x 6 mm thick straps
   b intermediate hoop : 50 mm x 6 mm thick straps
   c cage traps : 50 mm x 4.5 mm thick straps spaced 225 mm on centre around the hoop

d each hoop shall be able to withstand both a tangential point load of 740 N and a vertical point load of 1200 N applied at any point on the hoop. The maximum allowable deflection at the point of application of the load shall not exceed 25 mm and there shall be no permanent deflection of the hoops after removal of the load.

6 end caps shall be moulded.

7 fixing brackets shall be at maximum 2000 mm centres and be mechanically bonded into the concrete by means of suitable lugs or stainless steel anchor bolts bonding lug. The fixing shall be capable of withstanding shear and pull-out load of 5000 N.

8 when supported horizontally over a span of one metre, with the climbing face uppermost, and with a load of 1000 N applied at the centre of the span, the ladder shall not deflect more than 15 mm at the point of application of the load, and shall show no permanent deflection after removal of the load.

B Pultruded parts shall meet the following minimum mechanical properties.

Properties	**Test Method**	**Values**
Tensile Stress:	ASTM D638	
Longitudinal direction		207 MPa
Transverse direction		48 MPa
Compressive Stress:	ASTM D695	
Longitudinal direction		207 MPa
Transverse direction		103 MPa
Flexural Stress:	ASTM D790	
Longitudinal direction		207 MPa
Transverse direction		69 MPa
Shear Stress:	ASTM D2344	
Longitudinal direction		31 MPa
Transverse direction		31 MPa
Tensile Modulus:	ASTM D638	
Longitudinal direction		17 GPa
Transverse direction		17 GPa
Compressive Modulus:	ASTM D695	
Longitudinal direction		17 GPa
Transverse direction		17 GPa
Flexural Modulus:	ASTM D790	
Longitudinal direction		11 GPa
Transverse direction		6 GPa
Shear Modulus:		
Longitudinal direction		3 GPa
Transverse direction		3 Gpa
Density	ASTM D792	1.66 - 1.94 g/cm^3
Water absorption (24 hr immersion)	ASTM D570	max 0.60%
Barcol hardness	ASTM D2583	45
Coefficient of thermal expansion	ASTM D696	8 x 10^{-6}/°C
Thermal conductivity	ASTM C177	0.5 W/mk

2.05 FRP Covers

A Material

1 composition of glass reinforced plastic with a glass reinforcement content of 50 percent,

2 glass fibre 'E' type continuous strand glass mat or continuous glass strand rovings to BS 3749,

3 thickness shall be 5 mm minimum at any point,

4 structural decking units produced in 500 mm wide by 100 mm deep shallow trough sections,
5 vertical flanges shall incorporate a horizontal recess into which a seal and shear block is fitted,
6 to prevent ingress of water and dirt, an extruded plastic capping shall be fitted.

B The design loads shall be:
1 imposed loads : 1.5 kN/m^2,
2 personnel loads : 1.8 kN/m^2,
3 wind suction : 1.0 kN/m^2,
4 maximum deflection : L/150.

C Melded closure panels shall be provided at ends to suit installation configuration.

D Peripheral fasteners shall be grade 316 stainless steel.

2.06 FRP Weir Plate

A Material
1 composition of glass reinforced plastic with a glass reinforcement content of 50 percent,
2 glass fibre 'E' type continuous strand glass mat or continuous glass strand rovings to BS 3749,
3 minimum thickness shall be 6 mm.

2.07 FRP Lining

A Unless otherwise specified the interior concrete faces of all structures in contact with sewage or sewage gases shall be lined with a prefabricated FRP liner.

B The liner shall consist of a minimum thickness of 7 mm FRP laminate. The laminate liner base layer shall be composed of a 4 mm thickness layer with minimum 29 percent "E" glass reinforcement to a maximum 71 percent resin content. The outer layer (in contact with liquid) shall be composed of a resin rich 2 mm thick layer of approved vinyl ester with at least two layers of "C" glass veil meeting 90 percent resin to 10 percent "C" glass ratio by weight.

C FRP liner shall be shaped to match the required dimensions and configurations, as shown on the drawings, and installed in sections, as required, for proper concrete placement and FRP field jointing techniques.

D Each FRP liner shall be equipped with pre-moulded pipe openings, such that proper bonding can be obtained between the FRP liner and the pipe as otherwise specified, and as shown on the drawings.

E All field bonded FRP joints shall meet the minimum requirements of the liner and be installed such that the bond is water tight and no loss of strength occurs through the joint.

F Field applied joint strips shall be minimum 100 mm wide, 6 mm thick and composed of laminate consisting of 71 percent vinyl ester resin content to 29 percent "E" glass reinforcement.

G Prefabricated FRP liners shall have bonding lugs (concrete anchors) consisting of 100 mm long FRP strips or FRP round studs, bonded to the concrete adjacent face to each FRP panel, not to exceed 500 x 500 mm approximate spacing. The shape of each bonding lug

shall be to produce a secure bond in the cast-in-situ concrete such that the FRP liner is held firmly in place, in contact with the concrete surface, alleviating any tendency of the liner to become unbounded and "float" away from the concrete.

Part 3 - Execution

3.01 Preparation

The Contractor shall coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, including concrete inserts, sleeves, anchor bolts, and miscellaneous items having integral anchors that are to be embedded in concrete or masonry construction. Sleeves shall be set in concrete with top flush with finish surface elevations and protected from water and concrete entry.

3.02 General Installation

A For fastening to in-place construction anchorage devices and fasteners shall be provided where necessary for securing miscellaneous FRP fabrications to in-place constructions. These shall include threaded fasteners for concrete and masonry insets, toggle bolts, through-bolts, lag bolts and other connectors as required.

B Cutting, drilling and fitting shall be performed as required for installation of miscellaneous FRP fabrications. The FRP fabrications shall be set accurately in location, alignment, and elevation with edges and surfaces level, plumb, true, and free of rack and measured from established lines and levels.

C Temporary bracing or anchors shall be provided in formwork for items that are to be built into concrete masonry or similar construction.

D Items specified shall be as indicated and in accordance with manufacturer's instructions.

3.03 Workmanship

All field cut and drilled edges, holes and abrasions shall be sealed with a catalysed resin compatible with the original resin as recommended by the manufacturer. Sealing of the edges shall prevent premature fraying at the filed cut edges.

3.04 Installations of FRP Liners

A Joint strips shall be applied to the concrete side of the FRP liner on the internal faces of manholes or other sewage retaining structures.

B Immediately before taking over by the Employer, and after inspection for leakage, an additional joint strip shall be fixed on the internal face of the FRP liner.

C FRP liner shall be adequately braced and carefully handled such that excessive defections, breaking, or cracking of the liner does not occur during handling, installing and pouring concrete.

D A non-slip finish shall be paced on horizontal benching surfaces, platforms and step points by dusting the surface of the laminate with silica sand as soon as the resin has set to a soft gel. Surplus sand shall then be brushed no less than 24 hours later.

END OF SECTION 06610

DIVISION 7.

THERMAL AND MOISTURE PROTECTION

Section 07100

Waterproofing and Damp-proofing

Part 1 General

1.01 Description

A Furnish all plant, labour, equipment, appliances and materials and performing all operations in connection with sheet membrane and fluid applied waterproofing and bituminous damp-proofing

B The principal work of this Section includes, but may not be limited to:
1 application of waterproof membrane to all portions below ground and up to 300 mm above grade of tanks and structures and roofs, floors of wet rooms like toilets, kitchens and pantries etc.,
2 application of waterproofing to floors, walls and soffits of water tanks and reservoirs (internal faces), walls of wet rooms, walls of planters, etc.,
3 protective painting of concrete foundation and sunken courts in contact with soil.

1.02 Qualifications

A Waterproofing shall be executed by an approved specialist Sub-Contractor having a minimum of five years successful experience in the installation/application of the specified material. Only tradesmen experienced with the installation/application of the materials specified shall be employed.

B The manufacturer shall provide evidence indicating that the specified materials to be used have been successfully utilised on work of similar scope to that shown and specified for this Project. The waterproofing system examples cited shall have been completed and in use for a minimum two years without evidence of failure.

1.03 Submittals

A Product data shall include:
1 manufacturer's specifications,
2 installation instructions,
3 other data to show compliance with the Contract Documents.

B Shop drawings shall be prepared by the waterproofing membrane manufacturer.

C Samples of each type of following materials shall be provided:
1 self-adhesive waterproofing membrane sheets and protection boards: 300 mm square,
2 bituminous mastic: half litre container,
3 primer: half litre container,
4 fluid applied waterproofing: 300 mm square, on plywood.

D Guarantee stating that the waterproofing system installed will be waterproof and free from defects for a period of not less than ten years from date of substantial completion of the Works. In the event any leaks occur within the period stipulated, the Contractor shall, at the convenience of the Employer, effect all repairs and replacements necessary to remedy defects all to the complete satisfaction of the Engineer at no additional cost to the Employer.

1.04 Pre-installation co-ordination

After approval of all materials and prior to installation, a pre-waterproofing conference shall be held at job site. In attendance shall be representatives of Engineer, Contractor, sub-contractor and manufacturer. The parties shall review Drawings, Specifications and approved materials. They shall examine job site conditions, including inspection of structures, material labels and methods of storing materials; correct conflicts, if any, between approvals and specification requirements; confirm that all curbs and edges are provided and correctly installed; and review installation procedures, co-ordination of the work with other trades, scheduling and temperature requirements.

1.05 Final Inspection

Upon completion of the installation, an inspection shall be made by a representative of the material manufacturer in order to ascertain that the system has been properly installed. Should there be any deviation from this specification without the prior written consent of the material manufacturer, the manufacturer shall have the option of refusing the guarantee.

1.06 Delivery, Storage and Handling

A Products shall be delivered in their original, tightly sealed containers or unopened packages, all clearly labelled with the manufacturer's name, brand name, and number and batch number of the material where appropriate, type and class as applicable, and the date of manufacture and expiration (if any). Materials shall be delivered to site in ample time to avoid delay in job progress and at such times as to permit proper co-ordination of the various parts.

B Products shall be stored as directed in a neat and safe manner. The storage area shall be shaded, protected from rain and surface water, ventilated and maintained at a temperature between 10^{O}C and 24^{O}C, and shall be located away from all sources of excess heat, sparks or open flame. Containers of liquid material shall not be left open at any time in the storage area.

C Products shall be handled in a manner that will prevent breakage of containers and damage to products.

D Materials not conforming to these requirements will be rejected by the Engineer and shall be removed from the site by the applicator and replaced with approved materials, at no additional cost to the Employer.

E All safety precautions on product labels shall be observed. Containers shall not be welded, heated or drilled. All caps or bungs shall be replaced and empty containers disposed from site.

1.07 Environmental Conditions

A Bituminous damp-proofing shall not be applied during inclement weather or when the air temperature is outside the range recommended by the manufacturer.

1.08 Protection

A Waterproofing system installations shall be protected from damage during the construction period so that it will be without any indication of abuse or damage at the time of

completion. Other work damaged during waterproofing operations shall be repaired. Materials shall be prevented from running into, and clogging, drains.

B Local ordinances and fire regulations shall be complied with in the installation of hazardous materials specified or required under this section. All necessary precautions shall be taken against fire and other hazards during delivery, storage and installation of flammable materials specified herein.

Part 2 Products

2.01 Materials

Products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, will be considered acceptable but the decision of acceptability rests with the Engineer.

2.02 Waterproof Sheet Membrane

A Waterproofing membranes and associated materials shall be sourced and supplied by a single manufacturer with a minimum of ten years experience. The manufacturer shall operate a Quality System which is registered to ISO 9001.

B The waterproof membrane sheeting shall be impervious, cold applied flexible laminated sheet consisting of multi-layer, high-density, cross-laminated, polyethylene film with a backing of self-adhesive rubber bitumen compound, a combined thickness of 1.5mm and protected with silicone coated release paper. A special grade of compound formulated for hot and wet climates must be used. The total weight shall be not less than 1.6 kg/sqm gross. The membrane shall be supplied in roll form not less than 20 metres long, not less than one metre wide, wound on a rigid tube and shall, in all respects, comply with the requirements of British Code of Practice CP 102 and BS 8102.

C Performance and testing of characteristics shall be as follows:

Property	**Test Method**	**Typical Results**
Tensile strength at break - film	ASTM D638	Long 42 N/mm^2 Trans 51 N/mm^2
Tensile strength at break - membrane	ASTM D638	Long 4.2 N/mm^2 Trans 5.1 N/mm^2
Elongation at break - film	ASTM D638	Long 230%, Trans 180%
Elongation at break - compound	ASTM D638	Trans 1250%
Tear strength - film	ASTM D1004	Long 380 N/mm Trans 360 N/mm
Tear strength - membrane	ASTM D1004	Long 30 N Trans 30 N
Adhesion to primed concrete	ASTM D1000	2.0 N/mm
Adhesion to self	ASTM D1000	4.0 N/mm
Puncture resistance of membrane	ASTM E154	230 N 53 mm
Water absorption - after 24 hours	ASTM D570	0.13% by weight
Water absorption - after 35 days		1.0 % by weight
Environmental resistance	ASTM D543	Conforms
Water vapour transmission rate	ASTM E96	
at 25^{o}C, 75 % RH		0.3 g/m^2/24 hours
at 35^{o}C, 90 % RH		1.0 g/m^2/24 hours
Adhesive softening point	ASTM D36	110 ^{o}C

E Preformed asphalt board, composed of aggregate bonded in bitumen and encased between two layers of asphaltic felt shall be supplied as 3mm thick boards 1.829 metres x 0.914 metres (1.67 sq.m.) weighing approximately 6.5 kg. The boards shall be spot bonded into position with high quality solvent borne contact adhesive based on polychloroprene rubber specially formulated for hot climates to give a minimum coverage of 10 to 12 sq. metres per litre of spot bonded area.

F Prior to the application of the waterproof membrane to vertical and horizontal surfaces (except horizontal blinding), the concrete will be primed with one brush coat of compatible primer containing 50 percent aromatic hydrocarbon solvents and 50 percent bitumen solids to give an average coverage of approximately 10 to 12 sq. metres per litre, dependant on texture and porosity of concrete surface. The primer shall be compatible with the waterproofing membrane and recommended by waterproofing membrane manufacturer.

G Preformed triangular fillet shall be black triangular PVC extrusion with a wall thickness of 5mm, 40mm x 40mm coated on two faces adjacent to rounded corner with grey self-adhesive compound protected by silicone coated release paper. The angle fillet shall be provided between slabs and upstands.

H Bituminous mastic shall be cold applied gun grade rubber/bitumen mastic compound, for moulding into fillets, collars and tapes for sealing around pipes and irregularities.

I Where polyethylene sheeting is laid under slabs and floors it shall be turned up and jointed to the membrane as recommended by the specialist manufacturer.

2.03 Bituminous Damp-proofing

A Rubber bitumen emulsion shall comply with BS 3416 Type I, Class A or B. It shall be a water bound emulsion with a minimum 60 percent total solids content by volume, comprising bitumen with fine particles of rubber. Not less than 10 percent or more than 20 percent of the total solids shall be rubber. The consistency shall be such that it can be applied to the surface by brush at normal temperature comply with CP 231 for application of paint.

Part 3 Execution

3.01 Preparation

A All surfaces to which the waterproofing and damp proofing are to be applied shall be examined and application shall not proceed until unsatisfactory conditions have been corrected and approved by the Engineer. The installation of waterproofing shall be coordinated with adjacent work which shall be masked to prevent soil marks.

B The substrate shall be cleaned and prepared in accordance with the manufacturer's instructions. Concrete surfaces shall be ground and filled as required to meet tolerances specified by the manufacturer. Waterproofing shall be applied to substrate in accordance with the manufacturer's instructions.

C Waterproofing and damp proofing shall not proceed until all drains, piping, conduit, vents, ducts and other projections through the substrate have been installed.

3.02 Installation of Sheet Membrane Waterproofing

A Surfaces to which the waterproofing materials will be applied shall be surface dry, smooth and free of dirt, grease or oil and shall be free from holes, honeycombing and loose aggregate which prevent satisfactory application of waterproofing materials. All surfaces to be waterproofed shall meet the approval of the Engineer before application of waterproofing materials.

B Installation procedures shall be in accordance with the manufacturer's standards. The membrane sheet shall be installed with minimum 120 mm overlaps at edges and ends and shall be rolled down firmly and completely. If the work must be left partially complete, the exposed edges of outside strips of membrane shall be finished with a trowelled bead of mastic.

C The work shall not proceed to vertical surfaces when the outdoor temperature is less than 10^{o}C or more than 35^{o}C. If the outdoor temperature at the proposed time of application is not within the above limits, application must be delayed until the permissible temperature range prevails or another system must be submitted for approval complying with these Specifications.

D The Contractor shall coordinate the self-adhering waterproofing membrane work so that the placement of the protection board will follow the waterproofing membrane application by not more than five days.

E Over the cleaned concrete or concrete blockwork surface the primer shall be applied the manner and using quantities in accordance with the membrane manufacturer's printed instructions. The primer shall be allowed to dry before proceeding, but re-primed if not covered with membrane within 36 hours. After the primer has dried, the self-adhering membrane shall be applied to the concrete without stretching, with the polyethylene face out and it shall be smoothed down with heavy hand pressure or a small roller. The edges and ends shall be lapped as specified. The inside and outside corners shall be doubled by using an initial strip of 300 mm width membrane, cantered along the axis of the corner. The strip shall be covered by the regular application of self-adhering membrane and the exposed edges of the membrane shall have a trowelled bead of mastic over these edges. The membrane shall be applied in two layers and laps shall be staggered from one layer to the next. The membrane shall be covered with two layers of protection board to protect it from damage during construction. Prior to reinforcement being placed over blinding concrete, the membrane shall be covered with the protection board as above. The protection board shall terminate flush with the edges of the concrete base slab and edges shall be covered by overlapping with membrane material. Sidewall membrane shall extend down and out to the edge of the previously applied horizontal slab membrane. Where top of membrane terminates at a reglet, the membrane shall be extended therein and the reglet filled with rubberized mastic. Areas around piping and protrusions shall be provided with an additional layer of self-adhering membrane for a minimum of 300 mm in each direction. The membrane edges shall be coated and the gap between the membrane and protrusions filled with mastic.

H Within five days after membrane application, asphalt protection board shall be installed to vertical and horizontal membrane-on-concrete surfaces. The board shall be installed with polyethylene face out, in two layers and with butted edges and ends, adhered to the membrane by means of mastic or other approved compound. Joints in the second layer shall be staggered in relation to the joints in the first layer. The exposed edges and gaps between

penetration and edges of the protection board shall be pointed up with mastic. Protection board on horizontal slabs shall terminate at the outer corner of the concrete structure above and sidewall protection board shall extend down and out to cover the horizontal slab membrane.

I Backfilling shall not commence until the installation has been approved by the Engineer.

3.03 Installation of Bituminous Damp-proofing

A Bituminous damp proofing shall be installed in accordance with the manufacturer's printed instructions except as hereinafter specified.

B No coating shall be applied until the Engineer has approved the preparatory work.

C Surfaces shall be primed in accordance with manufacturer's instructions. The priming coat shall be made up by mixing 0.23kg. of approved powder detergent, or the equivalent of liquid detergent, with 45 litres of clean water and adding this to 4.5 litres of emulsion. The priming coat shall be applied at the approximate rate of 9 litres per 30 square metres. The second coat consisting of undiluted emulsion shall be applied as soon as the priming coat is dry, at the approximate rate of 9 litres per 15 square metres. The emulsion shall be applied by brush, squeegee or spraying strictly in accordance with the manufacturer's instructions and shall not be applied during, or when rain or dust storms are to be expected.

D Backfilling shall not commence until the second coat of emulsion is dry.

3.04 Testing and Guarantee

A On completion of waterproofing installation, areas shall be tested against leaks. No area shall be water tested within 48 hours after application.

B Water testing shall include flooding of tanked areas and slabs, either by section or entirely, for a minimum period of 48 hours. Flooding shall include proper damming of areas as required.

C Any area where leaks occur shall be drained, thoroughly dried, repaired, and then re-tested till no leak occurs over the whole area/s of test.

D At completion of flood testing, removal of all dams and traces of water shall be done and arrangements made for disposing off the water etc. All costs for water, for filling and for disposal as many times as necessary, shall be borne by the Contractor.

E Where shown on the Drawings installation of sandbeds or concrete applied over the waterproofing shall not start until such time as the membrane is leak free and has been accepted by the Engineer.

F All waterproofing works shall be guaranteed for a period of ten years beginning from the date the Engineer certifies the Works to be substantially complete.

3.05 Clean up

The Contractor shall remove all masking, protection, equipment, materials and debris from the work and storage areas and leave those areas in clean, undamaged and acceptable condition.

END OF SECTION 07100

Section 07200

Building Insulation

Part 1 General

1.01 Description

Furnish all plant, labour, equipment, appliances and materials and performing all operations in connection with Building Insulation.

1.02 Submittals

A Manufacturer's specifications and installation instructions shall be provided for the type of insulation.

B 600 x 600 mm square samples of the type of insulation shall be provided.

1.03 Delivery, Storage and Handling

A Insulation materials shall be delivered in the manufacturer's unopened containers or packages, fully identified with trade name, type, class and other identifying information. Delivery shall be sequenced to avoid project delays and to permit proper co-ordination of the work.

B Materials shall be stored above grade and protected from weather and damage from any source. The building insulation shall not become wet or soiled and the Contractor shall comply with other precautions and recommendations of the manufacturer to protect insulation from deterioration.

Part 2 Products

2.01 Insulation

A Rigid plastic insulation, which shall be 50mm thick on walls and 70 mm on roofs, shall be extruded rigid closed-cell polystyrene foam board with ship-lapped edges having the following properties:

Property	Typical Results	Test Method
Density	35 kg/m^3	
Five-year aged average thermal conductivity when tested at 24^oC	0.032 W/m.K	ASTM C 518 or DIN 52612
Compressive strength (av)	280 kPa	ASTMD1621 or DIN 53421
Water Absorption (av)	1%	ASTM D2842
Water vapour permeability (av)	0.79 perm.cm	ASTM C355

B Where required for fire rated construction rigid polyester impregnated fibre glass insulation with non-combustible fabric covering shall be provided. It shall comply with FS HH-1-

521E, Type 1, and be of the thickness, density and type tested and approved for the required ratings.

C Expanded polystyrene insulation which is not manufactured with, or contains chlorofluorocarbons (CFC's) which are known have harmful effects on the earth's ozone layer and the environment, shall be used.

D Adhesives that are compatible with the insulation, protection course and substrata materials shall be used.

E For securing fire rated insulation to the ceiling, galvanised steel clamps of suitable size and strength shall be provided to suit the installation.

Part 3 Execution

3.01 Acceptance of Surface

A All substrata, supports, and conditions under which this work is to be performed shall be examined and work shall not proceed until unsatisfactory conditions are corrected. Any defects in the work resulting from substrata, supports, and conditions shall be corrected by the Contractor without additional cost to the Employer.

3.02 Installation

A The manufacturers' instructions shall be complied with for the particular condition of use and type of insulation in each case. If printed instructions are not applicable to the condition of use, the manufacturer shall be consulted for specific recommendations before proceeding with installation.

B Insulation shall extend for the full thickness over the entire area to be covered, unless otherwise shown. Insulation shall be cut and joined tightly around all obstructions so that no voids exist in the insulation course.

C Mechanical attachments shall be used of the type and spacing as specified and as recommended by the insulation manufacturer for the thickness and condition of use shown. For adhesive applied insulation clips, adhesive and spacing of clips shall be that recommended by the manufacturer for the condition and substrata indicated.

3.03 Protection

Temporary protection shall be provided to insulation to prevent damage or deterioration from weather or physical abuse. Assemblies to permanently protect insulation shall be completed as soon as possible.

3.04 Extent Of Works

All buildings shall be insulated to meet the specified requirements for energy conservation. The basement area slab/beam soffits shall be insulated with rigid fibre glass in all areas exposed to the weather at ground floor level and all roofs/walls shall be insulated with the required thicknesses of extruded polystyrene unless larger thickness is shown on the Drawings.

End of Section 07200

Section 07250

Cementitious Fireproofing

Part 1 General

1.01 Description

Furnish all plant, labour, equipment, appliances and materials and performing all operations in connection with cementitious fire proofing.

1.02 Performance Requirements

A The cementitious fireproofing system shall provide a fire rated assembly rating of two hours to all exposed structural steel including cross-bracing and miscellaneous steel members.

1.03 Submittals

A The following product data shall be provided:
1 product characteristics, performance and limitation criteria,
2 manufacturer's installation instruction in accordance with Section 1300,
3 manufacturer's certificate in accordance with Section 01400,
4 proof that the products meet or exceed the specified requirements,
5 test reports in accordance with Section 01400,
6 certified test reports indicating the following:
a minimum bond strength of fireproofing shall be twenty times weight of fireproofing materials, tested in accordance with ASTM E760,
b fire test reports of fireproofing application to substrate materials similar to project conditions,
c reports from reputable independent testing agencies, of product proposed for use, which indicate conformance to ASTM E119 and ASTM E84.

B A 10 sq.m.sample shall be provided applied to representative substrates on site.

1.04 Quality Assurance

A Documentary evidence shall be provided indicating that the specified materials to be used, have been successfully utilized on work of similar scope to that shown, and specified, for this project for a minimum period of three years.

B Application shall be executed by an approved specialist sub-contractor having a minimum of three years successful experience in applying the specified material.

C The Contractor shall submit certification of acceptability of fireproofing materials to the authority having jurisdiction.

1.05 Environmental Requirements

A Spray fireproofing shall not be applied when temperature of substrate material and surrounding air is below 5°C.

B Ventilation shall be provided in areas to receive fireproofing during and 24 hours after application to dry material to maintain non-toxic, non-polluted working areas. Temporary enclosures shall be provided to prevent spray from contaminating air.

Part 2 Products

2.01 Materials

A Cementitious spray fireproofing shall be factory mixed, asbestos free, cementitious material blended for uniform texture and of non-fibrous materials conforming to the following requirements:
1 bond strength: ANSI / ASTM E736, 9.6 kN/m^2 when set and dry,
2 bond impact: ASTM E760, no cracking, flaking, or delamination,
3 dry density: ASTM E605, minimum average density of 240 kg/m^3 with minimum individual density of 224 kg/m^3,
4 compressive strength: minimum 24 kN/m^2,
5 water: clean, potable,

Part 3 Execution

3.01 Examination

A Prior to commencement of work the Contractor shall verify the following:
1 surfaces are ready to receive work,
2 clips, hangers, supports, sleeves, and other items required to penetrate fireproofing are in place,
3 ducts, piping, equipment, or other items, which would interfere with application of fireproofing, are not positioned until fireproofing work is complete,
4 voids and cracks in substrate are filled and projections are removed where fireproofing is exposed to view as a finish material.

3.02 Preparation

Substrate shall be cleaned of dirt, dust, grease, oil, loose material, or other matter, which may affect bond of fireproofing. Incompatible materials, which affect bond, shall be removed by scraping, brushing, scrubbing, or sandblasting and the surface shall meet the requirements of the manufacturer.

3.03 Protection

Adjacent surfaces and equipment shall be protected from damage by overspray, fall-out, and dusting, and ductwork, in areas where fireproofing is being applied, shall be sealed off.

3.04 Application

Fireproofing, overcoat and sealer shall be applied in accordance with the manufacturer's instructions. Fireproofing shall be applied in sufficient thickness to achieve rating, with as many passes necessary to cover with monolithic blanket of uniform density and texture.

3.05 Field Quality Control

A Installation shall be examined within one hour of application to determine variance due to shrinkage, temperature and humidity. Where shrinkage and cracking are evident, the mixture and method of application shall be adjusted as necessary.

B The installed fireproofing shall be re-inspected for integrity of fire protection, prior to concealment of work. Unacceptable work shall be corrected and further inspected to verify compliance with requirements, at no extra cost to the Employer.

3.06 Cleaning

Clean all work and remove excess material, overspray, droppings, and debris. Fireproofing shall be removed from materials and surfaces not specifically required to be fireproofed.

END OF SECTION 07250

Section 07270

Firestops

Part 1 General

1.01 Description

Furnish all plant, labour, equipment, appliances and materials and performing all operations in connection with fire stopping.

1.02 Performance Requirements

A Fireproofing Materials: ASTM E119 and ASTM E814 to achieve specified fire rating.

B Surface Burning: ASTM E84 with a flame spread / fuel contributed / smoke developed rating of 1/11/111.

1.03 Submittals

A The following product data shall be provided:
1 data on product characteristics, performance and limitation criteria,
2 manufacturer's installation instructions,
3 manufacturer's certificate stating that products exceed the specified requirements.

1.04 Quality Assurance

A The manufacturer shall provide documentary evidence indicating that the proposed materials have been successfully utilized on work of similar scope to that shown and specified for this project for a minimum period of three years. The work shall be executed by an approved specialist Sub-contractor having a minimum of three years successful experience in applying the specified material.

B Materials shall conform to applicable code for fire resistance ratings and surface burning characteristics. The Contractor shall submit certification of acceptability from authority having jurisdiction indicating approval of combustibility.

1.05 Mock-Up

A The Contractor shall provide a mock-up of applied firestopping material to a representative substrate surface. If accepted, the mock-up will demonstrate minimum standard for the Work. The mock-up may remain as part of the Work.

1.06 Environmental Requirements

A Materials shall not be applied when temperatures of substrate material and ambient air are below 15^{o}C. This minimum temperature shall be maintained before, during, and for three days after installation of materials.

1.07 Sequencing

A Sequence Work to permit firestopping materials to be installed after adjacent and surrounding work is complete.

Part 2 Products

2.01 Materials

A Fire resistance rating shall be equal to the hourly rating of the floor, wall, or partition into which the firestop will be installed. Firestopping materials shall be asbestos-free and capable of maintaining an effective barrier against flame and gases in compliance with the U.L. Building Materials Directory and conforming to the following:
1 durability and longevity: permanent,
2 side effects during installation: none,
3 long term side effects: none.

B Primers shall be of a type recommended by firestopping manufacturer for specific substrate surfaces.

C Finished colour shall be dark grey.

2.02 Accessories

A Dam material: as per manufacturer's instructions.

B Retainers: clips to support mineral fibre matting.

Part 3 Execution

3.01 Preparation

A The Contractor shall verify that openings are ready to receive the Work.

B Substrate surfaces shall be cleaned of dirt, dust, grease, oil, loose material, or other matter which may affect bond of firestopping material and incompatible materials, which affect bond, shall be removed.

3.02 Application

A Materials shall be applied in accordance with manufacturer's instructions and in sufficient thickness to achieve rating and uniform density and texture. Materials shall be installed at walls or partition openings which contain penetrating sleeves, piping, ductwork, conduit and other items requiring firestopping. After firestopping material has cured dam material shall be removed.

3.03 Cleaning

A Adjacent surfaces shall be protected from damage by material installation and cleaned of fire stopping materials.

END OF SECTION 07270

Section 07500

Membrane Roofing

Part 1 General

1.01 Description

The principal work of this Section shall be furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with membrane roofing system including, but may not be limited to, the following waterproofing membrane, insulation, sandbed, Sika tiles, cement sand mortar, geotextile fabric or natural stone

1.02 Submittals

A The following product data shall be provided:
- 1 manufacturers' specifications and installation instructions for roofing membrane and accessory items and for each item of proprietary material used, showing compliance with these Specifications,
- 2 copies of mix designs with support material for all mortars,
- 3 copies of manufacturer's certificate of mill tests of all cement, reinforcing steel and embedments,
- 4 shop drawings showing details, dimensions, locations and installation methods of roofing system including membrane, insulation, precast pavers, flashings and all accessories. The drawings shall indicate the following:
  - a profiles, slopes, low and high points, dimensions, joints,
  - b arrangement of units,
  - c detail of special design or shapes, anchors, inserts, joints etc.,
  - d connections to adjoining work or materials,
  - e reinforcing for each unit,
  - f method of installation and anchoring,
  - g positions of service outlets including roof drains, vent pipes, exhaust fans, roof hatches, skylights, etc.,
- 5 complete engineering data for fabrication, reinforcement and anchorage.

B Each precast unit when delivered shall be numbered clearly on an unexposed surface to correspond with identity numbers on erection drawings.

C Detailed outline of sequence and methods of erection shall be provided.

D Samples of membranes, insulation, sika tiles, aggregates and other items required by the Engineer.

E A written affidavit stating that the roofing applicator is licensed or approved by the roofing manufacturer.

F Guarantee stating that the roofing membrane system installed will be waterproof and free from defects for a period of not less than ten years from date of Substantial Completion of the Works. In the event any leaks occur within the period stipulated, the Contractor shall, at the convenience of the Employer, effect all repairs and replacements necessary to remedy defects all to the complete satisfaction of the Engineer at no additional cost to the Employer.

1.03 Mock-Up

The Contractor shall provide a 3m x 3m mock-up of roofing system with full sized architectural precast sika tiles units. The mock-up shall be representative of the finished work in all respects indicating joint conditions and all other features as will be used in the final work. The mock-up assembly will be used as a standard for judging acceptability of work on project and may be used in the finished work.

1.04 Quality Assurance

A Roofing and flashing shall be executed by a specialist roofing subcontractor licensed, franchised or approved by the roofing materials manufacturer, using experienced skilled roofers, having a minimum of five years experience in the installation of materials specified herein on works comparable to this Works.

B All roofing and flashing work shall be applied in strict accordance with the roofing manufacturer's written requirements and specifications applicable to roof conditions. Where additional work or materials, or greater quantities of materials than required by roofing manufacturer are specified herein, these Specifications shall govern.

C The roofing material manufacturer's representative shall inspect the work during roof installation, at no additional cost, and furnish a copy of his inspection reports to the Engineer. The reports shall be on the roofing manufacturer's standard inspection report form, dated and signed.

E Roofing work shall not proceed during inclement weather and the manufacturer's recommendations shall be followed for application and curing under specific climatic conditions.

1.05 Pre-Installation Co-Ordination

After approval of all materials, and prior to installation, a pre-roofing conference shall be held at the job site between Engineer, Contractor, roofing sub-contractor and manufacturer's representative. The parties shall review Drawings, specifications and approved materials and correct conflicts, if any, between approvals and specification requirements. They shall examine job site conditions, including inspection of deck, material labels and methods of storing materials and confirm that all curbs and edges are provided and correctly installed. They shall also review installation procedures, scheduling and temperature requirements, and establish protection methods for finished roof from other trades.

1.06 Final Inspection

Upon completion of the installation, an inspection shall be made by a representative of the roofing material manufacturer in order to ascertain that the membrane roofing system has been properly installed. If there is any deviation from this specification, without the prior written consent of the roofing material manufacturer, the manufacturer shall have the option of refusing the guarantee.

1.07 Delivery, Storage and Handling

A Roofing materials shall be delivered in manufacturer's unopened containers or bundles, fully identified with brand, type, grade, class and all other qualifying information. Bulk materials shall be delivered with certification from the manufacturer stating the name, type

and grade of each product used. Units shall be delivered from plant to project site in accordance with schedule and proper setting sequence. "Rejected" shall be marked conspicuously on materials which have once been wet or damaged and remove from job site.

B Materials shall be stored in a dry location, in such manner as to prevent damage or intrusion of foreign matter. Precast units shall be stored free of the ground and protected from mud or rain splashes. Units shall be covered with firmly secured covers and protected from dust, dirt or other staining materials.

C Precast units shall be transported, stored and handled in a manner to avoid undue strains, hair cracks, staining, or other damage.

D A certificate shall be provided accompanying each load (or furnish manufacturer's blanket certificate) for each bulk product used in the work.

1.08 Protection

A Waterproofing system installation shall be protected from damage during construction so that it will be without any indication of abuse or damage at the time of completion. The structure shall be protected from damage resulting from spillage, dripping and dropping of materials and any other work damaged during roofing membrane operations shall be repaired.

B Local ordinances and fire regulations shall be complied with in the installation of hazardous materials specified or required under this Section. All necessary precautions shall be taken against fire and other hazards during delivery, storage and installation of flammable materials specified herein.

Part 2 Products

2.01 Materials

Products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, will be considered acceptable but the decision of acceptability will rest with the Engineer.

2.02 Ancillary Buildings

A Water Proofing Membrane
1 provide the products and systems specified in the material manufacturer's latest published manual for the and type of substrate shown,
2 bitumen sheet membrane shall be flame bonded single-ply membrane, 4 (+/-0.2) mm thick composed of asphalt or bitumen modified with thermoplastic resins and reinforced with non-woven polyester fabric,
3 cant strips shall be cement and sand mortar, in the proportion of 1:3 by volume.

B Roof insulation shall be light-weight concrete with an average density of 500 to 700 kg/m^3 and average thickness shall be 100 mm.

C Standard sika tiles shall be 800 X 800 X 40 mm and water proofed with an appropriate additive and shall be manufactured by a specialist roofer having at least ten years experience. Tiles shall be of a strength capable of taking live roof load of 2.5 kN/m^2 and

shall have a special section formed at their edges so that when laid against each other two adjacent edges shall form a special joint section that will hold the sealant.

D Sika skirting and corner elements shall be laid as indicated on the drawings along the periphery and on the corners of the roof. They shall rest on the concrete against the upstands or parapet to ensure a continuous coved skirting providing the same profile as that of the slabs. Elements shall have rounded corners be waterproofed as for the sika tiles and shall have sealant at all edges.

E Sand shall be as specified in Section 03300 hereof.

F Joint sealant shall be as specified in Section 07920 hereof.

2.03 Storage Reservoirs

A Water proofing membrane shall be as specified in Section 07100 hereof.

B Geotextile fabric shall be needled polypropylene thermally bonded fabric with the following properties:

a	thickness	1.4 mm
b	weight	300 g/m^2
c	tensile strength	
	longitudinal direction	13 kN/m
	transverse direction	17 kN/m

C Sand bed shall be as specified in Section 03300 hereof.

D Natural stone shall be single sized, uncrushed aggregate of max size 20 mm and properties shall be as specified in Section 03300 hereof.

Part 3 Execution

3.01 Preparation

A Surfaces to receive membrane roofing shall be free of projections, voids, depressions, scale efflorescence, loose material, laitance, oil grease and other foreign contaminants. Before starting work, the Contractor shall inspect all surfaces to receive membrane and report in writing to the Engineer, any surfaces that are not suitable for correct application of the membrane. If any surfaces are unsuitable to receive membrane, the Contractor shall see that same are corrected by the respective trade prior to application of his work.

B All preparation of surfaces, including construction joints shall be completed before membrane waterproofing is installed.

3.02 Installation of Membrane Roofing.

A At the start of the installation, and periodically as work progresses, the Contractor shall provide the services of the manufacturer's technical representative at the job site as often as deemed necessary by the manufacturer to advise on all phases of this work. The roofing system shall be installed in strict accordance with manufacturer's direction for conditions of each application.

B All surfaces to receive roofing membrane shall be primed using products and methods recommended by the roofing membrane materials manufacturers. Cant strips shall be applied at all edges and around any penetrations in the roofing, as shown on Drawings.

C Roofing membrane shall be applied in accordance with the manufacturer's instructions and recommendations and joints shall be overlapped a minimum of 100 mm. All roof outlets, pipes, sleeves, and other projections through roof deck shall be flashed to provide tight construction throughout.

3.03 Flood Testing

A The horizontal areas of waterproofing shall be tested prior to the installation of insulation. Testing shall be by flooding sections of the waterproofed area, dammed as required, with a minimum 50 mm head of water for 48 hours. Any leaks shall be marked and repaired when the membrane is dry. Any area where leaks occur shall be drained, thoroughly dried, repaired, and then re-tested. At completion of flood testing, remove all dams and traces of water to the satisfaction of the Engineer.

B Installation of sand beds, insulation, stone filling, sika tiling, all of which are applied over the waterproofing, shall not start until such time as the membrane is leak free and has been accepted by the Engineer.

3.04 Insulation Installation

Light weight foam concrete shall be laid average 100 mm thick to the required falls and cross falls with one percent slope.

3.05 Protection and Cleaning

A All damage to the building resulting from this work or operations shall be made good. Particular care shall be taken to avoid staining any part of the exposed structural or finished work. Hoisting of materials shall be done with extreme care. All exposed surfaces shall be protected by approved means.

B At completion of work under this Section, the Contractor shall remove from the site and legally dispose of packaging, containers and other accumulated materials, and leave the work in a clean and satisfactory condition.

End of Section 07500

Section 07600

Sheet Metal Flashing

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with sheet metal flashings and expansion joint covers.

1.02 Qualifications

The work shall be performed by a firm having five years experience in the installation of materials specified herein on work comparable to this Work.

1.03 Submittals

A Samples of each metal shall be provided and the Engineer's review and acceptance of samples will be for colour and finish only.

B Shop drawings shall be provided showing metal flashings and accessories with complete information concerning fabrication, installation, joint details, and fastenings.

C Manufacturer's specifications and installation instructions and other data shall be provided to show compliance with the Contract Documents.

D A ten year guarantee shall be provided against leaks resulting from defects of materials or workmanship. Upon notification of such defects, within the guarantee period, make the necessary repairs and replacements at the convenience of the Employer at no additional cost to the Employer.

1.04 Delivery, Storage and Handling

Materials shall be delivered in tagged bundles or in manufacturer's unopened containers fully identified to show name, brand, type, grade and thickness and shall be stored in a protected and dry environment.

Part 2 Products

2.01 Materials

A Aluminium flashings and expansion joint covers shall be fabricated from 20 gauge NS3 or NS4 aluminium alloy to comply with BS1450.

B Aluminium shall be finished with 2 coats of fluoropolymer resin to a minimum thickness of 30 microns.

2.02 Fabrication

Units shall be custom fabricated. Measurements and dimensions shall be verified at the job site and work shall be coordinated and scheduled with the work of related trades.

Part 3 Execution

3.01 Conditions Of Surfaces

A Examine substrate, adjoining construction and conditions under which work is to be installed.

B Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 Installation

A Flashings and expansion joint covers shall be provided with all accessories to provide a watertight installation.

B Units shall be set level and plumb, true to line, be coordinated with other work and anchored securely in place with aluminium alloy screws and/or concealed non-ferrous clips.

C Concealed contact surfaces of dissimilar metals and metals contacting concrete shall be coated with bituminous paint as specified in Section 8520.

D In general, flashings and expansion joint pieces shall be furnished in appropriate lengths with joints welded as necessary. Angles and the like on flashings and expansion joint covers requiring dressing shall be mechanically welded where required for watertightness.

E Sheet metal shall be designed and detailed for a temperature of 21^{O}C at time of installation with allowance made for a 82^{O}C ambient temperature. All necessary adjustments shall be made for installations at other than design temperature.

3.03 Cleaning

A Upon completion of work, flux residues shall be removed with a solution of washing soda or ammonia, then drenched with clear water.

END OF SECTION 07600

Section 07724

Access Hatches

Part 1 General

1.01 Description

The principal work of this Section shall be furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Type A access hatches complete, as indicated in schedule on drawings and specified herein. Type B access hatches shall be constructed as specified in Section 05500

1.02 Quality Assurance

Unless otherwise specified all work specified herein shall be fabricated as specified in Section 05500 hereof.

1.03 Submittals

A Manufacturers installation instructions shall be provided.

B Shop drawings and product data indicating unit dimensions, method of anchorage, and details of construction shall be provided.

Part 2 Products

2.01 Materials

A Materials of construction for Type A access hatches shall be as indicated. Materials shall be new, sound and shall conform to the following:
- 1 Stainless steel type 316L access hatch.
  - a dimensions: as indicated on schedule.
  - b leaf type: double or single as indicated on schedule.
  - c safe working load: 7.5 kN/m^2.
  - d frame: 6 mm minimum thickness mill finished 316L stainless steel.
  - e door: 6mm min. thickness mill finished diamond plate 316L stainless steel.
  - f all hardware: type 316L stainless steel.
  - g grip handle: vinyl.
  - h fabricate frame with anchor flange around perimeter and 40 mm diameter drainage coupling.
  - I reinforce door with 316L stainless steel stiffness.
  - j bolt hinges to underside of door. Pivot on torsion bars.
  - k fabricate doors to open 90 degrees with assistance of spring operators and automatically lock into open position.
  - l furnish with snap lock and removable grip handle.
- 2 Aluminium Access Hatch
  - a dimensions: As indicated on schedule
  - b leaf Type: Double or single as indicated on schedule.
  - c safe working load: 7.5 kN/m^2.

d frame: 6mm minimum thickness mill finished aluminium channel.
e door: 6 mm minimum thickness mill finished diamond aluminium plate.
f all hardware: Type 304 stainless steel.
g grip handle: Vinyl.
h fabricate frame with anchor flange around perimeter and 40 mm diameter drainage coupling.
I reinforce door with aluminium stiffeners.
j bolt hinges on underside of door. Pivot on torsion bar.
k fabricate doors to open 90 degrees with assistance of spring operators and automatically lock into open position.
l furnish with snap lock and removable grip handle.

Part 3 Execution

3.01 Condition of Surfaces

The Contractor shall examine all conditions related to the work of this section and ensure they are satisfactory to perform a complete installation in operating order. Any unsatisfactory conditions shall be reported to the Engineer.

3.02 Installation

All products in this section shall be installed in accordance with manufacturer's instructions. All aluminium in contact with concrete shall be bituminous coated.

3.03 Clean-Up

All protective masking shall be removed and surfaces cleaned, leaving them free of all imperfections. All cartons, wrapping, etc., resulting from the work of this section shall be removed from site and disposed of in a legal manner.

END OF SECTION 07724

Section 07810

Metal Framed Skylights

Part 1 General

1.01 Description

The work included in this section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with prefabricated metal framed skylights (pyramid Type).

1.02 Standard Specifications

A Except as otherwise shown or specified skylight items shall be fabricated from extruded aluminium ASTM B221 or B308, finished with 3 coat of fluoropolymer resin to match the building aluminium. The profile of skylight members is indicated to establish the design intent only; it is the Contractor's responsibility to correctly sizing the skylight members and submit all design calculations to the Engineer for approval.

B Where units are not available as a standard manufactured product, units shall be custom fabricated complying with the requirements shown and specified.

C Each item shall be fabricated in the shop as a complete unit for coordination with adjoining work. Anchoring and flashing flanges, offsets, cant strips and nailers for roofing, expansion sleeves (concealed on exposed fascias), hardware and non-corrosive bearings for operating parts, and gaskets and sealant recesses shall be provided as required to make the installation weathertight.

D Except as otherwise shown, or specified, after completion of shop fabrication each unit of work shall be cleaned and treated.

1.03 Qualifications

The work shall be executed by an approved specialist sub-contractor having five years experience in the installation of materials specified herein on works comparable to this Work.

1.04 Submittals

A Copies of manufacturer's specification, standard drawings and installation instructions and other data as may be required shall be submitted to show compliance with these specifications.

B Samples of each exposed metal finish required for skylight units including 300 mm long sections of profiles with all attached accessories such as gaskets, beads, hardware etc., and polycarbonate sample fixed in the profile shall be provided. Samples of metal of the same alloy and gauge to be used for the work shall be submitted. Samples will be reviewed by the Engineer for colour, texture and specular gloss only.

C Shop drawings and structural calculations for the design, fabrication and installation of prefabricated skylight unit shall be provided including details at not less than 1:5 scale. The drawings shall show jointing, anchorage, accessory items, shop finishes,

polycarbonate thicknesses, fixing details, waterproofing terminations, and any other details as directed by the Engineer.

D The complete installed skylight shall be guaranteed by the Contractor for a period of five years from the date of Substantial Completion of the Works, against leakage, defective material and workmanship.

1.05 Testing

A The contractor shall carry out appropriate tests on the completed skylight installation to ensure that whole assembly is watertight and air-tight and shall provide test certificates from approved testing agency as directed by the Engineer.

1.06 Cleaning And Protection

The skylight shall be protected during construction operations and left absolutely clean (inside and outside) on completion of the works.

Part 2 Products

2.01 Skylight

A General
1. Barrel dome shaped skylights with double polycarbonate lights shall be provided in configurations as shown on Drawings. Sloped glazing must have a safety factor of 1.5.
2. The frame shall be as per approved sample with the Engineer.
3. The assembly must withstand 120 kg/m^2 horizontal pressure, 100 kg/m^2 negative pressure and 120 kg/m^2 downward pressure in any possible combination.
4. The assembly shall have 'U' value of 3.18 w/m^2k and shading coefficient of 0.81.
5. Skylight assembly shall be watertight and shall have continuous trench drainage system for collection of rain water and also shall have an interior gutter to collect and discharge condensate.
6. The framework shall be rigid extruded aluminium sections designed to meet the performance requirements.

B Aluminium Finish
1. Remove die markings prior to finishing operations and where necessary to remove die markings from any part of the work, all members must be finished by the same process, whether or not die marking exists. This work shall be performed in addition to the finish specified. Scratches, abrasions, dents and similar defects are unacceptable.
2. For aluminium with three coats of fluoropolymer resin all coatings shall have a minimum thickness of 40 microns and shall be tested, where required by the Engineer, using an Ultrasoniscope Eddy Current - thickness meter. The preparation of aluminium shall conform to BS 1615 and the finish shall match the building in colour, as per approved sample with the Engineer. All riveted and screened components are to be coated before assembly.

C The skylight system shall incorporate an integral extruded aluminium gutter system. Gutter intersections shall be mechanically fastened and shall incorporate a neoprene gasket under compression to provide a positive seal. The gutters shall include an

adjustable gutter support. The extruded aluminium adapter shall be positively sealed to the extruded aluminium gutter through the use of a neoprene gasket under compression.

D Hardware shall be fabricated of stainless steel complying with ASTM A167 or white bronze or aluminium and finished to match the components to which it is fixed. All hardware shall be approved by the Engineer.

E The Contractor may reinforce aluminium profiles with steel sections to support the loads, as long as the steel sections are galvanized, separated from aluminium sections and fully covered by matching aluminium profiles.

Part 3 Execution

3.01 Condition of Surfaces

The Contractor shall examine the substrates and adjoining construction, and conditions under which the work will be installed. Work shall not proceed until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 Installation Coordination

The complete installation of skylight units shall be fully coordinated and compatible with the roofing system.

3.03 Installation- Skylights

Skylight units shall be installed as shown, and in accordance with the manufacturer's instructions. Each unit shall be sat level and plumb, true to line and coordinated with other work. They shall be anchored securely in place, by welding, bolting, or screwing to the substrate where required for proper support. Where required for waterproof roof construction set flanges of units in roofing mastic, and leave surfaces smooth and clean for application of roofing and all other items to be embedded into or in contact with the roofing.

END OF SECTION 07810

Section 07910

Joint Fillers and Gaskets

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with joint fillers and gaskets.

1.02 Submittals

A The following manufacturer's data shall be provided:
1. Published data, or manufacturer's letter, clearly indicating that each product to be furnished complies with these Specifications, is recommended for the application shown, and is compatible with each other material in the joint system.
2. Complete instructions for handling, storage, installation and protection of each product.

B A sample of each type of exposed joint filler or gasket shall be provided. Samples will be reviewed by the Engineer for colour and texture only.

C Notwithstanding the types of joint fillers and gaskets specified herein, the Contractor shall in all cases be responsible for providing sealant materials the best of their respective kind, compatible with adjoining materials and suitable for the purpose intended, all at no additional cost to the Employer.

1.03 Delivery, Storage and Handling

A Materials shall be delivered in manufacturers' unopened containers or bundles fully identified with brand, type, grade, class and all other qualifying information.

B Materials shall be stored in a dry location in such a manner as to prevent damage or intrusion of foreign matter. Materials which have once been wet or damaged shall be conspicuously marked "Rejected" and removed from the job site.

Part 2 Products

2.01 General

A The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, may be acceptable subject to the Engineer's approval.

B Joint fillers and gaskets shall be provided as shown or, if not shown, the manufacturer shall be consulted to determine the proper size and shape considering joint movement and conditions at time of installation. They shall be as recommended by the manufacturer for proper performance in each specific condition of use.

C The Contractor shall provide only the type of joint filler which is compatible with the joint

surfaces and each sealant or caulking compound, as stated in the data published by the manufacturers of the joint filler and the sealant or caulking compound, or as certified by the joint filler manufacturer for each application.

D Pressure-sensitive adhesive shall be applied to joint fillers and gaskets, wherever applicable and at Contractor's option, to facilitate installation.

E. For exposed gaskets or joint fillers, the colour shall be provided as shown or, if the colour is not shown, it will be selected by the Engineer from the manufacturer's standard colours. For concealed joints, provide the manufacturer's standard colour which has the best overall performance characteristics shall be provided.

2.02 Expansion Joints

A Expansion joints shall be non-extruding, resilient bituminous type to ASTM D1751, bituminous type to ASTM D994.

B Closed cell, cross linked, non-absorbent, polyethylene joint filler shall be to ASTM D3575 and not less than 34.5 kPa for 25 percent compression deflection; resistant to petroleum oils and solvents and with surface water absorption of not more than 5 percent.

2.03 Concealed, Expanded Neoprene Gasket (Csng) - General Purpose

Closed Cell: ASTM D 1056, Grade SEC-41.

2.04 Moulded, Resilient Neoprene Gasket (Mrng) :

ASTM D 2000, 50 to 70 shore A durometer, non- cellular, moulded or otherwise fabricated to form the sizes and shapes shown or as required to effectively seal each joint.

2.05 Gasket Lubricant

Non staining lubricant which bonds and seals gasket in place when cured, as recommended by the gasket manufacturer.

Part 3 Execution

3.01 Condition of Surfaces

The Contractor shall examine the joint surfaces and the conditions under which the work is to be done. The work shall not proceed until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.02 Installation

A The installation of each type of joint filler or gasket shall comply with the manufacturer's instructions and shall be applied in continuous runs without voids or interruptions, except as may be otherwise shown. The joint filler or gasket shall be trimmed for tight fit around obstructions or elements penetrating the joint. The surface or self-skin on moulded or extruded types of cellular joint fillers shall not be punctured.

B The face edge of joint fillers shall be depressed accurately, wherever used as backup for sealant, as shown or as specified by sealant manufacturer for proper application of sealant.

C Exposed edges of joint fillers and gaskets shall be recessed slightly behind the face of adjoining surfaces unless shown otherwise.

3.03 Protection

Joint fillers and gaskets shall be protected during the remainder of the construction period so that they will be without indication of deterioration of damage at the time of completion of the Works.

END OF SECTION 07910

Section 07920

Sealants

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with joint sealants and accessories in building trade work.

1.02 Submittals

A. The following information shall be provided:
   1. Published data or manufacturer's letter, clearly indicating that each product to be furnished complies with these Specifications, is recommended for the application shown and is compatible with each other material in the joint system.
   2. Complete instructions for handling, storage, mixing, priming, installation, curing and protection of each type of sealant.

B. Samples of each type of exposed sealant shall be provided, samples shall be 300 mm long installed between two samples of the materials to be sealed, fully cured. Samples will be reviewed by the Engineer for colour and texture only.

C. Not-withstanding the types of sealant specified herein, the Contractor shall in all cases be responsible for providing sealant materials the best of their respective kinds, compatible with adjoining materials and suitable for the purpose intended, all at no additional expense to the Employer.

1.03 Environmental Conditions

The installation of sealants shall not proceed during inclement weather unless all requirements and manufacturer's instructions can be complied with, and unless the work can proceed in accordance with the agreements of the pre-installation meeting. The installation of sealants shall not proceed under extreme temperature conditions which would cause joint openings to be at either maximum or minimum width, nor when such extreme temperatures or heavy wind loads are forecast during the period required for initial or nominal cure of elastomeric sealants. Sealants shall not be installed when the ambient temperature is above 30^{o} C. Whenever possible, schedule the installation and cure of elastomeric sealants during period of relatively low temperatures (but well within manufacturer's recommended range) so that subsequent tensile stresses upon the cured sealants will be minimised.

1.04 Pre-Installation Meeting

Prior to the installation of sealants a meeting shall be held at the project site to review the material selections, installation procedures and co-ordination with other trades. In attendance shall be representatives of the Contractor, manufacturer, the Engineer and other trades or sub-contractors affected by the sealant installation. The parties shall examine sample applications to determine and record whether all parties agree that the proposed installations are likely to perform as required.

1.05 Sample Application

A. The Contactor shall provide sample applications of sealants at locations designated by the Engineer. Samples shall represent the primary types of materials, substrate surfaces, joint size, exposure, and other conditions to be encountered in the work. Preparation, priming, application, and curing, shall comply with manufacturer's recommendations and actual proposed methods. The applications shall be scheduled, with allowance for sufficient curing time, so that samples may be examined and any necessary adjustments made at least one week prior to date scheduled for commencing installation of the work.

B. Samples shall be visually examined for staining, dirt pickup, shrinkage, colour, general workmanship and appearance. Sealant shall be cut and pulled from each sample joint to examine for internal bubbles or voids, adhesion, and general compatibility with substrate.

1.06 Delivery, Storage and Handling

A. Materials shall be delivered in manufacturers' unopened containers, fully identified with brand, type, grade, class and all other qualifying information.

B. Materials shall be stored in a dry location, in such a manner as to prevent damage or intrusion of foreign matter. Materials which have once been wet or damaged shall be conspicuously marked "Rejected" and removed from the job site.

Part 2 Products

2.01 Materials - General

A. If more than one of the manufacturer's products comply with the requirements for any item specified herein, provide the specific product recommended by the manufacturer for the particular condition of use in each case.

B. The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, may be acceptable subject to the Engineer's approval.

C. Only sealants, and joint primers which are compatible with the joint surfaces and backing or filler materials, as stated in the manufacturer's published data, or as certified by the manufacturer for each application shall be provided. The Contractor shall confirm the compatibility of sealants that may be in contact with each other.

D. The Contractor shall determine the proper hardness or consistency of elastomeric sealants in consultation with the manufacturer, considering joint movement and exposure for the size of joint shown.

E. In general, provide sealants with the following ranges of hardness (fully cured sealant at 24^{o} C):
   1. For joints subject to maximum movement and nominal exposure to weather and abrasion: 15 to 25 Shore A durometer hardness.
   2. For joints subject to moderate movements and severe weather exposure or moderate abrasion: 25 to 40 Shore A durometer hardness.
   3. For joints subject to minimum movement and severe abrasion: 35 to 60 Shore A

durometer hardness.

F. In general, for elastomeric sealants, provide sealants having the lowest modulus of elasticity which is consistent with the degree of exposure to wear and abrasion. Any sealant exposed to traffic must have strength and modulus sufficiently high to resist damage by traffic.

G. For fully concealed joints, the manufacturer's standard colour of sealant which has the best overall performance characteristics for the application shown shall be provided. For exposed joints provide the colour shown, or if the colour is not shown, provide a colour, in each case selected by the Engineer from manufacturer's standard colours, to match or blend with adjoining materials in a manner to be determined by the Engineer.

H. Elastomeric sealants produced by any manufacturer who will not agree to send a qualified technical representative to the project site when requested, for the purpose of rendering advice concerning the proper installation of his materials, shall not be used and the sealant will be rejected by the Engineer.

2.02 Sealants

A. One-part silicone rubber sealant (1SRS) - exterior glazing shall be one-component elastomeric sealant, FS-TT-S-001543, class A, type II non-sag.

B. Two-part polyurethane modified sealant (2-PUMS) - exterior-general application shall be FS TT-S-00227, class A, type II non-sag, elastomeric sealant.

2.03 Interior Glazing Sealants

One-part high modulus silicone rubber sealant (1HMSRS) shall be one-component elastomeric sealant, FS-TT-S-001543, class A, type II non-sag acetoxy type of a colour to be selected by the Engineer.

2.04 Interior Sealants

A. Polyisobutylene/Polybutene Mastic Compound (PPMC) shall be heavy bodied non-drying, non-hardening, non-skinning compound specifically recommended as an acoustical sealant.

B. Silicone Sanitary Sealant (SSS) (All wet areas unless otherwise noted) shall be FS-TT-S-001543, class B, type II non-sag, elastomeric sealant containing fungicide for mildew resistance.

2.05 Miscellaneous Materials

A. Joint cleaners, primers and sealers shall be as recommended by the manufacturer of the sealant, for each specific joint surface and condition.

B. Pressure-sensitive polyethylene tape, or other plastic tape, as recommended by the sealant manufacturer shall be used to prevent bond of the sealant in the heel of the joint.

Part 3 Execution

3.01 Acceptable Conditions

The Contractor shall examine the component surfaces and fillers of the joints to be sealed, and the conditions under which the work is to be done. Work shall not proceed until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.02 Preparation

A. Bonding joint surfaces shall be cleaned to remove deleterious substances which might interfere with bond or otherwise impair the work. Elastomeric sealants shall not be applied to joint surfaces previously painted or treated with sealer, curing compound, water repellent or other coatings, unless a laboratory durability test of bond-cohesion has been performed and successfully demonstrated that bond will be durable. The test method shall comply with procedures of the Federal Specification, or other referenced standard, as applicable to the particular sealant.

B. Paint and other coatings or substances shall not be applied to surfaces adjoining joint surfaces until sealants have been installed and are nominally cured, so that adhesion will not be impaired by migration of such substances onto the joint surfaces.

C. Concrete and masonry joint surfaces shall be etch bonding surfaces with a 5 percent solution of muriatic acid to remove excess alkalinity and shall be rinsed thoroughly with a diluted ammonia solution, and then with clear water, and dry before installation of elastomeric sealants.

3.03 Installation

A. The manufacturer's instructions shall be complied with for the use and installation of each type of sealant, unless otherwise shown or specified.

B. The bonding joint surfaces shall be primed and sealed in accordance with the sealant manufacturer's recommendations and avoiding migration of primer or sealer onto adjoining surfaces and remove any spillage promptly.

C. Bond breakers shall be installed in joints as shown, and wherever recommended by the sealant manufacturer, to prevent bond of the sealant to surfaces where such bond might impair the performance of the sealant. The surface or skin of compressible rod type bond breaker shall not be punctured.

D. The Contractor shall comply with the manufacturer's printed instructions and recommendations, except as may be otherwise shown, or except as may be otherwise directed (and recorded) by the manufacturer's representative. The manufacturer's technical representative shall be present when beginning the installation of each major type of sealant.

E. The Contractor shall employ only tradesmen who are experienced in the use of the materials specified and shall use only the types of equipment recommended by the sealant manufacturer.

F. Compounds shall be applied in continuous beads or rivers, filling joint from the bottom without openings, voids or air pockets. Compounds shall be forced to sides of joint so as to carefully and thoroughly "wet" opposite joint bond surfaces, forming equal areas of contact with sealant. Compounds shall be confined to joint areas shown by use of masking tapes or other precautions to prevent spilling and migration onto adjoining surfaces and shall be applied in concealed compression joints accurately so that excess compound will not exude

from the joint.

G. Elastomeric sealants shall be applied to the depth shown or, if none is shown, applied in accordance with the manufacturers recommendations and the following general limitations:
   1. in joints subject to traffic or other abrasion, to a depth equal to 75 percent of the joint width, but not less than 10 mm and not more than 19 mm.
   2. in joints not subject to traffic or other abrasion, to a depth equal to 50 percent of the joint width, but not less than 6 mm and not more than 13 mm.

H. Exposed surfaces shall be tooled so as to compress sealants to the profile shown or, if none is shown, surfaces shall be slightly concave except for providing a slight wash on horizontal joints where horizontal and vertical surfaces meet. Against rough surfaces or in joints of uneven widths the appearance of excess sealant shall be avoided by locating the sealant well back into joint wherever possible. Excess sealant shall be removed promptly as the work progresses and the adjoining surfaces cleaned as may be necessary to eliminate any evidence of spillage.

I. If job progress, or any other condition, shall require the installation of sealants at temperatures below those recommended by the manufacturer, the manufacturer's representative shall be consulted to establish the minimum provisions required to ensure satisfactory work. The conditions under which such installations must proceed and the provisions made to ensure satisfactory work shall be recorded in writing.

3.04 Curing and Protection

The sealants shall be cured in accordance with the manufacturer's instructions, to obtain maximum bond to surfaces, cohesive strength and durability at the earliest possible date. The sealants shall be protected during the remainder of the construction period, so that they will be without any indication of deterioration or damage at the time of completion of the Works.

3.05 Performance Test

After curing exterior joints exposed to the weather, the sealant system shall be tested for leaks by applying a stream of water perpendicularly from a 19 mm hose at normal city water pressure or at a pressure determined by the Engineer. Approximately 5 percent of the exposed joint system where leakage could be observed shall be tested. The tests shall be conducted in the presence of the Engineer who will determine the actual percentage of joints to be tested, and the period of water flow exposure, based on any observed leakage. Any leaks shall be repaired and re-tested as directed.

END OF SECTION 07920

DIVISION 8.

DOORS AND WINDOWS

Section 08100

Metal Doors and Frames

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with hollow metal doors and frames.

1.02 Requirements of Regulatory Agencies

Doors and frames shall comply with fire rating requirements as specified and applicable local codes and shall be fabricated in accordance with these requirements for the door opening specified. Fire separation shall be provided as tested in accordance with ASTM E152 or equivalent test method.

1.03 Qualifications

Provide doors and frames manufactured by a firm specialising in the production of hollow metal work and, for hollow metal doors and frames for fire rated openings, manufactured by a firm whose units are inspected and tested for fire rated doors and the certificates are approved by the local authorities.

1.04 Submittals

A. Manufacturer's certification for each metal door and frame which is shown as fire rated. Doors should comply with requirements of the Government and/or local authorities in the Project country as applicable.

B. Shop Drawings:
Show typical details of all conditions at large scale (not less than 1:5) for every opening and number all doors in accordance with a plan agreed with the Engineer.

C. Samples . 450 x 600 mm cut-away sample door with provisions for:
1. Lockset.
2. Pair of hinges.
3. Corner section of door frame.

Part 2 Products

2.01 Materials

A. Cold-rolled sheet steel shall conform to ASTM A 366 and A 568, be free from scale, pitting or other defects, E finish and with stretcher levelled for doors.

B. Galvanized sheet steel shall conform ASTM A 526 and be galvanized in accordance with ASTM A 525 with coating Designation G 90 (275 g/sq. m) zinc coating and phosphatized.

C. Supports and anchoring devices shall be structural steel ASTM A 36; or sheet steel, ASTM A 366 cold-rolled; or ASTM A 569 hot-rolled and ASTM A 568; not less than 16 gauge (1.5 mm) fabrication; and comply with ASTM A 153, Class B.

D. Filler shall be sound deadening, heat-retarding mineral fibre insulating material.

E. Fasteners shall be galvanized or cadmium plated steel.
   1. Bolts and nuts shall be ASTM A 307, Grade A.
   2. Expansion bolts shall be FS-FF-S-325, Group III, expansion shield (self-drilling tubular expansion shell bolt anchors), Type 1 or 2 with galvanized bolts.
   3. Machine screws shall be FS-FF-S-92, Carbon steel, Type III cross-recessed, design I or II recess, style 2c flat head.

F. Sheet steel primers shall be one of the following, compatible with finish and intended service (refer to Section 09900).
   1. FS TT-P-57 Type I (Oil / Alkyd, Zinc Chromate, Iron Oxide base).
   2. FS TT-P-57 Type II (Alkyd, Zinc Chromate, Iron Oxide base).
   3. FS TT-P-86 Type III (Alkyd, Red Lead base).
   4. FS TT-P-664 (Rust-inhibiting, lacquer-resisting, Zinc Chromate, Iron Oxide base).

G. Galvanized steel primer shall be FS TT-P-641 Type II (Alkyd, Zinc Dust-Zinc Oxide).

H. Weather/acoustic seals shall be closed cell sponge neoprene.

I. Glazing shall be as specified in Section 08800 hereof.

J. Provide manufacturers standard hinges, pull and locking handles, door closures and all other hardware required for the operation indicated and as shown on the Drawings. Finish of all hardware items to be approved by the Engineer. All locks shall be grouped with a Master Key System.

2.02 Fabrication

A. Fabricate doors and frames to the design and dimensions shown in accordance with best shop practices. Unless otherwise shown, fabricate doors and panels to a thickness of 45 mm and take field measurements where co-ordination with adjoining work is necessary.

B. Make hollow metal work strong, rigid, neat in appearance and free from defects. Reinforce corners of doors as required to prevent twisting or sagging.

C. Form exposed surfaces free from warp, wave and buckle, with all corners square, unless otherwise shown. Form moulded members straight and true, with joints coped or mitred, well formed, and in true alignment. Dress welded joints on exposed surfaces smooth so they are invisible after finishing.

D. Provide undercuts and clearances for doors as required and for rated doors and panels within the limitations established by the authority having jurisdiction. Prepare doors and frames to receive weather seals and acoustic seals shown or specified.

E. Provide a full mitre continuously welded on back side at frame corners and stops with edges straight and true. Grind welds smooth and flush on exposed surfaces.

F. Accurately machine, file and fit exposed connections with hairline joints unless otherwise shown.
G. Conceal fastenings unless otherwise shown and countersink exposed screws using flat, Philips head screws.

H. Conform to the requirements of the "Structural Welding Code" of the American Welding Society for the welding of steel and provide welds of adequate strength and durability.

2.03 Door Construction

A. Doors shall be made of commercial quality, level, cold-rolled steel conforming to ASTM Designation A-366 and free of scale, pitting or other surface defects. Face sheets shall be 18 gauge for door openings size up to 2000 x 2200 mm and 14 gauge for door openings size greater than 2000 x 2200 mm. Zinc coating of not less than 0.183 kg/sqm shall be used for exterior door face sheets.

B. Door faces, as well as lock and hinge edges, shall have a smooth, seamless and unbroken surface. Doors shall be rigid and neat in appearance, free from warpage or buckle and corner bends shall be true and straight and of minimum radius for the gauge of metal used.

C. Lock and hinge edges shall be formed by full overlap of each face sheet around continuous angle reinforcements projection welded to each sheet at the hinge and lock edges for the full height of door assuring maximum strength.

D. Face sheets shall be stiffened by continuous vertical formed steel stiffeners. Stiffeners shall be formed from not less than 22 gauge steel, spaced not more than 150 mm apart and securely attached to face sheets by spot welds not more than 125 mm on centres. Spaces between the stiffeners shall be insulated the full height of the door and insulation shall be minimum 9.6 kg/cu.m density. Laminated core face sheets shall be bonded under controlled heat and pressure to an inner core consisting of honeycomb, polystyrene extending full width and height of the door. The honeycomb core shall have a minimum 12 mm cell and compression strength shall be 365 kN/sq.m minimum. The pre-expanded polystyrene slab core shall have a density of 16 kg/cu.m. Gypsum core board intended for openings requiring fire rated temperature rise doors. Core shall be mineral based fibreboard having a density of 288 kg/cu.m.

E. Edge seams formed by the face sheets at the lock and hinge stiles shall be closed by a continuous heli-arc weld extending the full height of the door and then ground, filled and cosmetically treated to provide a smooth, seamless surface.

F. All doors shall be mortised and reinforced to allow field application of hinges and locks in accordance with the approved hardware schedule and templates supplied by the hardware contractor. Where surface-mounted hardware is to be applied, doors shall have reinforcing plates only and all drilling and tapping shall be by others. The minimum gauges for reinforcing plates shall be as follows:
   1. Hinge and pivot reinforcements - 7 gauge
   2. Reinforcements for lock face, flush bolts, concealed holders, concealed or surface-mounted closers-12 gauge.
   3. Reinforcements for other surface-mounted hardware - 16 gauge.

G. Where specified or scheduled, doors shall be provided with mouldings in accordance with glass opening sizes shown on approved shop drawings.

H. Louvers shall be of the type of construction providing the free air space specified by the Engineer.

I. After fabrication, all tool marks and surface imperfections shall be dressed as required to make all faces and vertical edges smooth, level and free of all irregularities. Doors shall then be chemically treated to insure maximum paint adhesion and coated on all exposed surfaces with a rust inhibiting primer which is fully cured before shipment.

J. Hollow metal panels shall be made of the same materials and constructed and furnished in the same way as specified for hollow metal doors.

K. All doors shall be chemically washed, rinsed and dried prior to receiving one coat of baked-on texture prime paint.

2.04 Frame Construction

A. Frames shall be made of commercial grade cold-rolled steel conforming to ASTM designation A-366 and be 16 gauge for door openings up to size 2000 x 2200 mm and 12 gauge for door openings greater than 2000 x 2200 mm. Zinc coating of not less than 0.183 kg/m^2 shall be used for exterior openings.

B. All frames shall be custom made units with integral trim of the sizes and shapes shown on approved shop drawings.

C. All finished work shall be strong and rigid, neat in appearance, square, true and free of defects, warp or buckle. Moulded members shall be clean cut, straight and of uniform profile throughout their lengths.

D. Jamb depths, trim profile and backbends shall be as scheduled by the Engineer and shown on approved shop drawings.

E. Corner joints shall have all contact edges tightly closed with trim faces mitred and welded and finished smooth. Use of gussets will not be permitted.

F. Minimum depths of stops shall be 16 mm. Hospital or cut-off stops, where scheduled, shall be capped at 45^{o} at heights shown on the approved shop drawings. All jamb joints below these stops shall be ground and filled smooth.

G. When shipping limitations dictate, frames for large openings shall be fabricated in sections designed for splicing in the field by others.

H. Frames for multiple or special openings shall have mullion and/or rail members which are closed tubular shapes having not visible seams or joints.
   1. All joints between faces of abutting members shall be securely welded and finished smooth.
   2. Frames shall be mortised, reinforced, drilled and tapped at the factory for fully templated mortised hardware only in accord with approved hardware schedule and templates provided by the hardware contractor.
   3. Where surface mounted hardware is to be applied, frames shall have reinforcing plates only.

I. Minimum thickness of hardware reinforcement plates shall be:
   1. Hinge and pivot reinforcements-7 gauge, 38 mm x 220 mm min.
   2. Strike reinforcements-12 gauge
   3. Flush bolt reinforcements - 12 gauge

d. Reinforcements for other surface mounted hardware - 12 gauge.

J. Floor anchors shall be welded inside each jamb with holes provided for floor anchorage and minimum thickness of floor anchors shall be 14 gauge.

K. Frames for installation in masonry walls shall be provided with adjustable jamb anchors of the T-strap, stirrups and strap or wire type. The number of anchors provided shall be as follows per jamb:
1. Frames up to 2.2 m height - 3 anchors
2. Frames 2.2 m to 2.4 m height - 4 anchors
3. Frames over 2.4 m height - 1 anchor for each 600 mm or fraction in height.

L. Frames for installation in stud partitions shall be provided with steel anchors of suitable design not less than 18 gauge thickness, securely welded inside each jamb as follows:
1. Frames up 2.2 m height - 3 anchors
2. Frames 2.2 m height - 5 anchors
3. Frames over 2.4 m height - 5 anchors plus one additional for each 600 m or fraction over 2.4 m.

M. Frames to be anchored to previously placed concrete, masonry or structural steel shall be provided with anchors of suitable design as shown on approved shop drawings.

N. Dust cover boxes or mortar guards of not less than 24 gauge steel shall be provided at all hardware mortises on frames to be set in masonry or plaster walls.

O. All welded frames shall be provided with a steel spreader temporarily attached to the feet of both jambs to serve as a brace during shipping.

2.05 Labelled Doors and Frames

A All doors and frames for labelled openings shall be of the construction and design, having specific Underwriters Laboratories, Factory Mutual and Warnock Hersey International approval according to current procedures for 3-hour or 2 hour fire rating.

2.06 Weather/Acoustic Seals

A Shall comply with the Specifications and be formed to the profiles shown to receive weather seals and acoustic seals. Frames shall be drilled and tapped as required. Seals shall be installed in single lengths for each side with uniform exposure of 10 mm, using adhesive. Other attachments shall be as detailed and as recommended by the seal manufacturer.

2.07 Shop Painting

A. Clean, treat and paint surfaces of fabricated hollow metal work, inside and out, whether exposed or concealed in the construction. Thoroughly clean all metal surfaces of loose scale, shavings, filings, dirt and other deleterious materials by use of wire brushes or other effective means. Remove grease and oil by one of the methods specified in SSPC-SP-1-63 "Solvent Cleaning". Fill as required to seal seams in edges.

B. Finishes
1. Generally:
a. Remove die markings prior to finishing operations.

b. Where necessary to remove die markings from any part of the work, all members must be finished by the same process, whether or not die marking exists.
c. Perform this work in addition to the finish specified.
d. Scratches, abrasions, dents and similar defects are unacceptable.

2. Fluoropolymer Resinous Coating:
   a. AA-C12-RIX in colour to be selected by the Engineer
   b. Using 70 percent minimum "Kynar 500 Fluorocarbon Resin" (Pennwalt Chemicals Corp.) with dry film thickness of top coat of 0.025 mm (1.0 mil).
   c. Finish shall meet the following:
      1. Dry film thickness within minus 5 to plus 25 percent of specified thickness and testing device at processor's option.
      2. Abrasion resistance shall conform to ASTM D968 with coefficient of abrasion to average 70.
      3. Pencil Hardness shall beF-2H Minimum.
      4. Salt spray shall be to ASTM B117 to withstand 1,000 hours in 5 percent salt fog at $35^{O}C$ and shall retain adhesion, corrosion resistance, colour and gloss with no more than a few blisters no larger than No. 4 (ASTM D714).
      5. Humidity Test shall be to ASTM D2247 to withstand 1,000 hours, 100 percent relative humidity at 35 ^{O}C to 37 ^{O}C and shall retain adhesion, corrosion resistance, colour and gloss.
      6. Weatherometer shall be to ASTM G23 to withstand 500 hours exposure in Sunshine Arc Weatherometer, Model XW-R, under 60/60 Dew Cycle conditions with no significant evidence of chalk, colour or gloss change.
      7. Formability shall be to ASTM D1737 with no failure in adhesion or rupture of coating when bent 180 degrees around a 3 mm mandrel.
      8. Gloss shall be to ASTM D523 with average specular gloss of 30 for glossmeter geometry of 60 degrees.
      9. Adhesion shall result in no removal of finish after 1.5 mm cross hatching to base metal, impacting to the point of metal rupture, and subjecting to application and quick removal of cellophane tape.

Part 3 Execution

3.01 Inspection

A The contractor shall examine the substrates, adjoining construction and the conditions under which the work is to be installed and shall not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 Installation

A. Set hollow metal frames at locations shown, in perfect alignment and elevation, plumb, level, straight, true and free from rack.

B. Brace frames to prevent displacement.

C. Extend frame anchorages below fills and finishes, except over membrane waterproofed areas and anchor bottom of frames to floors with anchor bolts or with power driven fasteners. Co-ordinate the installation of built-in anchors for wall and partition construction as required with other work.

D. After wall construction has been completed, remove temporary braces, including spreaders at base of 3 sided frames and leave surfaces smooth and undamaged.

E. Apply hardware in accordance with hardware manufacturer's instructions and fully co-ordinate with him in making the necessary door and frame preparations for and fixing all hardware.
   1. Drill and tap metal door and frames for machine screws as required.
   2. Do not use self-tapping sheet metal screws.
   3. Anchor panels in place with concealed fasteners.
   4. Adjust door installation to provide uniform clearance at head and jambs, and to contact stops uniformly.
   5. Remove and replace doors which are found to be warped, bowed or otherwise damaged and cannot be properly fitted in frames.

F. Remove hardware before painting and re-fix after painting of doors is completed. Adjust and lubricate hardware for proper operation at completion and throughout the Contract Maintenance Period. Instruct Employer's staff in the proper maintenance and adjustment of all hardware supplied.

3.03 Protection and Cleaning

A Upon completion of installation, clean exposed metal surfaces as recommended by manufacturer and leave ready for final painting. Protect units during construction period against deterioration and damage. Replace damaged components as instructed by the Engineer.

END OF SECTION 08100

Section 08210

Wood Doors

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Wood doors and frames.

1.02 Requirements of Regulatory Agencies

Comply with requirements of NFPA and applicable local codes and fabricate door assemblies to comply with the requirements of NFPA No. 80 "Fire Doors And Windows" and be tested and rated for single point hardware by UL or local authorities and as per ASTM E 152 or equivalent test method.

1.03 Quality Criteria

A. Provide doors meeting or exceeding the minimum standards as set forth by the following organizations unless standards are modified or exceeded by this specification.
   1. Architectural Woodwork Institute (AWI), Fourth Edition Section 1300 and 1500.
   2. National Wood Window & Door Association (NWWDA) IS-I-87.
   3. Commercial Standard CS 171-58 Premium Grade.
   4. National Electrical Manufacturers Association (NEMA).
   5. National Fire Protection Association (NFPA).

B. All doors shall be the product of the same manufacturer to ensure uniformity of quality and appearance throughout the project.

C. Fire doors shall meet with the approval the local authorities.

D. Any discrepancies between the architectural drawings, and the procedures and limitations as set forth by the testing agencies shall be brought to the Engineer's attention.

E. Provide each labelled fire rated door with a label permanently attached to either the hinge stile or the top rail showing testing agency approval for classification scheduled.

1.04 Submittals

A. Shop Drawings
   1. Schedules and elevations indicating door sizes, construction, swing, label, undercut and applicable hardware locations.
   2. Dimension and detail openings for glass lights, louvers and grills.
   3. Number all doors in accordance with a plan agreed with the Engineer.

B. Samples. If doors are to be factory finished, manufacturer shall submit veneer samples of specified veneer with their standard finish colours at Engineer’s request.

1.05 Coordination

A. Contractor shall be responsible for coordination and obtaining all necessary information from hardware and metal frame manufacturers.

B. Door manufacturer shall be responsible for coordinating all necessary information received by the Contractor from hardware and metal frame manufacturers in order that doors shall be properly prepared to receive hinges and hardware.

1.06 Delivery, Storage And Handling

A. Doors shall be shipped palletized in stacks of no more than 30 doors per pallet and door edges shall be protected by heavy corner guards. Doors shall not be delivered to the building until weather-proof storage space is available. Doors shall be stored in a space having controlled temperature and humidity range between 30 and 60 percent. They shall be stacked flat and off the floor, supported to prevent warpage and protected from damage and direct exposure to sunlight. Other materials shall not be placed on top of stacked doors.

B. Factory finished doors shall be individually wrapped in black plastic bags to protect the finish from damage by contact with other doors and exposure to ultra violet rays.

C. Use all means necessary to protect doors from damage prior to, during and after installation.

1.07 Warranty

A Provide a written warranty from the door manufacturer that provides for the replacing, as originally furnished from the factory, any door exhibiting defects in materials or workmanship, including: delamination in any degree; warp or twist of 6 mm or more; telegraphing of any part of core unit through face to cause surface variation of 0.25 mm or more in any 75 mm span; or any defect which may, in any way, impair or affect performance of the door for the purpose which it is intended. Replacement under this warranty shall include hanging, installation of hardware and finishing.

Part 2 Products

2.01 Materials And Components

A. Cores
   1. Particleboard core shall conform to Type I density 450-480 kg/cu.m, Class 1, commercial standard #236-66.
   2. Mineral core shall be asbestos-free, non-combustible mineral composition with minimum 450 kg/cu.m density when tested in accordance with ASTM # C303-82 and with ten percent maximum absorption by weight with core in equilibrium at 90 oercent relative humidity and 21^{o}C.

B. Edge Banding Stiles
   1. Particleboard core
      a. Unless otherwise specified, a 38 mm double banded laminated hardwood stile shall be edge glued to the core.
      b. Outer band shall be of material compatible with face veneer of door.
      c. No finger joints shall be allowed in the outer band.
      d. 25 mm minimum softwood stile shall be used for edge framed construction.

2. Mineral core
   a. Shall be manufacturer's standard for application of full mortise hinges and the required label.
   b. No salt impregnation allowed.

C. Edge Banding Stiles
   a. Particleboard core
      1. 32 mm mill option hardwood when used with edge glued construction.
      2. 32 mm softwood shall be used for edge framed construction.
   b. Mineral core. Shall be manufacturer's standard for application of the required label.

D. Doorskins for wood veneered doors shall consist of a minimum 3-ply construction (face veneer, crossband and back veneer). Components shall be laminated to form a doorskin having a minimum thickness of 3.2 mm.
   1. Face veneers shall be of teak.
   2. Quality shall be governed by the ANSI/NWWDA and AWI (Sec. 1300-S-2).
   3. Minimum thickness prior to factory sanding shall be 0.6 mm.
   4. Crossband shall be thoroughly dried hardwood, extending full width and height of door with grain at right angles to the face and back veneers.
   5. Back veneer shall be mill option thoroughly dried hardwood extending full width and height of door with grain parallel to the face veneer.
   6. When plastic laminate door construction is specified:
      a. Unit shall consist of 3 plies (face, core, face).
      b. Faces shall have minimum thickness of 1.25 mm thick high pressure decorative laminate.
      c. Stile shall be mill option hardwood.

2.02 Lights

A Provide openings where shown for lights. Glazing beads shall be of hardwood. Glass in openings in doors and in transoms and sidelights shall be 6mm Georgian Wired clear polished plate glass in accordance with Section 08800.

2.03 Prefitting and Prematching

A. Prefit doors and panels in accordance with tolerance requirements of Commercial Standard CS 171 or NWMA Industry Standard I.S. 1, at the place of manufacture and provide standard bevel or radius to edges of doors as required by the installation.

B. Machine doors and panels for hardware requiring cutting of the doors at the place of manufacture. Machining shall be in accordance with hardware templates.

2.04 Shop Applied Lacquer

Door faces, edges and cutouts shall have one coat shop applied lacquer as specified at the place of manufacture. Surfaces shall be clean and dry before applying lacquer. Apply lacquer uniformly without runs, sags or bare spots to a dry film thickness of 25 microns.

2.05 Hardware

Provide first quality stainless steel door hardware including locks, with master key system, handles and door closures, etc.

Part 3 Execution

3.01 Inspection

The Contractor shall examine the Substrates, adjoining construction and the conditions under which the Work is to be installed and shall not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 Installation

A. Do not install doors until concrete, masonry, plaster, tile and other wet work is completed and dried in the areas to receive doors.

B. Doors shall be conditioned to the average prevailing moisture (humidity) of the locality before hanging and shall not be subjected to abnormal heat, dryness, or humidity. Avoid sudden changes such as forced heat.

C. Cutting, trimming, fitting and machining of prefinished doors will not be permitted.

D. Install doors in required openings as shown and install flush panels with concealed fasteners.

E. Apply hardware in accordance with hardware manufacturer's instructions. Adjust door installation to provide uniform clearance at head and jambs, and to contact stops uniformly. Remove and replace doors which are found to be warped, bowed or otherwise damaged and cannot be properly fitted in frames.

F. Remove hardware before painting and refix after painting of doors is completed. Adjust and lubricate hardware for proper operation at completion.

3.03 Cleaning And Protection

Upon completion of installation of doors, clean all exposed surfaces as recommended by the manufacturer.

END OF SECTION 08210

Section 08330

Rolling Shutters

Part 1 General

1.01 Description

The work covered by this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Rolling Shutters.

1.02 Requirements of Regulatory Agencies

All work shall be in accordance with the requirements of the authorities having jurisdiction and all applicable codes, rules and regulations, and ordinances.

1.03 Qualifications

Rolling shutters shall be installed and in full operative condition by experienced workmen in the type of installation required.

1.04 Submittals

A. Copies of manufacturer's specifications and installation instruction for each type of rolling shutter to show compliance with these Specifications.

B. Samples of each curtain slat shall be provided. The Engineer's review of samples shall be for design only and the requirements are the exclusive responsibility of the Contractor.

C. Shop Drawings:
   1. Detailed drawings of special components required for the proper installation including anchoring and supporting systems.
   2. Prepare details at 1:5 minimum scale as approved by the Engineer and show details of adjacent wall and ceiling finishes.
   3. Number all doors in accordance with a plan agreed with the Engineer.

1.05 Delivery, Storage And Handling

Deliver rolling shutters and accessories completely identified for installation procedure.

1.06 Electrical Wiring

Provide insulated wiring meeting local regulations and provide electric power to isolators situated near the motors and wire from the isolators to the motors, control buttons and switches. Provide motors and other devices which are compatible electrically with building system voltage.

Part 2 Products

2.01 Rolling Shutters

A. All shutters shall be provided by a single manufacturer.

B. Steel Shutters:
   1. Fabricate interlocking flat slats from rolled open hearth 18 gauge (1.2 mm) steel.
   2. Use malleable end locks and wind locks.
   3. Hot dip galvanize steel curtain with a high grade pure zinc coating 0.38 kg/m^2 of flat metal complying with ASTM A 90 and ASTM A153 free from blisters and other imperfections.
   4. Bowdlerize galvanised surfaces for paint adhesion.
   5. Fabricate a bottom rail and guides of structural steel.

C. Features
   1. Design curtain to safely withstand a wind loads of 735 N/mm^2 for internal shutters and 980 N/mm^2 for external shutters.
   2. Provide shutters with end locks, wind locks and weather seals.
   3. Provide each shutter with bottom bar of two angles back-to-back, weather seal and safety bar is attached.
   4. Coil each shutter on steel pipe of size sufficient to carry shutter load with a deflection not to exceed 1:400 of opening width, evenly balanced by springs. All springs shall be anchored to the same tension rod and held in position by the same adjusting wheel accessible from the outside of housing.
   5. Provide coil brackets of heavy cast iron or fabricated steel to house the ends of the coil. Fit ends of roller shaft into bracket hubs of sufficient thickness to provide ample bearing surface for roller shaft and curtain. Equip operator bracket hub and plug-in spring end of shaft with self-lubricating bronze bearings or permanently lubricated sealed ball bearings.
   6. Fabricate coil hood from not less than 24 gauge (0.60mm) galvanised sheet metal, reinforced as required for length of run. Provide removable ceiling panel for access to mechanism and removal of roller.

D. One and a half (1 1/2) Hour 'B' Label, tested in accordance with ASTM E152 or equivalent test method.

Part 3 Execution

3.01 Inspection

The Contractor shall examine the Substrates, adjoining construction and the conditions under which the Work is to be installed and shall not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 Installation

Install doors in accordance with manufacturer's instructions. Anchors and inserts for guides, brackets, motors, controls, switches, and other work shall be accurately located. Upon completion, doors shall be free from warp, twist, or distortion and shall be lubricated and adjusted to operate freely acceptable to the Engineer.

3.03 Cleaning and Protection

Following complete installation of each rolling shutter, clean surfaces, joints and bearings of unit in accordance with manufacturer's instructions and lubricate as recommended by manufacturer. Protect each rolling shutter during construction period from weathering,

deterioration or damage from any source so that it will be without any indication of use or damage at the time of completion of the Works.

END OF SECTION 08330

Section 08365

Rolling Service Doors

Part 1 General

1.01 Description

The work covered by this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with rolling service doors.

1.02 Requirements of Regulatory Agencies

All work shall be in accordance with the requirements of the authorities having jurisdiction and all applicable codes, rules and regulations, and ordinances.

1.03 Qualifications

Rolling Service Doors shall be installed and in full operative condition by experienced workmen in the type of installation required.

1.04 Submittals

A. Copies of manufacturer's specifications and installation instruction for each type of rolling door to show compliance with these Specifications.

B. Samples of each curtain slat shall be provided. The Engineer's review of samples shall be for design only and the requirements are the exclusive responsibility of the Contractor.

C. Shop Drawings
   1. Detailed drawings of special components required for the proper installation including anchoring and supporting systems.
   2. Prepare details at 1:4 minimum scale as approved by the Engineer and show details of adjacent wall and ceiling finishes.
   3. Number all doors in accordance with a plan agreed with the Engineer.

D. Operating and Maintenance Manuals. Three copies of the manufacturer's operating and maintenance manuals including parts lists and all other information needed for proper operation and maintenance of Rolling Service doors.

1.05 Delivery, Storage and Handling

Deliver rolling service doors and accessories completely identified for installation procedure.

1.06 Electrical Wiring

Provide insulated wiring meeting local regulations and provide electric power to isolators situated near the motors and wire from the isolators to the motors, control buttons and switches. Provide motors and other devices which are compatible electrically with building system voltage.

Part 2 Products

2.01 General

A. All doors shall be provided by a single manufacturer

B. Service door openings shall be equipped with approved insulated doors.
   1. Curtains:
      a. Curtains shall be of interlocking flat slats, rolled not drawn, formed in many curves without sharp bends from galvanized and bonderized steel material.
      b. Slats designed to adequately resist a minimum wind load of 980 N/mm^2.
      c. Inside curtain face shall be comprised of self-locking rigid PVC extrusion cover encasing 19 mm thick expanded polystyrene foam insulation. Use expanded polystryene insulation which is not manufactured with, nor contains, chlorofluoro-carbons (CFC's).
      d. Curtain to have a continuos thermal break from sill to above lintel, with no metal to metal contact on the interior side of the door.
      e. Ends of the alternate slats be provided with wind locks which engage bars and lock the curtains into the guide.
      f. Bottom of curtain shall be reinforced with two angles, separated by polystyrene expanded foam insulation, and fitted with neoprene bottom weatherseal.
   2. Counterbalance:
      a. Curtain to be coiled on a pipe or barrel of size sufficient to carry the door load with a deflection no to exceed 1:400 of opening width.
      b. To be evenly balanced by helical springs contained in the pipe.
      c. All springs shall be anchored to the same tension rod and held in position by the same adjusting wheel accessible from the outside.
   3. Coil Brackets shall be of precision formed steel plate, with sealed ball bearing and minimum thickness 4.8 mm designed to house ends of coils.
   4. Hoods:
      a. Coil to be housed with a minimum of 24 gauge steel-metal hood, galvanized and bonderized with a high grade zinc coating per ASTM standards.
      b. Lintel weather stripping to be applied to minimize air infiltration, comprised on nylon brush stripping attached to lintel extending the full width of the opening.
   5. Guides:
      a. Built structural steel roll-formed channels to form a slot of sufficient depth to retain curtains in guides against heavy wind pressure.
      b. Guide is designed with an integral wind lock bar.
      c. Structural Steel angles of minimum 4.8 mm thickness.
   6. Guide Insulation Assembly:
      a. Jambs at each of end of the opening will be totally weather stripped and furnished with a thermal break to minimize heat loss transmission from interior to exterior.
      b. Guide insulation assembly will be equipped with a continuos brush seal application extending from floor to lintel, both inside and outside.
   7. Test Procedure:
      a. Thermal transmittance test results in accordance with ANSI/ASTM C-236 will be submitted to the engineer upon request.
      b. Thermal transmittance due to conduction (of the total door and opening) shall not exceed the (U) value of 3.58 W/m^{2}k.

C. Safety Device and Weather Seal:
   1. Curtain bottom bars shall be provided with a weather seal and electrical safety device which shall be an electrical device working in conjunction with the operator control.

2. A compressible strip shall be mounted along the bottom of each rolling door curtain.
3. Strip shall compress, activating the electrical control that will automatically stop and return the door to its fully raised position.
4. Compressible strip shall also serve as a weather strip along the bottom of the door.

D. Electric Power Operators:
   1. Motor:
      a. Doors shall be provided with an electrically operated motor and controls wired for operation on voltage indicated in electrical drawings.
      b. Operator shall be bracket-mounted and provided with a protective galvanized sheet metal housing.
      c. Motor shall be high-starting tongue hoist-type having sufficient power to operate the door at an average speed of 0.3 m/s.
   2. Controller:
      a. Doors shall be controlled by a momentary contact, 3-button pushbutton station marked OPEN, CLOSE, STOP, and an automatic screw-type limit switch which will break the switch at termination of travel.
      b. Pushbutton stations shall be housed in NEMA 4X enclosures.
      c. High-efficiency work gearing, running in an oil bath shall be furnished together with a spring-set, solenoid-operated brake completely housed to protect against damage, dust, and moisture, and a magnetic reversing contactor in NEMA Type 4X enclosure.
      d. Emergency hand chain operator which does not affect the timing of the limit switch shall be provided to operate the door in case of power failure or removal of the motor for inspection or servicing.
   3. Operators:
      a. Operators shall be designed to transmit motion to the door without shock and shall automatically release motor from drive unit prior to stalling, so as to prevent damage to unit from overload.
      b. An efficient heat and current-sensing overload protective device, installed integrally with the unit, shall break the control circuit to eliminate damage to motor windings.
   4. Motors shall be the manufacturer's standard power, except motors shall be not less than 0.37 kW.

Part 3 Execution

3.01 Inspection

The Contractor shall examine the Substrates, adjoining construction and the conditions under which the Work is to be installed and shall not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 Installation

Install doors in accordance with manufacturer's instructions. Anchors and inserts for guides, brackets, motors, controls, switches, and other work shall be accurately located. Upon completion, doors shall be free from warp, twist, or distortion and shall be lubricated and adjusted to operate freely acceptable to the Engineer.

3.03 Cleaning and Protection

Following complete installation of each rolling shutter, clean surfaces, joints and bearings of unit in accordance with manufacturer's instructions and lubricate as recommended by manufacturer. Protect each rolling shutter during construction period from weathering, deterioration or damage from any source so that it will be without any indication of use or damage at the time of completion of the Works.

3.04 Manufacturer's Services

Furnish the services of the electric door operator manufacturer's field service technician to inspect each final installation and supervise initial operation of the units. Manufacturer's certificate shall be submitted to the Engineer prior to testing the equipment. Furnish the services of the electrical door operator manufacturer's trained representative for a minimum of 1 trip of 1 day to instruct plant personnel on proper operation and maintenance procedures. Service may be combined with the inspection services specified above.

END OF SECTION 08365

Section 08520

Aluminium Doors, Windows and Screens

Part 1 General

1.01 Description

The work included in this section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with aluminium doors windows and screens.

1.02 Qualifications

A. Provide aluminium doors, windows and screens manufactured by a firm specialising in their production.

B Installation shall be carried out by workmen experienced in the type of installation required.

1.03 Submittals

A. Copies of manufacturer's specifications and installations and other data to show compliance with these specifications.

B. Shop drawings of all components including full size sections of all typical members, dimensioned elevations, anchors and other accessories required. Show glass thickness, glazing details and anti-burglar aluminium grills screw-fixed to the framing or anti-burglary laminated glazing where shown on the drawings. Number all doors in accordance with a schedule agreed with the engineer.

C Samples
1. Set of samples for each type, finish and colour.
2. Specified alloy on 300 mm lengths of extrusion, show the maximum range or variation in colour and shade.
3. Approval shall be for colour, texture, and specular gloss only and compliance with all other requirements is the exclusive responsibility of the contractor.
4. Sample corners of door and window units, with hardware, representative of fabrication techniques and workmanship of the final products.

1.04 Warranty

Submit a guarantee for a period of five years that the fluoropolymer resinous coating will not develop excessive fading or excessive non uniformity of colour or shade and will not crack, peal pit or corrode.

1.05 Delivery, Storage and Handling

Deliver all components to project site completely identified. Before dispatch from the manufacturer’s works all exposed surfaces shall be protected with a suitable low tack tape, or other means of protection recommended by the manufacturer. Adhesion resistance to atmospheric conditions and elasticity of the tape shall be suited to the purpose intended. If

during fixing or glazing any protection is removed, it must be refitted or replaced immediately afterwards.

Part 2 Products

2.01 General

A Except as otherwise indicated, units shall comply with all applicable requirements including air infiltration tests, water resistance tests, and applicable load tests specified in ANSI/AAMA 302.9 classification "PA-3 HP 60" and shall be suitable for a design wind load of 1780 n/m^{2}..

1. Tested in accordance with DD4 1971 up to severe exposure for water and air filtration or ASTM E 283 and E 331 and a certification of testing shall be provided.
2. Test reports indicating compliance shall be submitted prior to approval.
3. Doors, windows and screen units shall meet or exceed the following values.
   a. Air infiltration shall not exceed 0.046 l/sec./m of ventilator perimeter when subjected to a static pressure drop of 298 n/mm^2 (80 km/hr.).
   b. No water leakage shall occur during 15 minute application of 204 litres/sqm of window area under a static pressure of 298 n/mm^2 (80 km/hr).
   c. Maximum deflection of any member shall not exceed 1/175 of its span when tested for performance under uniform loading in accordance with ASTM E 330. When the load is removed there shall be no evidence of permanent deformation or damage.
4. Permanent deformation, disengagement or breakage of frame members and weld or fastener damage or failure shall not occur under loading equal to 1.5 times the design load and pressure, positive or negative. Permanent deformation is defined as deflection without recovery exceeding length 1000.

B. Anchorage disengagement or breakage shall not occur when installed unit is subjected to a force equal to 2.5 times the design load.

C. Make provisions at sill to drain water and condensation to exterior face of the frames.

2.02 Materials

A. Aluminium extrusions
   1. Shapes as shown and as required to fulfil performance requirements, but not less than 3 mm thick and not less than 150 mm wide, unless otherwise shown.
   2. Suitable alloy and proper temper for extruding and fabricating with adequate structural characteristics, and suitable controlled alloy and temper as recommended by aluminium manufacturer to provide required colour and colour matching.

B Aluminium sheets and plates
   1. Minimum 3 mm thick or as required to fulfil performance requirements.
   2. Suitable alloy and proper temper for forming and fabricating with adequate structural characteristics and suitable for finishing as required.

C Steel angles, plates, bars, rods and other steel accessories required to join or reinforce assembly of aluminium components. ASTM a36 and ASTM a283, galvanized or, if galvanising is not compatible with alloy or component parts, shop painted with zinc chromate primer after cutting to size.

D Aluminium angles, plates, bars and other aluminium members required to join or reinforce assembly of aluminium components. Alloys recommended by manufacturer or fabricator to develop required strength of assembly.

E Fasteners. Stainless steel type 300 series, selected to prevent galvanic action with the components fastened. Where exposed in finished surfaces, use oval-head countersunk Phillips heads with colour to match adjacent surfaces.

F Weather stripping. Moulded PVC gaskets, moulded expanded neoprene gaskets or moulded neoprene gaskets, factory applied in an integral dovetail self-locking groove.

G Bituminous paint. As specific in Section 09900 hereof.

H Hardware
1. Provide manufacturer's standard hinges, supporting arms, door closures, pull and locking handles, locks (with master key system) and all other hardware required for the operation indicated.
2. Hardware shall be fabricated of stainless steel complying with ASTM A167 and finished to match the component to which it is fixed.

I Glass and glazing. As specified in Section 08800 hereof.

2.03 Aluminium Doors and Windows

A General
1. Construct aluminium door, window and screen units to the sizes and dimensions shown on the drawings and as specified.
2. Doors and openable parts of the window and screen units (ventilators) shall be complete with all necessary hardware including bolts.

B Unit construction
1. Glazed doors, windows and screens:
   a. Provide framed members, fabricated with mitred joints, structurally welded with reinforcing inserts to develop the full strength of the metal and maximum rigidity in the frame assembly.
   b. Fabricate doors of thickness indicated on the drawings and of sections which shall allow replacement of glass from inside without disassembly of doorstile and rails.
   c. Provide snap on extruded aluminium glazing stops with exterior stops anchored for non-removal.
   d. Provide sound deadening filler material on inside of stiles and rails.
   e. Clearances for door shall be 2 mm at jambs and heads, 6 mm clearance above finish floor except for carpet and 15 mm for carpets.
   f. Mortise, reinforce, drill and tap doors to receive hardware in accordance with hardware schedule.
   g. Openable (not sliding) windows shall be "turn & tilt" type wherever shown on the drawings.
2. Ventilators:
   a. Mitre cut all corners, weld throughout entire section profile and dress welds smooth on all exposed and contact surfaces.
   b. Vent members shall be designed to overlap the frame members to provide an uninterrupted compression seal around the entire perimeter of the window members providing true pressure equalising and to allow frictionless operation during opening and closing.

3. Frames, mullions and transoms:
   a. Mitred, sealed rigidly and permanently joined.
   b. Frames to be in one piece of largest size possible.
   c. Provide intermediate support members where shown on the drawings or as required.

2.04 Aluminium Finishes

A General:
1. Remove die markings prior to finishing operations.
2. Where necessary to remove die markings from any part of the work, all members must be finished by the same process, whether or not die marking exists.
3. Perform the work in addition to the finish specified.
4. Scratches, abrasions, dents and similar defects are unacceptable.

B Finish shall be a one component fluoropolymer 3 coat system, factory applied with a total dry thickness of. 40 microns conforming to/exceeding the requirements of AAMA 605 by an approved applicator.

2.05 Aluminium & Glass (External) Colours

A Colour of the aluminium and outer glass shall be as specified in the particular specifications.

B Contractor may select glass from an established manufacturer in North America, Western Europe or Japan, with the provision that both the manufacturer and the colour shall be approved by the engineer.

C The engineer will require at least four mock-ups of different colours to be made in order to make a final selection of the colours.

2.06 Fabrication

A Complete the welding, cutting, drilling and fitting of joints prior to finishing.
1. Weld with electrodes and by methods recommended by the metal manufacturer in accordance with applicable recommendations of the AWS.
2. Use only methods which will avoid distortion or discoloration of exposed faces.
3. Grind weld areas smooth before proceeding with other treatment.

B Conceal all fastenings unless otherwise shown or specified.

C Fit and assemble all work in the shop as far as practicable. Mark and disassemble units which are too large for shipment to project site. Retain units in sizes as large as possible for shipment and erection.

D Carefully fit and match all work with continuity of line and design, using rigidly secured joints with hairline contact, mitred corners, unless otherwise shown.

E Reinforce members and joints with steel or aluminium plates, bars, rods or angles for rigidity and strength as needed to fulfil performance requirements using concealed fasteners for jointing which cannot be welded.

F Separate unlike metals or alloys with a heavy coating of bituminous paint or other suitable permanent separation as required to prevent galvanic action.

Part 3 Execution

3.01 Inspection

The contractor shall examine the substrates and adjoining construction and conditions under which the work is to be installed and shall not proceed with the work until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 Installation

A Verify dimensions of openings by field measurements so that aluminium doors, windows and screens will be accurately designed, fabricated and fitted to the structure.

B Co-ordinate aluminium doors, windows and screens, with the work of other trades and provide items to be placed during the installation of other work. Check the location of such items and verify that they have been set accurately in relation to the final location of doors, windows and screens.

C Erect the doors, windows and screens, in accordance with the manufacturer's written instructions and recommendations and employing only experienced erectors.

D Erection tolerances shall be variation from plumb: 3 mm maximum and variation from level: 3 mm maximum.

E Cut and trim component parts during erection only with the approval of the manufacturer or fabricator and in accordance with his recommendations.
1. Do not cut through reinforcing members.
2. Restore finish completely to protect material and remove all evidence of cutting and trimming.
3. Remove and replace members where cutting and trimming have impaired strength or appearance.

F Do not erect members which are observed to be warped, bowed, deformed or otherwise damaged or defaced to such extent as to impair strength or appearance. Remove and replace members damaged in the process of erection, as directed.

G. Set units level, plumb, and true to line, with uniform joints.
1. Support on metal shims and secure in place by bolting to clip angles and similar supports anchored to supporting structure.
2. Use only the types of equipment, ropes, wedges, spacers, shims and other items during erection which will not stain or mark the finish of units.

H Paint concealed contact surfaces of dissimilar materials with a heavy coating of bituminous paint, or provide other separation as per manufacturer's recommendations.

I Weld with electrodes and by methods recommended by manufacturer of material being welded, and in accordance with appropriate recommendations of the AWS.
1. Use only methods which will avoid distortion or discoloration of exposed faces.
2. Grind exposed welds smooth, using only clean wheels and compounds which are free of iron or iron compounds.
3. Restore finish of component parts after welding and grinding.

J Solder and braze only to fill or seal joints (not to form structural joints), and in accordance with component part manufacturer's recommendations. Grind smooth and restore finish.

K Paint clip angles and other ferrous metal parts which will be concealed, with zinc chromate paint.

L Seal joints in concealed manner, unless exposed sealant is shown.

M Adjust ventilators and hardware to provide a tight fit at contact points and at weather stripping. Lubricate hardware and other moving parts.

3.03 Protection and Cleaning

A Carefully remove protective material and clean down aluminium doors, windows and screens. Cleaning and protective methods shall be carefully selected, applied and maintained so that finishes will not become uneven or otherwise impaired as a result of unequal exposure to light and weathering conditions.

B Remove deleterious materials from surfaces of aluminium immediately.

END OF SECTION 08520

Section 08710

Finish Hardware

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Finish Hardware.

1.02 Requirement of Regulatory Agencies

Furnish hardware in accordance with NFPA Standard No. 80 for openings specified for a fire rated opening or to receive a UL label. In case of conflict between type of hardware specified and type required for fire protection, furnish type required by NFPA and UL. Furnish hardware of type listed by UL for usage with the types and sizes of fire doors and frames required. Unless otherwise shown or specified, arrange doors at fire rated openings to remain in the normally closed position by furnishing each unit with an automatic closing device. Furnish active latch bolts of UL approved throw that cannot be held in retracted position.

1.03 Hardware Schedule

Refer to the door schedule on the Drawings.

1.04 Detail Requirements

A. Where the type of hardware specified is not adaptable to the finished size of members requiring hardware, submit an item having a similar operation and quality to the Engineer for review.

B. Make finish hardware to template, with wood and/or machine screws as applicable to door and frame details. Furnish templates and schedules to door and frame manufacturers and other trades requiring same so that doors and frames can be cut, reinforced and prepared in the shop to receive hardware.

C No names, designs, or labels will be permitted on turn-pieces, operating trim of lock sets or latch sets, push bars, pull handles or plates.

D. Where several manufacturers are specified for one type of hardware, use only the products of one manufacturer.

1.05 Submittals

A. Copies of manufacturer's specifications, maintenance and keying manuals, and installation instructions (templates to suit each particular installation), for each item of finish hardware. Include photographs, catalogue cuts, marked templates and other data as may be required to show compliance with these Specifications.

B. Samples:
   1. One sample of each typical item of exposed hardware.
   2. The Engineer's review of samples will be for design, pattern, finish and colour only.

3. All other requirements are the exclusive responsibility of the Contractor.
4. After final review, deliver samples to job site for comparison with hardware delivered for installation.
5. Unblemished samples may be used in work.

C. Finish Hardware Schedule:
1. Copies of finish hardware schedule covering complete identification of all items required for the project.
2. Include manufacturer's names and identification of finishes.
3. Include a separate schedule of key and master key system with final submittal of schedule.
4. The Engineer's review of schedules shall neither be construed as a complete check nor shall relieve the Contractor of responsibility for errors, deviations or omissions from requirement to provide complete hardware for project.

D. Original of statement stating that the finish hardware work complies with these Specifications, and that the methods of installation were proper and adequate for the condition of installation and use. Statement of application shall be signed by the Contractor.

1.06 Delivery, Storage and Handling

A. Delivery:
1. Deliver hardware in manufacturer's original, unopened packages.
2. Package and label each item of hardware separately.
3. Tag each item in accordance with the final hardware schedule.
4. Each package shall contain appropriate fastenings, instructions and installation templates.
5. Protect all items from loss or damage in shipment.

Part 2 Products

2.01 Hardware Finishes

A. Produce finishes to exact match with Engineer's selected samples.

B. Reduce variance in hue in the colour of each finish, as much as possible, whether the base material is cast, forged or stamped, or when plating is applied over steel, brass or bronze.

C. Finishes of the same designation, that come from two or more sources, shall match when the items are viewed at arms length and approximately 600 mm apart.

D. Unless otherwise specified, match the finish of each item of hardware with the finish selected for lock sets and latches.

E. Type of finish for each hardware is indicated on the Drawings.

2.02 Fasteners

A. Provide concealed fastenings where-ever possible.

B. The use of self-tapping or sheet metal screws is prohibited except for the application of flush mounted push and kick plates.

1. Concealed Fasteners. Furnish hardware with items with appropriate type and length of screws or other fastenings suitable to ensure permanent anchorage.
2. Exposed Fasteners. Furnish hardware with counter sunk Philips oval head type screws where concealed fastening is not possible. The finish or colour of these screws is to match that of the hardware item being fastened.

2.03 Butt Hinges

A. Provide all hinges with machine or wood screws as required by door and frame construction. Where door jamb or trim projects to such an extent that the width of leaf specified will not allow the door to clear such frame or trim, furnish hinges with leaves of sufficient width to clear. Furnish template hinges in accordance with door and frame material required.

B. Sizes for 45 mm door thickness shall be 100 x 100 mm.

C. Quantities per door leaf:

	Height of Door	No. of Hinges
1.	1.50 m or less	2
2.	1.51 m to 2.25 m	3
3.	2.26 m to 3.00 m	4

D. Hinge Base Metals. Interior: Stainless Steel.

E. Butt Hinge Characteristics. The following apply throughout the work:
   a. Ball Bearing. Bearings contained within, or flush, with barrels and minimum metal gauge 3.3 mm.
   b. Plain Bearing. Five knuckle flush barrel and minimum metal gauge 3.3 mm.
   c. Pins. All interior hinges are to have non-rising pins. All exterior hinges are to have non-removable pins (NRP).
   d. Tips: Button.
   e. Application. Full mortise.

2.04 Mortise Locks, Latches and Deadlocks

A. Furnish mortise type lock sets and latch sets as scheduled.

B. All lock sets, latch sets or deadlocks to be furnished complete with trim and 5-pin cylinders.

C. Provide strikes for each lock set, latch set or deadlock with lips of sufficient length to protect frames. Provide a minimum 21 mm throw on lock sets and latch sets for pairs of doors and a minimum 21 mm throw on deadlocks for pairs of doors.

2.05 Cylinders

A Standard 5-pin cylinders keyed into building system to suit lock functions.

2.06 Narrow Stile Door Locks

A Locks to be furnished less cylinders. Master keyed cylinder 5-pin to be supplied as specified for Mortise locks.

2.07 Panic Devices

A. Single Doors: Rim type for single door; UL-Listed for fire exits and cylinder outside or no outside operation.

B. Double doors: One rim type and one rim vertical type, UL-listed for fire exits.

C. Furnish panic devices where scheduled, subject to the following:
   1. Keyed devices shall be furnished less cylinders. Cylinders shall be as herein before specified, keyed to building system.
   2. Outside Trims and Pulls shall be as specified.

2.08 Overhead Surface Door Closers

A. Closer sizes shall be as recommended by the manufacturer unless larger sizes are scheduled. They shall be full rack and pinion and have independent closing speed and latch regulating valves with adjustable backcheck and furnished for 180 degree opening where partitions will permit.

B. Additional features shall include reversible (non-handed) application permitting regular or parallel arm placement to suit door and installation requirements.

C. Overhead surface door closers shall be provided to all doors.

2.09 Flush Bolts

To be furnished in pairs (top and bottom of door) with the top bolt in a length sufficient to locate the flush bolt operator no more than 1.8 m above the finished floor. Furnish standard strikes for top bolts and "Dust-Proof Strikes" for bottom bolts. Flush bolts for metal doors to comply with ANSI A115.4 and for wood doors to have min 10 mm rods with a throw of min. 15 mm.

2.10 Pull Handles

Pull Handles shall be 225 mm “D” Handles located directly opposite each other where handles are require each side of the door. Provide bolt through fixing employing counter sunk corrosion proofed bolts with cup washes and locking patches.

2.11 Push Plates

Push plates shall be 300 mm X 100 mm X 2 mm minimum metal thickness.

2.12 Emergency Exit Devices

Emergency Exit Devices shall comply with the performance and dimensional requirements of BS 5725 or DIN 7140 and be mortise type with latches and vertical bolts concealed with stainless steel exposed surfaces unless otherwise specified. Keyed emergency devices shall be master keyed together with other locks.

2.13 Kick Plates

Surface mounted, bevelled 3 sides, 1.25 mm minimum metal thickness and mounted with oval head Philips fasteners. Size 100 mm high x door width less 37 mm for single doors or door leaf less 19 mm for pairs.

2.14 Door Stoppers

Door stoppers shall be provided for all metal, wooden and aluminium doors and shall be floor mounted except in wet areas. Size shall be 47 mm diameter with a 38 mm projection and wall mounted projection to be at least 63 mm and provided with a 45 mm long 12 g screw.

2.15 Keying System - Keying Control

A. Provide 3 change keys per cylinder.

B. Great grand master key system shall cover all door types such as wood, metal, aluminium doors, etc. The system has to be designed by the hardware supplier for approval of the Engineer and the Employer.

C. Cylinders have a minimum of 5 pins.

D. Provide keys of nickel silver only.

E. Provide 5 keys for each master key level.

F. Doors with panic devices shall have key operation from both sides.

G. Finish of cylinders shall be US 15 to match finish of the hardware finish.

H. Provide temporary cylinders for use during construction only.

I. Provide 10 construction keys during construction period.

J. After completion of installation and prior to handing over to the Employer, the architectural hardware supplier shall organise the transfer from construction master key system to the approved master key system.

K. Provide steel key cabinet with cabinet lock having capacity of 200 hooks.

L. On handing over each key shall be fitted to a coloured nylon key tag with clear labelling of cylinder/key marking. All individual keys shall be placed on the hooks inside the key cabinet except the master keys, which are to be handed over in a sealed envelope by the hardware supplier's AHC. Each key shall have its door number punched on it.

Part 3 Execution

3.01 Installation General

A. Receive hardware for doors as shown and scheduled, and as specified in the applicable hardware Sections of these specifications. Store in a locked space to prevent loss.

B. Install to doors as recommended by hardware manufacturer and as required. Fit locks and latch in their respective doors and remove before painting. Reinstall after painting of doors is completed. Upon completion, adjust and lubricate hardware for proper operation.

C. Instruct Employer's personnel in the proper adjustment and maintenance of hardware.

3.02 Hardware Mounting Heights

A. Following mounting heights shall apply unless otherwise shown or specified:
   1. Lock Sets and Latches:
      a. 950 mm to centre of handle from floor.
   2. Butt Hinges:
      a. 300 mm to centre of lowest hinge from floor.
      b. 175 mm to centre of upper hinge from top of door.
      c. Space other hinges equally between lower and upper hinges.
   3. Door Pulls:
      a. 1120 mm from finished floor to centre of pull.
      b. Centre line in 125 mm from edge of flush doors and centred on stile of narrow stile glass doors.
   4. Deadlocks:
      a. Centre line of cylinder to align with centre line of cylinder for lock sets, unless indicated otherwise.
   5. Cross-Bar of Exit Device:
      a. 950 mm from finished floor to centre of cross bar.
   6. Push Bar:
      a. 1050 mm from finished floor to centre of push bar.
   7. Push Plate:
      a. 1120 mm from finished floor to centre of plate through mounted to pulls.
   8. Flush Bolt Operating Mechanisms:
      a. Top bolt: 1650 to 1800 mm above finished floor.
      b. Bottom bolt: 250 to 300 mm above finished floor.

3.03 Final Adjustments and Checking

Hardware supplier shall assist the Contractor in adjusting and checking the installation of finish hardware.

1. Check, test and adjust moving parts to ensure free and smooth operation.
2. Furnish to the Employer the special tools required to adjust and maintain hardware.
3. After the building is completed and in use, adjust hardware to compensate for air movement and other conditions, so that all items will operate properly.
4. A factory representative of the lock and latch manufacturer shall examine all hardware furnished, with an Employer's Representative, 6 months after handing over to the Employer and shall adjust the hardware for proper operation.

END OF SECTION 08710

Section 08800

Glazing

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with glazing.

1.02 Reference Standards

The work shall conform to the codes and standards of the following agencies:

1. Conform requirements of FS DD-G-451d for the applicable quality hereinafter specified for each type of glass, except that for heat absorbing glass.
2. Acceptable range of colour and/or defects (as defined by FS DD-G-451d) shall be determined by samples of such defects and/or colour range. Glass which does not fall within the accepted sample range shall be subject to rejection by the Engineer. In the event that such samples are not or cannot be provided, the Engineer will determine the acceptability of glass relative to colour and/or observable defects in each case.
3. Comply with recommendations and requirements of "FGMA Glazing Manual" published by the Flat Glass Marketing Association.
4. Comply with recommendations and requirements of the "Glazing Sealing Systems Manual" published by the Flat Glass Marketing Association, except that for heat absorbing glass and insulating glass. Comply with the manufacturer's recommendations when they are at variance with FGMA.
5. Comply with recommendations and requirements of "Installation Recommendations for Tinted Glass", Technical Service Report No. 104, latest edition published by Pittsburgh Plate Glass Company.

1.03 Submittals

A. Manufacturer's Data:
   1. Statement from the glass manufacturer that he has reviewed glazing details including the use of sealants and gaskets and that each product to be furnished is recommended for the application shown.
   2. Statement from the glass manufacturer that he has reviewed all glass thicknesses as specified and application of heat absorbing glass for the effects of partial or full shading under the expected service temperature ranges and that the resulting thermal stresses will not reduce the "Glass Statistical Factor" below 2.5.
   3. Manufacturer's literature for glazing gaskets and each type of glazing sealant (refer to Section 07920).

B. Provide the manufacturer's certification or guarantee of performance of the following glass types supplied for the designed and specified performance required:
   1. Insulating Glass Units.
   2. High Performance Reflective - Tinted Glass.
   3. Georgian Wired Glass.
   4. Laminated Glass.
   5. Tempered/toughened Glass.
   6. Mirror Glass.

7. Glass Blocks.

C. Samples
   1. Each type of glass, glazing sealants and gasket.
      a. Provide 300 x 300 mm samples of each type of glass specified.
      b. Provide colour range samples for heat absorbing glass if production run colour variations are expected.
      c. Provide 300 x 300 mm samples of expected production run appearance defects (if any) of heat absorbing glass.
      d. Provide 300 mm long samples of glazing gaskets.
      e. Provide cured glazing sealant samples as specified in Section 07920.
   2. Samples will be reviewed by the Engineer for colour and texture only and compliance with all other requirements is the exclusive responsibility of the Contractor.

1.04 Sample Installation

A. Prepare sample installation as required to match specified work in all respects before proceeding with the work.

B. Glaze sample in the presence of both glass and glazing materials manufacturers, not less than one week in advance of the scheduled glazing work.

C. Before actual glazing work proceeds examine the sample in the presence of those present earlier and obtain the Engineer's approval to proceed.

1.05 Delivery, Storage and Handling

A. Deliver glazing materials to project site in manufacturer's unopened containers, fully identified with trade name, colour, size, hardness, type, class and grade.

B. Store glass in accordance with manufacturer's recommendations and protect from weather, staining, damage and loss. Provide cushions at edges to prevent impact damage and protect faces from scratches and abrasion.

1.06 Environmental Conditions

A. Do not perform glazing operations when temperature is below $4^{O}C$, unless the manufacturer of the glazing materials specifically recommends application of his materials at lower temperatures.

B. Consult the manufacturer and establish the minimum provisions required to ensure satisfactory work when work progress when temperature below $4^{o}C$.

C. Record in writing to the manufacturer, with copy to the Engineer, the conditions under which glazing work was performed and the provisions made to ensure satisfactory work.

Part 2 Products

2.01 Clear Glass

A. Float Glass. Type I, class 1, quality q3, transparent, flat, float glass of glazing quality 6, 8 or 12 mm thick

B. Wired Glass. 6 mm. thick polished plate, glazing quality.

2.02 Heat Absorbing Glass - Tinted

Float Glass. Type I, class 2, style B, flat, float heat absorbing, 6 and 8mm thick. Light reducing quality with lower light transmission and colour as selected by the Engineer.

2.03 Insulating Glass

A. Fabrication:
   1. Fabricate units at factory with sheets of glass hermetically sealed at all edges with a permanent elastomeric sealant and a protective metal edge strip of aluminium or stainless steel.
   2. Metal edge strip and the frame to permit screwing in of the security grill in ground floor windows.
   3. Glass quality shall be as specified for each type. The outer light shall be 8mm thick tempered reflective tinted; 0.54 shading outside coefficient; air gap shall be 12mm; and inner light : 6mm clear float glass

B. Manufacturers of insulating glass units shall have been in the business of producing units of similar size and configuration for not less than ten years. The insulating glass units shall be guaranteed by the Contractor for a period of ten years from the date of Substantial Completion of the Works not to develop material obstruction of vision as a result of dust or film formation on the internal glass surfaces as a result of the failure of the hermetic seal. In addition provide the manufacturer's standard guarantee valid for ten years from date of shipment to the project site.

2.04 Tempered/Toughened Glass

A. Glass for tempering/toughening
   1. Float. Type I, class 1, quality q3, reflective, flat, float glass of glazing quality.
   2. Heat Absorbing, Type I, class 2, style B, flat, float heat absorbing. Light reducing quality with lower light transmission and colour as selected by the Engineer.

B. Sizes and Cutting:
   1. Prior to tempering/toughening or heat treating, cut glass to required sizes as determined by accurate measurement of openings to be glazed, making allowance for required edge clearances. Cut and process edges in accordance with glass manufacturer's recommendations. Do not cut or treat edges in the field.

C. Full Tempered/Toughened Glass:
   Provide glass tempered/toughened to increase flexural strength 4-5 times its strength before treatment. Locate tong marks along an edge which will be concealed in the glazing system. Do not exceed maximum warpage in either face of each piece, in any direction, as listed in the latest printed literature of Eckelt, PPG Industries or Pilkington.

D. Heat-Strengthened Glass:
   Strengthened by manufacturer's standard heat-treatment process, which increases the flexural strength to not less than 2 times the strength before treatment. Do not exceed maximum warpage in either face of each piece, in any direction; as listed in the latest printed literature of Eckelt PPG Industries or Pilkington.

2.05 Mirror Glass

A. Type I, Class 1, quality q1, if less than 2.25 m2 or quality q2, if more than 2.25 m2.

B. Provide silvering, copper backing and protective coating conforming to FS DD-M-411.

C. Mirror glass shall be guaranteed by the Contractor for a period of five years from the date of Substantial Completion of the Works not to show evidence of silver spoilage. In addition provide the manufacturer's standard guarantee valid for a period of five years from date of shipment to the project site.

2.06 Glass Blocks

Glass block shall be proprietory make, square, of size 190 x 190 x 80 mm as manufactured by Vegla, W. Germany or by Solar White, USA or approved equal.

2.07 Glazing Sealants

Refer to Section 07920 hereof for specifications and manufacturers of the types of sealants suitable for glazing work.

2.08 Glazing Gaskets

Refer to Section 07910 hereof for specifications and manufacturers of the types of sealants suitable for glazing work.

2.09 Miscellaneous Glazing Materials

A. Setting Blocks. Neoprene or silicone blocks of 70 to 90 Shore A durometer hardness, tested for compatibility with specified glazing sealant. Use silicone only for silicone glazing.

B. Spacers. Neoprene or silicone blocks of 40 to 50 Shore A durometer hardness, adhesive backed on one face only, and tested for compatibility with specified glazing sealant. Use silicone only for silicone glazing.

C. Mirror Mastic. An adhesive setting compound manufactured specially for setting mirrors to plywood backing.

2.10 Fabrication

Cutting:

1. Obtain sizes from shop drawings or by field measurement.
2. Cut glass to fit each opening with minimum edge clearances and bite on glass as recommended by glass manufacturer.
3. Do not nip glass edges.
4. Factory cut all glass.
5. Take field measurements of each opening, before glazing, to verify adequate bite on the glass and minimum edge clearance.
6. Openings which do not fall within the tolerances for which precut glass has been sized shall be glazed only with glass specially cut to fit such openings.

Part 3 Execution

3.01 Condition Of Surfaces

The contractor shall examine substrates and adjoining construction, and conditions under which work is to be installed and shall not proceed with work until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 Preparation

A. A pre-installation meeting shall be held at the Site with the glass manufacturer's representative, sealant manufacturer's representative, glazier and fabricator of framing or other supporting structure to receive glass to review the glazing procedure applying glazing materials and installing removable stops; evaluate suitability of specified compounds and sealants for anticipated weather conditions and review co-ordination with other work.

B. Before beginning work, inspect sash, frames and rebates to receive glass to determine that other trades have completed preparatory work and that sash and frames are ready to receive glazing materials.

C. Sash, frames and members shall be adjusted, plumbed, and squared. All rivets, screws, bolts, nail heads, welds, and other projections shall be finished flush in glazing rebates. All corners and intersections shall be sealed and watertight.

D. Operable sash shall be fastened and kept stationary until glazing compounds, except non-setting types, have cured or set.

E. Surfaces to receive glazing materials shall be free of dirt, dust, grease, oil, and other foreign materials, and shall be painted or sealed before glazing work is begun.

3.03 Installation, General

A. Installation of each light of glass shall be watertight and airtight, and capable of withstanding temperature changes, wind loading (exterior glass) and impact from operation (doors and operable sash), without failure of any kind including loss or breakage of glass, failure of seal, exudation of sealant and excessive deterioration of glazing materials.

B. Inspect each piece of glass immediately before installation. Do not install any pieces which have damaged edges, scratches or abrasion or any other evidence of damage. Remove labels from glass before installation.

C. Do not begin glazing until all cleaning and repairing of concrete and masonry surfaces has been completed.

D. Aluminium glazed frames requiring dry glazing method shall be glazed in accordance with manufacturers written specification which shall become a part of the work herein as though written out in full.

E. Follow "Surround Preparation" instructions of FGMA Glazing Manual and also thoroughly clean glazing surfaces of glass and frame.

F. Do not begin glass installation until rebates and glazing stops have been primed and are thoroughly dry. Do no glazing when ambient temperatures are less than $4^{o}C$.

G. All glass shall be clean cut.

1. Nipping to remove flares or to reduce oversize dimensions will not be permitted.
2. Shop cut to fit openings allowing required clearance.
3. Openings to receive glass shall be perfectly square.
4. Any out of square shall be reported and corrected before glass is sized.
5. Protect edges of glass from abrasion with ground or adjacent surfaces.

H. Cut glass accurately to fit openings. Sizes of glass indicated on the Drawings are approximate only and the actual sizes required shall be determined by measuring the frames to receive the glass. Size glass to permit required clearance and bite around full perimeter of glass as set forth in the FGMA Manual.

I. Apply glazing compounds and other materials in strict accordance with manufacturer's printed recommendations.

J. Glass shall be set without springing and with proper clearances at all edges. Edge clearance and tolerance shall be in accordance with recommendations of FGMA Glazing Manual, latest edition.

K. All edges of exposed glass shall be ground and polished to profiles indicated, except as specified for glass mullions and entrance glass doors.

3.04 Glazing Methods

A. Interior Channel Glazing Method:
1. Metal doors, pressed metal frames and other interior openings required to receive glass, apply back-bed of elastic glazing compound over full face of backstop, and install spacer shims at least two at each edge and not greater than 600 mm o.c. to maintain uniform 3 mm thickness of bedding.
2. Press glass into back bed of compound.
3. Seal around entire perimeter of glass with elastic glazing compound.
4. Apply and secure face stops over 3 mm spacer shims and fill the space between face stops and glass with elastic glazing compound.
5. Tool compound at both sides of glass even with sight line.
6. When glass size is more than 1250 mm -(width plus height), install setting blocks at quarter points and use pre-shimmed polybutylene tape against fixed rebate in lieu of the glazing compound.
7. Tape shall be set slightly below the sight line for tolerance when pressure is exerted against the glass. Where tape is used, it shall be even with sight line.

B. Exterior Tape/Liquid Polymer Sealant Method:
1. At all areas where glass is set into frames, apply 3 mm minimum thickness pre-shimmed glazing tape over full face of backstop, using polybutylene tape and maintain precise edge at sight line except for sill which shall be kept back to receive final application of sealant.
2. Do not break tape except at corners and seal together with longitudinal pressure.
3. Set glass on neoprene setting blocks at quarter points allowing required clearance around full perimeter of glass.
4. Allow no direct contact between glass and frame.
5. Apply full heel bead of liquid polymer sealant around entire perimeter of glass.
6. Set 3 mm minimum thickness spacer shims on front face of glass as required to maintain uniform joint width, shove face stops into place, and secure.
7. Fill-in and finish with liquid polymer sealant. Interior shall receive sealant at full perimeter and exterior at sill only.

8. Trim tape at jambs and head even with sight line and tool all sealant to tight joint.

C. Exterior and Interior Dry Seal Glazing Method:
   1. At all aluminium frames requiring gasket glazing set glass using setting blocks and applicable materials specified in accordance with manufacturer's written specification.
   2. Replace all aluminium face stops in proper alignment with member securing in place without distortion and rattles.

3.05 Insulating Glass Glazing

Set insulating glass units as per manufacturer's recommendations to prevent water leakage. Do not glaze metal bound and organic bound insulating glass units with oil based mastic or other glazing compounds which might have a deleterious effect on the hermetic seal of the units. Completely conceal edge binding of insulating glass units with glazing material and extend material a minimum of 3 mm onto glass surfaces at each edge, to provide glazing seal independent of hermetic seal.

3.06 Structural Glazing Gaskets

A. Comply with gasket manufacturer's printed instructions and recommendations.
   1. Mitre-cut corners of loose zipper strips slightly longer to provide permanent compression at joints.
   2. Use special tool to install and remove filler strips.
   3. Lubricate as may be required, in accordance with manufacturer's instructions.
   4. Use lubricants recommended by gaskets manufacturer.

B. Comply with glass manufacturer's printed instructions for the use of setting blocks, liquid or tape sealants and weep holes in the glazing recess of lock strip gaskets.

3.07 Field Quality Control

After completion of exterior glazing and nominal curing of sealants and glazing compounds, test for water leaks. Conduct tests in the presence of the engineer in accordance with "Specifications for Field Check of Metal Curtain Walls for Water Leakage", AAMA Standard FC-1-76, except perform tests on not less than 5 percent of all exterior lights.

3.08 Protection

A. All glass shall be protected from damage until acceptance of the work and if glass is broken remove and replace with specified type. Contractor shall be responsible for protection of glass and the replacement of all such damaged materials after glazing work is completed.

B. Glass breakage or damage to metal caused by negligence or any other reason shall be replaced at the expense of the Contractor.

C. Contractor may, at his own option, carry glass breakage insurance, but failure to carry proper insurance shall in no way relieve him of his responsibility in this regard.

D. All glazed openings shall be identified with markers such as tapes or flags that are not in contact with the glass, but which are held in position away from the glass.

E. All glass shall be examined on a monthly basis during the guarantee period to detect any formation of staining and/or etching. If staining or etching is noticeable, notify Engineer immediately for determination of proper remedial procedures. Plaster, mortar, paint spatter, or any other coating shall be removed immediately after contact and shall not be permitted to collect or remain on glass surfaces.

3.09 Clean Up

A. Remove all labels, excess glazing compounds, stains, and spots from glass and metal on completion of glazing.

B. Remove all rubbish and debris from the site at the end of each day's work. Clean compound smears and stains from adjacent surfaces as the work progresses.

C. At the completion of the work under this Section, all glass surfaces shall be thoroughly cleaned and washed. At the completion of the entire project all glass surfaces shall be thoroughly cleaned and washed.

END OF SECTION 08800

DIVISION 9.

FINISHES

Section 09200

Lath and Plaster

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Portland cement plasterwork.

1.02 Quality Assurance

A Work shall be carried out by persons skilled in plastering and rendering.

B Finish surfaces within following tolerances and deviations.
1. Finish Plaster:
   a. Straight, true, square with adjoining work, smooth or keyed where required free from imperfections impairing appearance or performance.
   b. Where not textured, not deviating more than 3mm from a 180mm straight edge placed anywhere on surface.
   c. Make angles plumb and true.
2. Ceilings:
   a. Make surface of ceilings and bulkheads horizontal, vertical or sloping as applicable and level.
   b. Do not deviate more than 5 mm from a 3 m straight edge.

1.03 Submittals

A Manufacturers' Data. Manufacturers' specifications and installation instructions for each material required, including other data to show compliance with Contract Documents.

B Sample Panel
1. Sample panels of each finish not less than 1.5 meters square, on movable frames for preliminary review.
2. Sample panels shall be representative of materials, colours, textures and workmanship for the entire work.
3. Acceptance will be for colour and texture only.
4. For final review of each finish complete one wall or ceiling area on job site before proceeding with the work.

C Accessories. Samples of all miscellaneous accessories as specified herein.

1.04 Co-ordination

A The work of this Section shall be co-ordinated with that of associated trades. In no case shall work requiring inspection be concealed by plaster until it has been approved by the Engineer.

B Make all changes and adjustment of the materials of this Section necessary to accommodate the prescribed work of other Sections, including cutting and patching.

1.05 Delivery, Storage and Handling

A Manufactured materials shall be delivered in original unopened packages, containers, or bundles, bearing manufacturers name and brand.

B Store plaster, cement and lime off ground, under water tight cover, away from sweating walls and other damp surfaces, until ready for use. Remove damaged or deteriorated materials from site at first reasonable opportunity.

1.06 Environmental Conditions

A Temperature and ventilation shall comply with ASTM C926 and/or BS 5492 as appropriate.

B Ventilate building spaces as required to remove water in excess of that required for hydration of plaster. Begin ventilation immediately after plaster is applied and continue until it sets.

1.07 Protection

Protect all fixtures, frames, inserts and other contiguous work from rusting, soiling or clogging due to plastering.

Part 2 Products

2.01 General

Products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified may be acceptable subject to the Engineer's approval.

2.02 Materials

A Aggregates
1. Portland Cement Plaster Base Coats: ASTM C 897, natural sand or BS 1199/1200 as appropriate.
2. Portland Cement Plaster Finish: ASTM C 897 and either graded silica sand passing a 30 mesh screen in colour required to match Engineer's sample or gem silica sand passing a 30 mesh screen in colour required to match Engineer's sample.

B Bonded Plaster. Bonding Agent. Provide a bonding agent composed of a resinous formulation for use in bonding plaster work to walls, columns etc. in accordance with ASTM C 631.

C Portland cement for all uses ASTM C150 Type I or Type II or BS12.

D Miscellaneous Accessories
1. Corner Beads shall be not less than 0.45 mm galvanized steel, formed with a bead not exceeding 5 mm, with expanded flanges at least 63 mm wide.
2. Casing and stop beads shall be not less than 0.60 mm galvanized steel, formed with expanded wing unless otherwise shown.
3. Metal Corner Reinforcement:

a. Expanded large mesh diamond lath fabricated from zinc alloy.
b. Welded wire mesh fabricated from 1.2 mm diameter zinc coated (galvanized) wire and specially formed to reinforce external corner of Portland cement plasters on exterior exposures while allowing full plaster encasement.

4. Control Joints - Two Piece Type. Pair of galvanized steel casing beads with back flanges formed to provide slip joint action, adjustable for joint widths 3 mm to 15 mm.
5. Control Joints - One Piece Type folded pair of galvanized non-perforated screed in 'M' shape configuration, with expanded flanges.
6. Strip lath shall be expanded copper bearing steel not less than 1.36 kg/sq. m.
7. Masonry nails and screws shall be stainless steel Grade 316 L.
8. Building Paper. Bituminous water proof building paper complying with BS 1521 Grade A1.

E Water shall be potable and free from deleterious materials.

F Metal Lath
1. Shall be galvanized steel lathing having a minimum shortway aperture of 6 mm and weighing a minimum of 1.25 kg/sqm complete with a protective coating of black asphaltic paint.
2. Shall comply with BS 1369.
3. Lathing shall be mechanically fixed to masonry or concrete to the complete approval of the Engineer.

2.03 Mixes

A General
1. Proportions
   a. All mixes are by volume unless otherwise specified.
   b. All mix proportions are suggestive only, variations to meet local conditions and achieve the desired finish are permitted within the limits specified in ASTM C926 or BS 5492/5262 as appropriate.
2. Lime Putty
   a. Make from hydrated lime; machine- mix with water to putty form.
   b. Allow to stand at least 15 minutes before using.

B Portland Cement Plaster Mixes:
1. Base coat. ASTM C 926 or BS 5492/5262 as appropriate as follows one part Portland cement with three to five parts natural sand and 1/4 part lime putty
2. Brown Coat. ASTM C 926 or BS 5492/5262 as appropriate as follows one part Portland cement with three to five parts silica sand and 1/4 part lime putty.
3. Finish Coat. ASTM C 926 or BS 5492/5262 as appropriate as follows one part Portland cement with three to five parts silica sand and 1/4 part lime putty.

Part 3 Execution

3.01 Condition of Surfaces

A The Contractor shall examine substrata and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 Preparation

A Acceptance of Background. Ensure the following background conditions are satisfied before applying coatings:
1. Adequately true and level to achieve specified tolerance.
2. Adequately fixed.
3. Free from contamination and loose layers.
4. Adequately prepared to give a good bond.
5. Free of any coatings of bituminous compound or any other detrimental waterproofing or damproofing agent.

B Preparation of Surfaces
1. Comply with ASTM C 926 or BS 5262 Para 20 for all plaster.
2. Do not apply materials to damp or wet surfaces or to concrete that is less than 6 weeks old.
3. Do not begin plastering until:
   a. Openings, chases or other apertures required for services are formed.
   b. Fixing for pipes, fixing pads, and plugs have been fixed.
   c. Making good has been completed.
   d. Cut ends of metal mesh beads etc., damaged areas of conduit, switch and outlet boxes etc. have been coated with black tar-based paint.

C Bonding Agents shall not be used in lieu of metal lath or wire lath for monolithic bonding of plaster to concrete ceilings or wall surfaces which require more than 10mm of plaster, to produce required lines or surfaces.

3.03 Installation

A General
1. The term "Plaster" shown on the Drawings means Portland cement plaster unless otherwise noted.
2. Apply 2-coat work on all bases.
3. Apply finish coat with a reasonably uniform thickness over entire surface with ceilings level and with vertical surfaces flat, straight and plumb.
4. Make interior angles square, and make arises square but slightly rounded.
5. Solidly grout hollow metal frames occurring in plaster walls with plaster specified for base or brown coat.

B Mixing
1. Use mechanical mixers for mixing plaster.
2. Hand mixing is not permitted.
3. Do not use frozen, caked or lumped material.
4. Clean mechanical mixers, mixing boxes and tools after mixing each batch; keep free of plaster from previous mixes.
5. Thoroughly mix plaster with proper amount of water until uniform in colour and consistency.
6. Retempering not permitted; discard plaster which has begun to stiffen.
7. Provide waterproof protection under mixer.

C Machine Applied Plaster
1. Determine proper consistency by slump test as follows:

a. Take slump test samples from nozzle of plastering machine hose using a 50 x 100 x 150mm slump cone.
b. Samples will be taken at random as often as may be required and without prior notice.
c. Portland Cement Plaster: Maximum 63mm slump.

D Method of application shall be by hand or machine application. Limit machine application to base coats, except where machine texture finish is specified.

3.04 Thickness of Plaster

A Portland Cement Plaster: 20 mm total.

3.05 Application of Portland Cement Plaster

A To avoid abrupt changes in the uniform appearance of the succeeding coat, each plaster coat shall be applied to an entire wall or ceiling panel without interruption. Joining of wet plaster to set plaster should be made at naturally occurring interruptions in the plane of the plaster, such as arises or wall and ceiling openings. Where this is not possible, such joining shall be cut square and straight and at least 150mm away from a joining in the preceding coat.

B Apply Portland Cement Plaster in accordance with ASTM 926 or BS 5262/5492 as applicable.

3.06 Application of Miscellaneous Accessories

A Corner Beads
1. Provide on all external corners and arises and in single lengths where the length of a corner or arris does not exceed the standard stock lengths.
2. Mitre or cope the beads at corners and fasten securely with tie wires, hardened galvanized nails, staples or offset head or hook head lath nails spaced not more than 200 mm staggered.

B Casing or Stop Beads
1. Provide where shown and where plastering terminates and is not covered by other finish.
2. Provide sheet metal closures at reveals.
3. Set the beads level, plumb and true to line.
4. Install in lengths as long as is practicable and align joints with concealed splice or tie plates.
5. Secure beads with tie wire, hardened galvanized nails or other accepted methods.
6. Space fastenings not more than 200mm apart.

C Strip Lath. Where plaster is to be applied across differing backgrounds and over chases provide strip lath 600mm wide located centrally over joint except that where small widths of one material are involved completely bridge the one material with mesh wide enough to extend 75mm each side.

3.07 Application of Bonding Agent

A Apply in accordance with manufacturer's printed instructions.

3.08 Field Quality Control

A Plaster Sampling. Samples may be taken from work in place at any time. Areas represented by samples which show oversanding or wrong aggregate proportion will be rejected.

3.09 Patching

A Work containing cracks, blisters, pits, checks, or discoloration will not be accepted.
1. Remove such work, including rejected work, and replace with new.
2. Patching of defected work permitted only with the Engineer's approval.

B Perform cutting, patching, repairing and pointing-up operations neatly and thoroughly.
1. Repair the cracks and indented surfaces by moistening the plaster and filling with new material, troweled or tamped flush with adjoining surfaces.
2. Point-up and finish surfaces around fixtures, outlet boxes piping, fittings, tile and other work flush with adjacent plaster.
3. Where new plaster adjoins plaster which has been installed more than 48 hours, cut existing plaster at an angle of approximately 45 Deg. with the surface before installing new plaster.

3.10 Curing, Cleaning and Protection

A Make provisions to minimize the spattering of plaster on other work.

B Promptly clean windows and other surfaces which have been soiled.

C Protect plaster from the weather, premature drying, marking, dirt, dust, marring or other damage throughout the construction period so that it will be without any indication of damage at the time of Substantial Completion of the Works.

D Cure plaster continuously for 15 days.

E In hot weather the undercoat shall be protected to avoid rapid drying out. Polyethylene sheet to ASTM C171 shall be held against the surface to prevent evaporation.

END OF SECTION 09200

Section 09250

Gypsum Board

Part 1 General

1.01 Description

A The work included in this section comprises furnishing all labour, plant, equipment, appliances and materials and performing all operations in connection with Gypsum Board installations.

B The principle work of this section includes:
1. Gypsum Board Wall Linings
2. Gypsum Board Partition System
3. Suspended Gypsum Board Ceiling

1.02 Submittal

A Manufacturer's specifications, installation instructions and other data to show compliance with the Contract Documents.

B Detailed shop drawings at full scale of all unusual conditions in connection with gypsum board construction.

1.03 Delivery, Storage and Handling

A Deliver materials to project site in manufacturer's unopened bundles and containers with manufacturer's name, brand, type and grade clearly indicated thereon.

B Store materials above grade in a dry ventilated space, under cover and in accordance with manufacturer's printed instructions. Protect from soiling or damage.

C Avoid exposure of material to the weather by using protective covers. Handle materials to avoid damage.

1.04 Environmental Conditions

Install gypsum board only when temperature, humidity and ventilation can be maintained at or above levels recommended by gypsum wallboard manufacturer.

Part 2 Products

2.01 Materials

A Provide gypsum board materials, including accessories and fasteners produced or recommended by a single manufacturer.

B Gypsum Drywall Board
1. 12.5 mm thick, unless otherwise shown.
2. Complying with the following requirements:

a. Face Layer: ASTM C36, with tapered edges, Type X, unless stated otherwise.
b. Base Layer: ASTM C36, Type X, unless stated otherwise.
c. Water Resistant: ASTM C630, with tapered edges.

C For all applications of fasteners involving gypsum board comply with manufacturer's printed recommendations.

D Joint compound, joint tape and finishing compound shall conform to ASTM C475, be asbestos-free and shall be as recommended by the gypsum drywall board manufacturer.

E Laminating adhesive shall be of a type recommended by gypsum drywall board manufacturer.

F Sealants shall be of a type recommended by gypsum drywall board manufacturer to produce required acoustical ratings, and refer to Section 07920.

G Galvanized steel or plastic cornerbeads, edge trim and control joints, of sizes and profiles as recommended by the gypsum drywall board manufacturer shall be provided to suit the intended use. Trim materials, profiles and sizes shall be approved by the Engineer.

H Structural member's accessories shall be in accordance with ASTM C645. Galvanized steel studs, furring channels and runners, of type, size and gauge shall be provided as recommended by the gypsum drywall board manufacturer to suit the intended use.

I Ties shall comply with the requirements of Underwriter's Laboratories, Inc., and the gypsum drywall board manufacturer and be either 1.2 mm tie wire or 13 mm x 0.38 mm galvanized steel strapping.

J Acoustical insulation shall be of type and thickness as recommended by the gypsum drywall board manufacturer to produce the required acoustical ratings.

K Water shall be potable and clean and free of deleterious material.

L Primary Suspension Members for Ceilings
1. Hanger inserts shall be galvanized steel flats, 25mm x 5mm with 11 mm holes on centre line and lower ends with approved hanger inserts for rod hangers.
2. Hangers shall be 5mm x 25mm galvanized steel straps or 6mm diameter galvanised rods as approved with adjustable height.
3. Carrying channels shall be 38mm, 0.7 kg/m galvanized cold rolled steel channels.

2.02 Mixes

Mix joint compound in the proportions recommended by the approved gypsum drywall board manufacturer. Retempering of mix or the use of partially set joint compound will not be permitted. Allow complete breakdown of binder before use.

Part 3 Execution

3.01 Condition Of Surfaces

The Contractor shall examine the substrata and adjoining construction and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory conditions have been corrected.

3.02 Installation

A Framing Members

1. Install framing members for drywall board to produce rigid flat, surfaces with supports at all edges of drywall board in accordance with ASTM C754 unless more stringent requirements are specified by the manufacturer.
2. Space metal studs at maximum 400 mm centres. Align runner tracks accurately to the partition layout as required to limit deflection to L/120 at 360 Pa.
3. Provide additional framing and blocking as required to support drywall board at openings and built-in anchorage and attachment devices for other work.

B Gypsum Wallboard

1. Install gypsum wallboard to produce rigid true surfaces and to comply with required sound resistance ratings accordance with ASTM C840 unless more stringent requirements are specified by the manufacturer.
2. Install maximum practical lengths of wallboard with minimum number of end butt joints. Where butt joints are necessary, stagger joints and locate as far as possible from centre of walls.
3. Install control joints as shown, and as recommended by manufacturer and as directed by the Engineer.
4. Install metal trim accurately at exposed edges, doors, and other locations as shown. Fasten trim securely.
5. Use joint compound and apply before inserting face layer into frame.
6. Cut openings in wallboard for electrical outlets, piping and other penetrations. Maintain close tolerances so that edges will be covered by plates or escutcheons.
7. Do not allow electrical outlets back to back on opposing sides of partitions.
8. Install water-resistant wallboard where shown.

C Single Layer Application: apply wallboard from ceiling to floor by single length of wallboard, where possible. Hold joints back at least 200 mm from corners of door frames. Space screws at not more than 400 mm centres.

D Double Layer Application

1. Apply on base layer on walls vertically with long joints on framing members. Space screws at not more than 400 mm centres.
2. Screw, attach or apply face layer to base layer with laminating adhesive, with joints on surface spaced 250 mm from the parallel joints in the base layer.

E Sound Rated Partitions

1. Provide the combination of wallboard, sealant and framing to produce the ratings shown.
2. Apply acoustical sealant at perimeters of partitions to produce the required STC ratings.
3. Provide acoustical sealant in back of control joints, around outlets boxes, and at perimeter of all cutouts to completely seal all openings and joints.
4. Install acoustical insulation where shown.
5. Form continuous layer for full height and length of partition and tightly abutting web of studs.
6. Fit carefully behind electrical outlets and other penetrations.

F Water Resistant Drywall

1. Use as a substrate for ceramic tile and elsewhere as shown.

2. Pre-cut panels to required size and make necessary cut-outs. Apply compound to all cut or exposed panel edges before installation.
3. In areas to receive ceramic tile finish, treat all joints and fastener heads with water resistant compound.

G Ceilings

1. Use only height adjustable rod hangers or strap hangers. Wire hangers are not acceptable.
2. Provide hangers and inserts necessary to support suspended ceilings below concrete slabs. Give particular attention to the correct location and alignment of hangers and inserts.
3. Frame openings so that recessed items finish flush.
4. Provide sufficient hangers for runner channels on each side of light fixtures, ceiling diffusers grilles, access panels and other items penetrating the ceiling.
5. Fasten drywall board to furring channels at not more than 300 mm centres.

H General Finishing Requirements

1. Fill openings around cutouts with compound or acoustical sealant as recommended by the manufacturer.
2. Reinforce all joints at tapered edges and interior corners with joint reinforcing tape set in joint compound
3. Fill all joints, fastener heads, trim recesses, cracks and other depressions with joint compound.
4. Finish smooth and flush so that joints, screws and other items will not be visible after painting.

3.03 Field Quality Control

Finish surfaces within 6 mm in 2.4 m for plumb, level, warp and bow.

END OF SECTION 09250

Section 09300

Tile Work

Part 1 General

1.01 Description

A The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with ceramic and quarry tile installation.

B The principal work of this Section includes, but may not be limited to, the following:
1. Ceramic tiles to walls.
2. Ceramic tiles to floors.
3. Quarry tiles to floor

1.02 Qualifications

Executed by a firm having a minimum of five years experience in the installation of materials specified herein on works comparable to the Works.

1.03 Submittals

A Manufacturer's product data, including installation instructions, use, limitations and recommendations. Provide certifications stating that materials comply with requirements.

B Duplicate samples for each tile type shall be provided each consisting of four tiles mounted on rigid panel board including grouted joints. The Engineer's acceptance shall be for colour, pattern, texture and joint width only. Compliance with other requirements is the responsibility of the Contractor.

C Shop drawings shall be provided for installation and erection of all parts of the work. The Contractor shall include plans, elevations and details where tiles terminate and at meeting of floor and walls; details of control and explanation joints. Field measurements shall be taken before submitting shop drawings.

1.04 Delivery, Storage And Handling

A Deliver, store and handle materials and products in a manner to prevent damage. Deliver materials and products in unopened factory labelled packages indicating the name, brand, type, class, size and colour. Sequence deliveries to avoid project delays and to permit proper co-ordination of the work.

B Store and handle in strict compliance with manufacturer's instructions and recommendations. Replace damaged items with no change in Contract price.

1.05 Co-ordination

A Completely co-ordinate the work specified in this Section with all other work. Verify field dimensions and condition of work which adjoins material of this Section. Notify the

Engineer of deviations from the Contract Documents before proceeding with the work specified in this Section.

B Commence work only after grounds, anchors, plugs, hangers, bucks, electrical and mechanical work which are to be in or behind tile work are installed.

1.06 Quality Assurance

A Method of installation of ceramic tile shall be in strict accordance with manufacturer's recommendations.

B Obtain each material required for any one type and colour of the work from a single source, so as to minimise variations in appearance and quality.

1.07 Extra Stock

Deliver to Employer at his specified store two unopened boxes of each type and colour of tile installed.

Part 2 Products

2.01 Materials

A Products and manufacturers specified hereinafter are specified for the purposes of establishing minimum quality standards.

B Products which are equal to, or better than, those specified and which conform to the Engineer's design requirements and colour selections, may be acceptable subject to the Engineer's approval.

2.02 Ceramic Tiles

A Conform to BS 6431 or DIN 18166.

B Average water absorption $\leq$ 3 percent.

C To be acid and alkali resistant.

D Average Compressive Strength not to be less than 20 N/mm^2.

E Suitable for heavy duty purposes as recommended by the manufacturer for similar building types.

F Tiles shall be selected from a range as manufactured by Buchtal Ceramic Works, West Germany, or other equal and approved.

G Ceramic tiles shall be of the following types as designated below of sizes shown on the Drawings or specified herein and of colours as selected by the Engineer.

1. Wall Tiles
   a. Size 240 X 115 X 6 mm thick glazed.
   b. Provide tile trim shapes as required to suit the installation.
2. Floor Tiles
   a. Size 115 x 115 X 8 mm thick unglazed.
   b. Provide tile trim shapes as required to suit the installation.

2.03 Tile Accessories

A Metal edge strip shall be shaped, finished and anchored as shown.

B Trim Shapes
1. Shapes as shown for typical conditions, and as required to make a complete installation at all conditions.
2. Match type, class, colour and edge of adjoining field units.
3. Co-ordinate sizes with field units.

2.04 Quarry Tiles

A Quarry floor tiles shall be 150 X 150 mm of approved pattern and colour.

B Coved skirting to match tiles shall be 150 mm high with bull nose top and cove at bottom. Internal angles and rounded external angles.

2.05 Setting Materials

A Portland Cement shall be ASTM C 150 Type I or BS12, white where required.

B Pigments
1. Pure mineral pigments.
2. Resistant to alkalis.
3. Non-fading.
4. Weatherproof.
5. Colours as required and approved by the Engineer.

C Water shall be potable and clear and without deleterious substances.

D Sand shall be to ASTM C 144 or BS 1199/1200.

2.06 Mortars and Grouts

A Latex Mortar Setting Beds
1. One part Portland cement with three parts sand mixed dry and then gauged with a sufficient quantity of liquid latex additive No. 3701 (Laticrete International).
2. Amount of gauging liquid required and the consistency of cement setting bed for using a dry tamp method shall be as recommended by the manufacturer of the liquid latex additive.

B Liquid Latex Mortar (Thin Set)
1. "Laticrete 4237 Liquid" as manufactured by Laticrete International and Portland cement.
2. Mixed in the ratio of 2.25 kg. Portland cement to 1 litre “Laticrete 4237 liquid” unless otherwise recommended by liquid latex manufacturer.
3. Addition of fine sand to cement shall be only as necessary for filling rough surfaces and as recommended by the liquid latex manufacturer.
4. Use of the above is required for all thin set applications and as slurry bond coats at mortar and bed applications.

C Grout for non-vitreous tiles shall have colour as shown or as required, gauged with "Laticrete 3701 grout admix".

D Grout for vitreous tiles shall have colour as shown or as required, gauged with "Laticrete 3701 grout admix".

E Tile adhesive shall be water-resistant complying with ANSI A 136.1 and as recommended by the tile manufacturer to suit the type of application.

F Chemical resistant tile grout shall be as recommended by the tile manufacturer and approved by the Engineer.

2.07 Sealant

A Sealant for tiles shall be based on silicone type recommended for tile work as manufactured by Dow Chemical, General Electric or other equal and approved. Colour to match adjoining tile colour.

Part 3 Execution

3.01 Condition of Surfaces

A Thoroughly examine all surfaces to receive work of this Section, and notify Engineer in writing of all conditions which would adversely affect this work.

B Do not commence work in any area where such notice of adverse conditions has been sent to the Engineer, until corrective work has been completed or waived.

C Starting of work in any area without issuance of such notice should constitute acceptance of conditions in the area by the Contractor who shall be responsible for the satisfactory results of his work. Any defects occurring thereafter shall be corrected without additional charge to the Employer.

D Allow slabs to dry adequately before applying materials. At the direction of the Engineer, perform simple calcium-chloride test to ensure concrete surfaces are free of contained moisture.

E Fill all cracks in sub-surfaces using approved crack-filler in accordance with manufacturer's printed instructions.

F Clean subfloors of all remaining dirt and loose particles before application of flooring materials.

G Underlayment used to correct floor slabs with surfaces not constructed to specified tolerances shall be provided as part of the work in Section 03300. Small dips and minor imperfections on the floor surface shall be corrected using specified latex levelling mortar as part of the work under this Section at no additional cost to the Employer.

H Allowable Variations in Substrata Levels:
1. Mortar Set Floors: 1/500 distance and 9 mm total maximum variation from levels shown.

2. Mortar Set Walls and Ceilings: 1/400 distance and 6 mm total maximum variation from planes shown.

I Thin-Set Work: same as allowable variation in finished work.

3.02 Preparation

A Etch substrata with 10percent solution of muriatic acid as may be required to remove curing compounds or other substances that would interfere with proper bond of specified mortar for tiles.

B Rinse with water to remove all traces of acid.

C Seal substrata with sealer as recommended by manufacturer of mortar.

3.03 Installation

A Unless otherwise shown or specified comply with applicable requirements of:
1. ANSI A 108.1 through A 108.6, ANSI 137.1.
2. Recommendations of TCA, "Handbook for Ceramic Tile Installation".

B Comply with the manufacturers' instructions for the installation of each material required.

C Tile applicator shall install all tiles using lighting conditions that will represent the proposed lighting required in the areas involved. Requirement will be insisted upon in order to achieve uniformity in laying out tiles.

D Tiles shall be applied to full wall areas where mirrors and surface mounted accessories are to be installed.

E Surfaces to receive tile finish shall be clean and free of all foreign matter detrimental to the bond.

F Room temperatures at areas in which tile materials are being installed shall be maintained at not less than 5^{o}C for a period of twenty-four hours prior to commencement of work, during work, and afterwards until completion of construction. Areas in which tile work is being done shall be closed to traffic until the installation has set.

G Lay out work so that no tile less than half size occurs
1. Align joints in floor tile at right angles to each other and straight with walls to conform to patterns selected.
2. Verify locations of accessories before installing tile.
3. Co-ordinate with plumbing and other trades.

H Allowable Variations in Finished Work
1. Do not exceed the following deviations from level and plumb and from elevations, locations, slopes and alignments shown:
   a. Floors: 1/1000 run, any direction; +/- 3 mm at any location; 0.8 mm offset at any location.
   b. Walls: 1/800 run, any direction; +/- 3 mm at any location; 0.8 mm offset at any location.
   c. Joints: +/-0.8 mm joint with variation at any location; 1/600 run for deviation from plumb and true; and for other variations in alignment of joints.

I Lay out tile work in pattern shown using field tile and trim shapes as shown.
1. Centre tile fields both directions in each space or on each wall area and adjust to minimise tile cutting.
2. Use uniform joint widths for ceramic tile and for quarry tile unless otherwise shown or approved. Cut field tile, not trim shapes, unless otherwise shown.

J Extend tile work into recesses and under equipment and fixtures in the spaces shown or scheduled to receive tiles.
1. Form a complete covering without interruptions except for control and expansion joints and as required to comply with requirements.
2. Terminate work neatly at obstructions, edges and corners without disruption of pattern or joint alignments.

K Use liquid latex mortar for thin-set tile work, unless otherwise shown.

L Latex Mortar Setting Beds for Quarry Tiles
1. Install quarry tiles over latex mortar setting beds with a slurry bond coat of Liquid Latex Mortar as hereinbefore specified.

M Use appropriate adhesive for setting tiles where adhesive installation is shown.

N Non-Slip Tile Installation
1. Use non-slip tiles in areas shown as "Non-Slip".
2. Install as specified for normal ceramic tiles of the same type and class.

O Install a continuous stainless steel edge strip adequately anchored into the substrata where shown or where exposed edge of ceramic tile flooring meets carpet or other soft floor covering.

P Provide control joints or expansion joints where shown or required by ANSI or TCA standard or by job condition for proper workmanship.
1. Install removable divider strip of proper width and depth of the tile and setting bed.
2. Remove strips after grouting tiles and properly curing the work.
3. Install joint fillers and sealants, in control joints and expansion joints, of type as recommended by the tiling manufacturer.

3.04 Grouting

A Do not commence grouting for at least 24-hours after placing of tile.

B Follow specific instructions of listed standards.

C Mix and apply in strict accordance with manufacturer's instructions.

D Grout wall and floor tiles with indicated grout mixed to a workable stiff consistency in accordance with manufacturer's directions.

E Force maximum grout into joints with trowel or squeegee.

F Before grout sets, strike or tool joints to base of cushion and fill all skips and gaps.

G Do not permit setting bed materials to show through grouted joints.

H Cure grout joints by maintaining damp condition.

3.05 Sealant Application

A Apply silicone sealant in joints where ceramic tile terminates at thresholds, floor drains, control joints in walls and other areas indicated.

B Co-ordinate with trades affecting these items.

C Application of sealant shall conform to applicable requirements set forth under Section 07920. Requirements therein shall become a part of the work under this Section as though written out in full herein.

3.06 Cleaning and Protection

A After tile has thoroughly set, sponge and wash tile thoroughly and diagonally across joints.

B Remove all surface cement and take care not to damage tile or adjacent materials.

C Do not use acid cleaners.

D Finally, clean all tiles using dry cloths.

E Remove from the site and legally dispose of at the end of each day, all cartons, rubbish and debris resulting from the work of this Section.

F Protect tiles after cleaning with non-staining heavy Kraft paper or other approved coverage until acceptance of the building by the Employer.

3.07 Maintenance Literature

Upon completion of all work specified herein, the Contractor shall furnish to the Employer, literature on the "Care of Ceramic and Quarry Tiles" for future maintenance use.

END OF SECTION 09300

Section 09420

Precast Terrazzo

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with precast terrazzo floor tiles

1.02 Qualifications

The terrazzo work shall be performed by a firm having five years experience in the installation of materials specified herein on projects comparable to this Project.

1.03 Submittals

A Manufacturer's specifications and installation instructions for each material, to show compliance with the Contract Documents.

B Three samples of each of the tiles and 300 mm long divider strips. Samples shall be reviewed for colour, pattern and texture only.

C Shop drawings showing large scale details of layout, jointing and edge conditions, and showing plans for layout of work including details of anchorage and other special features required including control and expansion joints.

1.04 Delivery, Storage and Handling

A Deliver materials in manufacturer's unopened containers, fully identified with trade name, grade and colour. Store materials above grade, protected from the weather, soiling or damage from any source and in accordance with manufacturer's instructions.

1.05 Co-ordination

Completely co-ordinate the work specified in this Section with all other work. Verify field dimensions and condition of work which adjoins material of this Section. Notify the Engineer of deviations from the Contract Documents before proceeding with the work specified in this Section. Commence work of this Section only after work of other Sections, to be covered by terrazzo tiles, has been installed.

Part 2 Products

2.01 Precast Terrazzo Units

A Conform to BS 4131 and units shall be as follows:
1. Tiles - 250 x 250 x 25 mm thick; or 300 x 300 x 30 mm thick.
2. Skirtings - 250 x 100 x 20 mm thick.
3 Wall strings – min. 100 mm wide x 20 mm thick cut into profile of treads and risers.
4. Tread and riser units shall be one piece construction as shown on the Drawings.

B Terrazzo units shall be formed on hydraulic presses.

C Face section of terrazzo units shall consist of:
1. Portland Cement conforming to ASTM C-150 Type I or BS 12.
2. Nonstaining white marble chips.
3. Selected natural aggregate (clean and free of all impurities).
4. Background cement and colours.
5. Aggregate proportion shall be not less than 70 percent selected aggregate and 30 percent matrix.
6. No aggregate with a value below Ha 10 as tested for abrasion resistance in accordance with ASTM C-241 shall be used.

D Back or underlying section of terrazzo units shall consist of Portland Cement and coarse sand. Back section shall have a cement/sand ratio of 1:3.

E Terrazzo units shall be compressed to produce the exact size as per drawings with square, flush edges. Compressive strength shall be minimum of 27.5 N/mm^2 when tested in accordance with ASTM C-150 after curing for one day in moist air and 6 days in water.

F Water absorption shall comply with the following requirements when tested in accordance with Appendix 'A' of BS 4131.
1. Tile face: No single results shall be more than 0.4 g/cm^2.
2. Total absorption: No single result shall be more than 8 percent.

G Transverse strength shall comply with the following requirement when tested in accordance with Appendix 'B' of BS 4131. No single result shall be less than 3 N/mm^2.

H Marble chips shall be natural sound marble chips without flats or flakes of sizes and colours necessary to match sample.

I Cement, sand and water shall be as specified in paragraph 2.02 hereof.

2.02 Setting Materials

A Standard brand of Portland cement, conforming to current ASTM C-150, Type I or BS 12.

B Sand shall be clean, sharp, durable bank sand, free from silt, loam, clay, soluble salts and/or vegetable matter; shall conform to ASTM C-144 or BS 1199/1200; and be graded fine-to-coarse within the following limits:

Sieve No.	% by wt Passing
No. 8	100
No. 16	90-100
No. 30	60-90
No. 50	25-55
No. 100	0-15

C Water shall be potable and clean, free from oils, acids, alkalis, organic and other injurious matter.

2.03 Additional Materials

A Metal divider strips shall be white alloy or zinc alloy, 3 mm thick top angle shape approved by the Engineer and overall depth shall suit conditions of the job.

B Cleaning solution shall be specially prepared neutral chemical terrazzo cleaner that will not change colour of terrazzo or damage it in any way.

C Terrazzo sealing compound shall be penetrating type, free from harmful alkali or acid content. The sealer shall be specially prepared for the terrazzo trade and shall not yellow terrazzo or leave tacky finish on surface after buffing.

2.04 Mortars and Grouts

A Mix bedding mortar in accordance with Tile Council of America Specifications for Conventional Cement Mortar and ANSI A108.1, 1976. Mortar bed mix shall be one part Portland cement, 6 parts damp sand and up to 1/10 part hydrated lime by volume. When mixed with water, the mortar shall be of such consistency and workability to allow maximum compaction during tamping of mortar bed. Grout shall be inorganic Portland cement dry curing grout, ready to use with addition of water. Colour of grout shall be selected by the Engineer.

Part 3 Execution

3.01 Condition of Surfaces

A The Contractor shall thoroughly examine all surfaces to receive work of this Section, and shall notify Engineer in writing of all conditions which would adversely affect this work. Work shall not commence in any area where such notice of adverse conditions has been sent to the Engineer, until corrective work has been completed or waived.

B Starting of work in any area without issuance of such notice should constitute acceptance of conditions in the area by the Contractor who will be responsible for the satisfactory results of his work. Any defects occurring shall be corrected without additional charge to the Employer.

C Slabs shall be allowed to dry adequately before applying materials. At the direction of the Engineer, simple calcium-chloride tests shall be performed to ensure concrete surfaces are free of contained moisture.

D All cracks in sub-surfaces shall be filled using approved crack-filler in accordance with manufacturer's printed instructions.

E Subfloors shall be cleaned of all remaining dirt and loose particles before application of flooring materials.

F Underlayment used to correct floor slabs with surfaces not constructed to specified tolerances shall be provided as part of the work in Section 03300. Small dips and minor imperfections on the floor surface shall be corrected using specified latex levelling mortar as part of the work under this Section.

G Allowable variations in substrata levels for mortar set floors shall be 1/500 distance and 9 mm total maximum variation from levels shown.

3.02 Preparation

A Substrata shall be etched with 10 percent solution of muriatic acid as may be required to remove curing compounds or other substances that would interfere with proper bond of specified mortar for tiles and rinsed with water to remove all traces of acid. Substrata shall be sealed with sealer as recommended by manufacturer of mortar.

3.03 Installation

A The manufacturers' instructions shall be followed for the installation of each material required. Tiles shall be installed using lighting conditions that will represent the proposed lighting required in the areas involved. The requirement will be insisted upon in order to achieve uniformity in laying out tiles.

B Room temperatures at areas in which tile materials are being installed shall be maintained at not less than $5^{O}C$ for a period of twenty-four hours prior to commencement of work, during work, and afterwards until completion of construction. Areas in which tile work is being done shall be closed to traffic until the installation has set.

C Work shall be laid out so that no tile less than half size occurs. Joints in floor tiles shall be aligned at right angles to each other and straight with walls to conform to patterns selected. Locations of accessories shall be verified before installing tiles and shall be co-ordinated with plumbing and other trades.

D Do not exceed the following deviations from level and plumb and from elevations, locations, slopes and alignments shown:

1. Floors: 1/1000 run, any direction; +/- 3 mm at any location; 0.8 mm offset at any location.
2. Joints: +/-0.8 mm joint with variation at any location; 1/800 run for deviation from plumb and true; and for other variations in alignment of joints.

E Tile work shall be extended into recesses and under equipment and fixtures in the spaces shown or scheduled to receive tiles to form a complete covering without interruptions except for control and expansion joints and as required to comply with requirements. Work shall be terminated neatly at obstructions, edges and corners without disruption of pattern or joint alignments.

3.04 Application Over Conventional Mortar Bed

A Mortar bed shall be mixed and applied in accordance with Tile Council of America Specifications for conventional Cement Mortar and ANSI A108.1.

1. Apply the mortar bed with reinforcing mesh over entire area.
2. Mortar mix shall be of such consistency or workability as to promote maximum density, determined by stroking of mortar surface with a trowel.
3. When of correct consistency, the trowelled surface readily assumes a smooth, slickened appearance.
4. Screed and tap mortar bed firmly.
5. Mortar beds shall be in thickness required, determined by the depression.
6. Any required pitch which is not already in the slab must be provided in the mortar bed.

B While the mortar bed is still fresh but stiff enough to set tile, tiles shall be set as follows:

1. Trowel or brush a thin layer 1 mm to 1.5 mm in thickness, of neat Portland cement paste over the bed and/or the back of tile.

2. Press tile firmly into the bed, tamping with wood blocks to obtain smooth surface.
3. All tiles shall be aligned properly with straight joints in even widths.
4. Tamping shall be completed within one hour after placing tile.
5. Adjusting work out of line shall be done within the one hour period.
6. Refer to drawings for location of expansion joints. All such joints shall be clear of grout to receive sealant.

3.05 Control Joints at Exposed Locations

A Setting beds shall be cut through at perimeter joints and at projections through the floor. Nooprene or butyl rubber strip (Shore A Hardness 70) shall be installed full depth of setting bed and caulking of joints with approved pouring grade sealant will be done under Section 07920.

B Control joints shall be provided where floor tiles meet restraining surfaces such as perimeter walls, cove bases, curbs, columns, pipes, etc. Control joints shall not exceed 10 m centre to centre each way in floors, located as directed by Engineer. Control joints shall be formed in neat, straight lines and tiles shall be cut cleanly and to accurate radius at exposed junctions with pipes, etc. Control joints shall be same width as grouted joints, but not less than 6 mm.

C Control joints that will be exposed in the finished work shall be filled to full depth of setting beds from sub-surface to rear face of tile, with control joint backing. The remaining void shall be kept clear of grout and debris. After completion of grouting operations, control joint sealant of colour to match adjoining grout will be applied under Section - 07920.

3.06 Divider Strips Installation

A White alloy or zinc divider strips of 3 mm wide shall be provided and adequately anchored into the substrata at 2 m centres in both directions and between terrazzo tiles and dissimilar floor finishes where thresholds do not occur. Where divider strips are located across door openings, strips shall be located on the door side, in line with the edge of doorstop, terminating at the rebate.

3.07 Grouting

A Grouting shall not commence for at least 24 hours after placing of tiles and shall follow specific instructions of listed standards and be applied in strict accordance with manufacturer's instructions.

3.08 Cleaning and Sealing

A After tiles have thoroughly set, they shall be sponged and washed thoroughly and diagonally across joints. All surface cement shall be removed taking care not to damage tile or adjacent materials. Acid cleaners shall not be used.

B As soon as terrazzo surfaces are thoroughly dry, sealer shall be applied. Sealing shall be done in strict accordance with manufacturer's directions, leaving a polished surface approved by the Engineer.

3.09 Protection and Clean Up

A Tiles shall be protected after cleaning and sealing with non-staining heavy Kraft paper or other approved coverage. Torn or worn papers shall be replaced until acceptance of the building by the Employer.

B All cartons, rubbish and debris resulting from the work of this Section shall be removed from the site and legally disposed of at the end of each day.

3.10 Maintenance Literature

Upon completion of all work specified herein, the Contractor shall furnish to the Employer, literature on the "Care of Terrazzo" for future maintenance use.

END OF SECTION 09420

Section 09510

Suspended Ceilings

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with suspended ceilings and accessories. The principal work of this Section includes, but may not be limited to, suspended mineral fibre acoustical ceiling and suspended linear metal ceilings.

1.02 Qualifications

The acoustical ceilings work shall be performed by a firm having five years experience in the installation of materials specified herein on works comparable to the Works and shall be carried out by experienced tradesmen who are capable of producing work of the highest standard of quality in the industry.

1.03 Performance/Design Criteria

Ceiling assemblies shall be provided to achieve the fire-resistance classification or rating as required and shall comply with the material and installation requirements of the UL "Building Materials Test" and other referenced guides for the UL design numbers corresponding with the construction systems shown.

1.04 Submittals

A Manufacturer's specifications and installation instructions for each material, to show compliance with the Contract Documents.

B Three sets of full sized samples of each of the acoustical material specified. One metre lengths of linear metal and 300 mm lengths of exposed tees and mouldings. Each set of samples shall show the full range of texture and colour to be expected in the completed work. The Engineer's acceptance will be for colour and texture only and compliance with all other requirements is the exclusive responsibility of the Contractor.

C Detailed shop drawings, including reflected ceiling plans of acoustical ceilings, before proceeding with work showing locations of all items of work which are to be co-ordinated with the acoustical ceilings, or to be supported by the acoustical ceiling system, and giving details in suitably large scales, all edge conditions, fixing details and accessories.

D Manufacturer's specifications and installation instructions for acoustical material, suspension system and other products required.

E Certified laboratory test reports and other data as may be required to show compliance with the Contract Documents.

1.05 Mock-Up

The Contractor shall provide a 3 x 3 m mock-up of each type of acoustical ceiling in spaces within the building to be designated by the Engineer, including all services outlets such as sprinklers, supply and return air grilles and lighting fixtures, etc. The mock-up shall be representative of the finished work in all respects and may, when approved, form part of the permanent work.

1.06 Delivery, Storage and Handling

A Deliver materials to the project site in manufacturer's unopened containers, clearly indicating manufacturer's name, brand, type, style, size, colour, texture and all other identifying information.

B Store materials in a dry location, off the ground and in a manner to prevent damage, deterioration and intrusion of foreign matter.

C Replace materials which have been damaged, or are otherwise unfit for use, as directed.

1.07 Environmental Conditions

Acoustical materials shall not be installed unless temperature and humidity conditions closely approximate to the interior conditions which will exist when the building is occupied. Temperature and humidity conditions shall be maintained before, during and after installation. Plastering, concrete and tiling work (including grinding) shall be complete and dry and windows and doors shall be in place and glazed.

1.08 Extra Stock

A Provide 1 percent of installed quantity of each type of acoustic tile to the Employer's store where directed.

Part 2 Products

2.01 Materials

Material type and face size shall be as shown with the following minimum characteristics:

1. Light Reflectance: ASTM C 523, 0.75 or more.
2. Flame Spread: ASTM E 84, Flame Spread 25 or less.
3. Sound Absorption: ASTM C 423, NRC not less than 0.65.
4. Sound Transmission Class: ASTM E 90, not less than 35.
5. Suspension System: ASTM C 635, Heavy Duty Classification.

2.02 Aluminium Ceiling and Panel Ceiling

Aluminium panels shall be:

1. Easily removable 600 x 600 mm aluminium alloy
2. Finished with primer and top coat with acoustic quality and fire resistant
3. Colour selected by the Engineer

2.03 Gypsum Ceiling

As specified in Section 09250 hereof.

2.04 Primary Suspension Members

A Hanger inserts shall be galvanised mild steel flats, 25 x 5 mm with 11 mm holes punched on centre line and lower ends for strap hangers. Manufacturer's appropriate hanger inserts for rod hangers and the system shall be designed to develop the full strength of the type of hangers used.

B Hangers shall be galvanised steel strap hangers 25 x 5 mm or 6 mm diameter galvanised steel rod hangers with facility for length adjustment to achieve accurate levelling.

C Carrying channels shall be galvanised cold rolled steel channels 38 x 25 mm, 0.7 kg/m.

2.05 Trim

Metal wall mouldings shall be roll formed steel with manufacturer's standard baked-on white enamel coating to match finish of acoustical material.

2.06 Acoustic Tile System

Exposed grid mechanical suspension system for acoustic tiles shall be the manufacturer's standard design system complying with ASTM D 635 Structural Classification "Heavy Duty". The system shall be complete with hangers, main tees, cross tees, splices, angle moulding, hold down clips and accessories as required and shall include components as follows:

1. Main tees shall be 38 x 25 mm wide formed of 0.63 mm galvanised cold-rolled steel section and bottom flange and faced with a roll formed galvanised steel cap. They shall be capable of supporting lighting fixtures and acoustical ceiling tile with maximum deflection not to exceed 1/360 of span between hangers or other supports.
2. Cross-Tees shall be 38 x 25 mm wide formed of 0.63 mm galvanised cold-rolled steel with double web bulb tee section and bottom flange and faced with a roll formed galvanised steel cap. Web ends of cross-tees shall be die formed for the tablock attachment to adjoining tee through the main tee, to provide alignment with a minimum of torsional movement and lateral displacement.
3. Accessories shall be galvanised steel, specifically designed for use with the main components.
4. All rolled formed parts shall be chemically cleaned, electro-galvanised and bonderised and finished with a white baked-on enamel coating, to match finish of acoustic tiles unless otherwise shown.

2.07 Metal Systems

Suspension system for metal units shall be the manufacturer's standard system complete with edge trim of Hunter Douglas Limited or approved equal.

Part 3 Execution

3.01 Condition of Surfaces

The Contractor shall examine the substratas and adjoining construction and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory conditions

detrimental to the proper and timely completion of the work have been corrected in a manner acceptable to the Engineer.

3.02 General Requirements For The Installation Of Acoustical Systems

A Verify all measurements and dimensions at the project site.

B Co-ordinate the work with the work of other trades, with particular attention given to the work of mechanical and electrical trades.

C Install all materials and systems in accordance with manufacturer's printed instructions unless otherwise shown or directed.

D Make all exposed surfaces of acoustical units level and flush with all joints straight and true. Neatly cut and fit units around light fixtures and around other items protruding through acoustical ceilings. Install all exposed members with flush hairline joints.

E Factory drill acoustic tile occurring at hidden loud-speakers and fire alarm gongs.

F Centre tile or board pattern both directions in each major space or room as shown or directed and where possible adjust pattern so that edge pieces will be not less than 1/2 unit in width.

G Run grain of units in one direction, as shown or directed and align joints in both directions unless otherwise shown.

H Use procedures that will minimise damage or soiling of the units during installation.

I Replace units which are damaged or cannot be adequately cleaned as directed.

3.03 Installation of Mechanical Suspension System, General

A Install primary suspension members and mechanical suspension system in accordance with manufacturer's instructions to support required loads. Prevent deflection in excess of 1/360 of the span. Spirit level accurately in both directions.

B Co-ordinate spacing of hangers, carrying channels, runners and moulding with the location of electrical fixtures and other items occurring in or on the ceiling.

C Comply with the requirements of ASTM C 636 and the following:
1. Attachment device locations shall be co-ordinated to final layouts.
2. Hangers shall be spaced not more than 150 mm from each end and not more than 100 mm o.c. between ends of members to be supported. Provide additional hangers for support of fixtures and other items to be supported by the ceiling suspension system, as required to prevent eccentric deflection or rotation of supporting runners. Provide necessary bracing and supports to allow for irregular stresses imposed on the suspension system by any mechanical ductwork connection to air handling fixtures.
3. Provide mouldings where ceilings meet walls, partitions and other vertical elements. Provide mitre cut inside and outside corners.

D Co-ordinate spacing of hangers and other suspension members with the location of electrical fixtures and other items occurring in or on the ceiling. Provide additional members or heavier members where necessary to suit interferences.

3.04 Installation of Acoustic Tile, Exposed Grid System

Install tiles with edges resting on flanges of tees. Cut and fit tiles neatly against abutting surfaces. Support edges by wall mouldings. Install wall mouldings continuously where tile abuts other material and at wall intersections where tile terminates, except as otherwise detailed. Align mouldings accurately and fasten securely to constructions.

3.05 Installation of Linear Metal Ceilings

A Install linear metal ceilings and secure to the suspension system in the manner recommended by the manufacturer,

B Maintain straight joint lines.

C Install wall mouldings continuously where ceiling abuts other material and at wall intersections where ceiling terminates, except as otherwise detailed. Align mouldings accurately and fasten securely to constructions.

3.06 Cleaning and Protection

Upon completion of the work remove all unused materials, debris, containers and equipment from the project site. Clean and repair surfaces that have been stained, marred or otherwise damaged. Protect acoustical ceilings during the construction period to prevent damage. Replace damaged units with new.

END OF SECTION 09150

Section 09650

Resilient Flooring

Part 1 General

1.01 Description

The work included in this section comprises furnishing all labour, plant, equipment, appliances and materials and performing all operations in connection with Resilient Flooring.

1.02 Submittal

A. Manufacturer's specifications and installation instructions for each material, to show compliance with the Contract Documents.

B. Three samples of each of the tiles of colours selected by the Engineer and for the resilient base 600 mm long sample of each type and colour. Samples shall be reviewed for colour, pattern and texture only.

C. Shop drawings showing large scale details of layout, jointing and edge conditions, and showing plans for layout of work including control and expansion joints.

1.03 Delivery, Storage and Handling

Deliver materials to job site in manufacturer's unopened containers clearly marked with manufacturer's name, brand, size, thickness, grade, colour and design. Store materials as per manufacturer's recommendations.

1.04 Environmental Conditions

Maintain temperature in spaces receiving resilient flooring at 21^{o} C, minimum at least 48 hours before, during, and after installation.

Part 2 Products

2.01 General

Products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better that those specified, may be considered acceptable subject to the Engineer's approval.

2.02 Materials

A Primers and adhesives for resilient flooring and base shall be of a type recommended by the manufacturer and best suited for the purpose.

B Resilient bases (VB) shall be smooth finish FS SS-W-40, type II (vinyl) including premoulded outside corners and end stop units and unless otherwise shown, provided with

bases 100 mm high set-on-cover type and straight type as required. Bases shall be minimum 1.2 m lengths and shall be of colours as selected by the Engineer.

C Synthetic rubber (VET) shall be manufactured by Nora-Freudenberg, Weinheim, Germany or approved equal and in colours as selected by the Engineer.

D Floor tiles shall be 600 X 600 X 3 mm; Noraplan-Homogen, Article No. 243.

Part 3 Execution

3.01 Condition of Surfaces

The Contractor shall examine substrate, adjoining construction, and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory condition detrimental to the purpose and timely completion of the work have been corrected.

3.02 Preparation

A Clean substrate to remove deleterious substrate which would impair the work.

B Fill cracks, holes, and depressions in the substrate. Surfaces shall be smooth, level and at proper elevation, and shall not vary more than 1:900 in any direction from level, plumb or slopes shown. Remove roughness and protrusions from concrete surfaces by grinding. Use compounds for filling complying with resilient flooring manufacturer's recommendations.

C Prime, seal or cover substrate if it is of a kind or in a condition which the manufacturer of the resilient flooring recommends to be primed, sealed or covered. Use materials complying with manufacturer's recommendations.

D Test concrete floors to ensure that they are dry before installation of resilient flooring.

3.03 Installation

A Install resilient flooring in accordance with the manufacturer's printed instruction and recommendations.

B Apply primer to concrete surfaces and work well into surface. Use minimum quantity that will assure complete surface coverage with a non-absorptive base. Allow primer to dry before applying adhesive. Prime coat may be omitted if recommended by resilient flooring manufacturer.

C Adhesive shall be applied to substrate with properly notched steel trowels and shall become tacky before applying resilient flooring.

D Extend resilient flooring into
1 Closets and offsets.
2. Under movable equipment of the rooms.
3 Spaces shown or scheduled to receive resilient flooring, including recessed covers within those spaces.
4 Extend unexposed edges of flooring under set-on bases and similar trim work.
5 Scribe, cut and fit exposed edges of flooring and base adjoining other work accurately and neatly with a tight joint.

E Tile units shall be laid symmetrically about centre line of major room or space in a square pattern, unless otherwise shown and adjusted so edge units are not less than one-half of tile width. Tile units shall be laid with bottom surface securely bonded to substrate and top surface left smooth, clean and free from imperfections. Tiles shall be fitted tightly so each unit is in contact with surrounding tiles and joints in proper alignment. Neat tight joints shall be formed where exposed edges abut other surfaces. Tiles shall be aligned with graining running in one direction and joints in both directions shall be in a square pattern unless otherwise shown.

F Resilient bases shall be secured to surfaces with water proof adhesive, with joints tight and with top and bottom edges in firm contact with adjacent surfaces. The longest lengths possible shall be used and angles and corners shall be mitred or coped.

3.04 Cleaning and Protection

Just prior to Substantial Completion of the Works, clean the resilient flooring and base. Wash thoroughly with a cleaner recommended by the flooring manufacturer, in accordance with his recommendations. Protect tiles after cleaning with non-staining kraft paper or other approved coverage until acceptable of the building by the Employer.

END OF SECTION 09650

Section 09700

Special Floorings

Part 1 General

1.01 Description

This section covers the supply and installation of special polymer flooring.

1.02 Submittal

A Copies of product data and colour charts for colour selection.

B Three sets of 300 x 300 x 50 mm concrete panels with samples of each material.

C Test report from an approved testing laboratory attesting conformance with the minimum physical/chemical characteristics of material proposed.

1.03 Manufacturer

Special flooring shall be the product of a firm which has been, and is now, engaged in manufacturing polymer floor systems for the past ten years.

1.04 Delivery, Storage and Handling

Deliver materials to job site in manufacturer's unopened containers clearly marked with manufacturer's name, brand, size, thickness, grade, colour and design. Store materials as per manufacturer's recommendations.

Part 2 Products

2.01 General

A Products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, may be considered acceptable subject to the engineer's approval.

B Materials

1 Stonclads GS system, or approved equal, with the following characteristics:

Property	Test method	Typical results
Compressive strength	ASTM C579	69 n/mm^2 after 7 days
Tensile strength	ASTM C307	12 n/mm2
Percent elongation	ASTM D790	0.15
Flexural strength	ASTM C580	27.5 n/ mm^2
Flexural modulus of elasticity	ASTM D790	13,790 n/ mm^2
Hardness (Shore.Durometer)	ASTM D2290	85 - 90
Bond strength	ACI committee 403 pp. 1139-1141	2.8 n/ mm^2 (100% concrete failure)
Indentation	Mil-d-3134	No indentation
Coefficient of friction	ASTM D2047	0.6

Property	Test method	Typical results
Flammability	ASTM D635	Self-extinguishing, extent of burning max. 6 mm
Coefficient of linear thermal Expansion	ASTM D-696	3.5 x 10-5 inch by inch per Per degree f.
Water absorption	ASTM C413	0.2%
Heat resistance		60°C (for continuous exposure)
Limitation		93 °C (for intermittent spills)
Heat deflection	ASTM D648	43 °C
Cure rate (at 25oc)		Allow 6 hours for foot traffic, 18 hours for light traffic, 24 hours for normal operations.

2. Stonkote sealer:
   a. Shall be of 100 percent solids.
   b. Two component ambient-cure coating based on a modified aliphatic amine curing agent.
   c. Diglycidyl ether of bisphemel a epoxy resin.
   d. Physical/chemical characteristics:

Property	Typical results
Solids	100%
Solvent	None
Pot life	20 minutes
Min. Dry film thickness	3-5 mils/coat
Theoretical coverage at 3.0 mils dft	18.5 sqm/unit
Cure rate at 25 °C	4-5 hours for tack-free light traffic, 10-12 hours for light traffic, 24 hours for normal operations
Temperature limitation	60 °C – continuous exposure, 93 °C - intermittent exposure
Fire resistance for dry film	Self-extinguishing

Part 3 Execution

3.01 Condition of Surfaces

A The contractor shall examine substrate, adjoining construction, and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 Preparation

A Clean substrate to remove deleterious substances which would impair the work.

B Fill cracks, holes and depressions in the substrate. Surface shall be smooth, level and at proper elevation and shall not vary more than 1:900 in any direction from level, plumb or slopes shown. Remove roughness and protrusions from concrete surfaces by grinding. Use compounds for filling complying with resilient flooring manufacturer's recommendations.

C. Prime, seal cover substrate if it is of a kind or in a condition which the manufacturer of the resilient flooring recommends to be primed, sealed or covered. Use materials complying with manufacturer's recommendations.

D. Test concrete floors to ensure that they are dry before installation of resilient flooring.

3.03 Installation

A Install resilient flooring in accordance with the manufacturer's printed instruction and recommendations.

B Chase edges of areas where the installed floor does not butt against a vertical surface. Chase shall be 18 mm channel, saw-cut to a straight line, and chiselled to 6 mm depth.

C Where required an expansion or control joint shall be saw-cut after floor installation and filled with manufacturer's flexible epoxy or urethane caulk systems.

END OF SECTION 09700

Section 09870

Coating Systems for Ferrous Metals

Part 1 General

1.01 Description

Provide all labour, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in Contract Documents and as specified herein. The work included in this section includes:

1. Coatings for all ferrous surfaces, interior and exterior.
2. Submerged ferrous metal surfaces.
3. Structural and miscellaneous steel, including tanks, hoppers, and similar equipment.
4. Equipment furnished without factory finished surfaces.
5. Exposed galvanized metal except handrails, grating, piping, and checkered plate.

1.02 Submittals

Manufacturer's Data

1. Manufacturer's current printed product description, materials safety, and technical data sheets for coating systems.
2. Name and experience of manufacturer's recommended coating applicator, including list of installations painted, responsible officials and telephone numbers.
3. Detailed mixing, thinning, and application instructions, minimum and maximum application temperature, and curing and drying times between coatings.
4. Instructions for surface preparation requirements and number and types of coats required for each surface.
5. Color charts for each coating system.
6. Certifications from manufacturer verifying factory applied prime coatings are compatible with specified finish coatings.
7. Detailed maintenance manual including the following information:
   a. Product name and number.
   b. Name, address and telephone number of manufacturer and local distributor.
   c. Detailed procedures for routine maintenance and cleaning.
   d. Detailed procedures for light repairs such as scratches and staining.
8. Certified information for sandblasting abrasive, including:
   a. Particle size distribution.
   b. Dust generation at proposed operating pressure and distance and safety measures proposed for operatives.
   c. pH value.
   d. Soluble chloride content.
   e Analysis for free silica.
   f. Trace toxic contaminants.

9 Safety measures proposed for applicators

B. Sample Panels: apply a complete coating system to a panel of the same material as that on which the coating will be applied and submit for approval for each color specified. Approved sample panels will be used for quality control in applying coating systems.

C. Certificates of Compliance.

D. Inspection Reports.

E. Test Reports.

1.03 Delivery, Storage and Handling

A. Deliver materials in original, unopened packages and containers bearing manufacturer's name and label, including the following information:
   1. Name or title of material.
   2. Manufacturer's stock number and date of manufacture.
   3. Manufacturer's name.
   4. Contents by volume, for major pigment and vehicle constituents.
   5. Thinning instructions, where recommended.
   6. Application instructions.
   7. Color code and name.

B. Storage
   1. Store materials near or on site in a suitable location, protected from exposure to extreme weather.
   2. Keep area clean and accessible.
   3. Restrict storage to coating materials and related equipment.
   4. Keep temperature of storage area between $18^{O}C$ and $32^{O}C$.
   5. Comply with Local Laws and Regulations.
   6. Clothes and Cotton wastes that might constitute of fire hazard shall be placed in closed metal containers or destroyed at the end of each workday.
   7. Provide approved fire extinguishers in material storage area.

1.04 Quality Assurance Provisions

Submit name and experience record of manufacturer's recommended coating applicator including list of utility or industrial installations painted, responsible officials, architects, or engineers concerned with the project and the approximate contract price. Inspect surface and correct defects prior to application of each coat.

1.05 Environmental Conditions

A. Unless otherwise recommended by coating manufacturer, the ambient temperature shall be between $7^{o}C$ and $35^{o}C$ when applying coatings other than water-thinned and epoxy.

B. Water-thinned coatings shall be applied only when ambient temperature is between $10^{o}C$ and $32^{o}C$.

C. Epoxy coatings will be applied only within the minimum and maximum temperatures recommended by the coating manufacturer.

D. Coatings, except water-thinned types, shall be applied only to surfaces that are completely free of moisture as determined by sight or touch.

E. Do not apply to surfaces which have visible frost or ice.

Part 2 Products

2.01 Manufacturers

A. No substitutions shall be considered that decrease film thickness, number of coats, surface preparation, performance criteria or the generic type of coating specified.

B. Furnish coatings and coating products under this Section from a single manufacturer unless otherwise specified.

2.02 General

A. Compatible materials shall be used as primer and finish coats of systems. Compatible barrier coats may be used between factory-applied prime coats, or finish on existing surfaces to be refinished, and subsequent field coats with the Engineer's approval.

B. Colors shall be as scheduled or selected by the Engineer, except prime and intermediate coats shall be tinted as approved by the Engineer to facilitate inspection of coverage for each coat.

C. All products submitted shall conform to federal, state, and local requirements limiting the emission of volatile organic compounds.

2.03 Hazardous Materials Restrictions

Paints and painting practices shall comply with all applicable state and local laws enacted to ensure compliance with Federal Clean Air Standards.

2.04 Materials

A. VOC:
   1. Maximum 0.33 kg/liter for shop applied primers.
   2. Maximum 0.42/liter for field applied coatings.

B. Abrasive
   1. Chose particle size, shape, and specific gravity to produce desired surface profile for coating adhesion recommended by coating manufacturer. If not listed in manufacturer's literature, provide for a 50 to 75 microns average profile.
   2. pH value: Not less than 4 nor greater than 10 when mixed in neutral water.
   3. Soluble Chloride: none.
   4. Free Silica: meet government regulations.
   5. Trace Toxic Contaminants: to meet government regulations.

C. Universal primer:
   1. Percent Solids: minimum 55 $\pm$ 2 percent
   2. Abrasion: maximum loss per ASTM D 4060; 150 mg loss after 1000 cycles of CS-17 wheel.
   3. Hardness: minimum per ASTM D 3363; 3H.

D. Epoxy-polyamide finish
   1. Percent Solids: minimum 55 $\pm$ 2 percent

2. Abrasion: maximum loss per ASTM D 4060; 150 mg loss after 1,000 cycles of CS-17 wheel.
3. Hardness: minimum per ASTM D 3363; 3H.

E. High-build acrylic polyurethane finish
1. Percent Solids: minimum 68 ± 3 percent.
2. Abrasion: maximum loss per ASTM D 4060; 125 mg loss after 1000 cycles of CS-17 wheel.
3. Hardness: minimum per ASTM D 3363; 2H

F. High-build epoxy maintenance coating
1. Percent :Solids 85 ± 5 percent.
2. Abrasion: maximum loss per ASTM D 4060; 130 mg loss after 1000 cycles of CS-17 wheel.

G. Colors as selected by Engineer from manufacturer's standards.

Part 3 Execution

3.01 Workmanship

Paint and coatings shall be applied so as to produce an even film of specified thickness. Edges, corners, crevices, and joints shall receive special attention to ensure that they have been thoroughly cleaned and that they receive an adequate thickness of paint. Finished surfaces shall be free from runs, drips, ridges, waves, laps, brush marks, and variations in color, texture, and finish. Coverage shall be complete so that the addition of another coat of paint would not increase the coverage. Adjacent surfaces shall be protected by the use of drop cloths or other approved precautionary measures.

3.02 Items not to be Coated

Unless otherwise specified all ferrous metal surfaces shall be sandblasted and then coated. Hardware, hardware accessories, nameplate data tags, machined surfaces, and similar items not to be coated, but in contact with coated surfaces, shall be removed or masked prior to surface preparation and painting operations. Following completion of coating of each piece, removed items shall be reinstalled. Removal and installation shall be done by workmen skilled in the trades involved.

3.03 Preparation

A. Surfaces to receive paint and protective coatings shall be cleaned as specified prior to application of coating materials.

B. Examine surfaces to be finished, and correct surface defects before application of any coating material.

C. Beginning the work of this section without reporting unsuitable conditions to the Engineer constitutes acceptance of conditions.

D. Marred or abraded areas on shop-primed and factory-finished surfaces shall receive touch-up restoration prior to any other coating applications.

3.04 Sandblasting

A. All sandblasting shall be done in strict accordance with the referenced specifications of the Steel Structures Painting Council, relevant sections of which have been reproduced hereinafter.

B. When items to be shop primed or shop primed and finish coated in the shop, surface preparation shall be as specified in this Section.

C. The Engineer shall have the right to witness, inspect, and reject any sandblasting done in the shop.

D. When sandblasting is done in the field, care shall be taken to prevent damage to structures and equipment. Pumps, motors, and other equipment shall be shielded, covered, or otherwise protected to prevent the entrance of sand. No sandblasting may begin before the Engineer inspects and approves the protective measures.

E. The following surface preparations for metal surfaces to be painted or given protective coatings shall form part of this Section:
   1. White Metal Blast Cleaning (For very corrosive atmosphere): removal of all visible rust, will scale, paint and foreign matter by blast cleaning by wheel or nozzle (dry) using sand, grit or shot.
   2. Near-White Blast Cleaning (For high humidity, chemical atmosphere, marine or other corrosive environment): blast cleaning nearly to White Metal Cleanliness, until at least 95 percent of each element of surface area is free of all visible residues.
   3. Commercial Blast: blast cleaning until at least 67 percent of each element of surface area is free of all visible residues.
   4. Brush-Off Blast Cleaning: blast cleaning of all except tightly adhering residues of mill scale rust and coatings, exposing numerous evenly distributed flecks of underlying metal.
   5. Solvent Cleaning: removal of oil, grease, dirt, soil, salts and other contaminants by cleaning with solvent, vapor alkali, emulsion or steam.

F. Surface preparations shall be done to the satisfaction of the Engineer. No painting or protective coating shall be applied before the Engineer has inspected and approved the preparation.

G. After sandblasting, dust and spent sand shall be removed from the surfaces by brushing or vacuum cleaning.

3.05 Application of Protective Coatings

A. Shop Coating
   1. Fabricated metalwork and equipment which requires coating may be shop primed with specified primer.
   2. Any such work delivered to the job site with any other shop coat shall have this coating removed and the specified coating applied in the field.
   3. Manufactured equipment with approved corrosion-resistant factory finishes and galvanized finishes shall be exempt from this requirement of stripping.

B. Field Coatings
   1. Except where in conflict with the manufacturer's printed instructions, or where otherwise specified herein, use choice of brush, roller, air spray, or so-called airless spray application.

a. Any spray painting must first have the approval of the Engineer.
b. Areas inaccessible to spray coating or rolling shall be coated by brushing or other suitable means.

2. Give special attention to ensure that edges, corners, crevices, welds, bolts, and other areas, as determined by the Engineer, receive a film thickness at least equivalent to that of adjacent coated surfaces.
3. All protective coating materials shall be applied in strict accordance with the manufacturer's printed instructions.
4. Prime coat shall be applied to clean surfaces within a 4-hour period of the cleaning, and prior to deterioration or oxidation of the surface, and in accordance with the manufacturer's recommendations.
5. Coatings shall be applied in dry and dust-free environment.:
6. No coating or paint shall be applied during following conditions:
   a. When the surrounding air temperature, measured in the shade, is below 15^{o}C.
   b. To wet or damp surfaces.
   C. In rain, fog or mist, or when the relative humidity exceeds 85%.
   d. When it is expected that the relative humidity will exceed 85% or that the air temperature will drop below 5^{o}C within 18 hours after the application of the coating or paint.
   e. Dew or moisture condensation shall be anticipated.
7. If above conditions are prevalent, painting shall be delayed until surfaces are dry.
8. The day's coating shall be completed in advance of the probable time of day when condensation will occur in order to permit the film a sufficient drying time prior to the formation of moisture.
9. Care shall be exercised to avoid lapping or dripping paint on adjacent surfaces:
   a. Coatings shall be sharply cut to lines.
   b. Finished coated surfaces shall be free from defects or blemishes.
   c. Drop cloths shall be used to protect floors, fixtures, and equipment.
   d. Care shall be exercised to prevent paint from being spattered onto surfaces from which such paint cannot be removed.
   e. Surfaces from which paint cannot be removed shall be painted or repainted as required to produce a finish satisfactory to the Engineer.
   f. Whenever two coats of a dark colored paint are specified, the first coat shall contain sufficient powdered aluminum to act as an indicator of proper coverage, or the second coating shall be of a contrasting color.
10. Surfaces inaccessible after assembly shall be coated before erection:
    a. No structural friction connections, high-strength bolts, and nuts shall be painted before erection.
    b. Areas damaged during erection shall be hand or power-tool cleaned and recoated with prime coat.
11. Touch up of surfaces shall be performed after installation.
12. All surfaces to be coated shall be clean and dry at the time of application.

C. Time of Coating
   1. Manufacturer's recommended recoat time shall be complied with.
      a. Sufficient time shall be allowed to elapse between successive coats to permit satisfactory recoating, but, once commenced, the entire coating operation shall be completed without delay.
      b. No additional coating of any structure, equipment, or other item designated to be painted shall be undertaken without specific permission of the Engineer until the previous coating has been completed for the entire structure, piece of equipment, or other item.
   2. Piping shall not be finish coated until it has been pressure tested and approved.

D. Thickness of Coating: dry film thickness specified shall be achieved and verified for each coat.

3.06 Testing and Inspection

A. Inspection Devices
   1. The Contractor shall provide, until final acceptance of coating and painting, inspection devices in good working condition for detection of holidays and measurement of dry film thickness (DFT) of coatings and paints.
   2. Furnish U.S. Department of Commerce, National Bureau of Standards-certified thickness calibration plates to test accuracy of DFT gauge and certified instrumentation to test accuracy.
   3. Dry film thickness gauges shall be made available for the Engineer's use until final acceptance of application.
   4. Holiday detection devices shall be operated in the presence of the Engineer.
   5. Inspection devices shall be operated in accordance with the manufacturer's instructions and when directed by the Engineer's representative.

B. Conduct DFT measurements and electrical inspection of the coated surfaces.

C. Recoat and repair as necessary for compliance with the specifications.

D. After repaired and recoated ferrous metals areas have cured, final inspection tests shall be conducted by the Engineer.
   1. Coating thickness specified in microns on ferrous substrates shall be measured with a nondestructive magnetic type dry-film thickness gauge such as the Elcometer, manufactured by Gardner Laboratories, Inc.
   2. Discontinuities, voids, and pinholes in the coatings will be determined with a nondestructive type electrical holiday detector.
   3. Epoxy coatings and thin film coatings shall be checked for discontinuities and voids with a low-voltage detector of the wet-sponge type, such as Model M1 as manufactured by Tinker and Rasor.
   4. Use a non-sudsing type wetting agent, such as Kodak Photo-Flo, which shall be added to the water prior to wetting the sponge.
   5. A high-voltage, low-current, spark type detector such as Model EP, manufactured by Tinker and Rasor, shall be used for electrical inspection of coal tar enamel only.
   6. Tape-type coatings shall be inspected for holidays using a device designed for use in detecting such flaws.
   7. Pinholes shall be marked, repaired in accordance with the manufacturer's printed recommendations, and retested.
   8. No pinholes or other irregularities will be permitted.
   9. Coatings not in compliance with the specifications will not be acceptable and shall be replaced and reinspected at Contractor's expense until the requirements of the specifications are met.

3.07 Cleanup

Upon completion of the work, staging, scaffolding, ventilation equipment and containers shall be removed from the site or destroyed in an approved manner. Paint spots, oil, or stains upon adjacent surfaces shall be removed.

3.08 Paint and Coating Schedule

A. The schedule here-in shall indicate the coating system to be used. The list shall not be construed as a complete list of surfaces to be coated, but rather as a guide as to the application of the various coating systems. Surfaces shall be painted except those specifically deleted herein. Where reference is made to ferrous metal in this schedule, it shall not include stainless steel or galvanized metals except as specified in paragraph C.

B. Painting Systems
   1. System A
      a. Metals subject to corrosive moisture or atmosphere and condensation.
      b. All metal surfaces shall be sandblasted in accordance with paragraph 3.04 using proper abrasive size to achieve 35 to 40 micron anchor pattern. Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed.
      c. Coating shall be applied by airless spray but by brush for small areas. Coating thicknesses shall be:

Component	Minimum Film Thickness
Primer	50 microns
Intermediate Coat	100 microns
Finish Coat	50 microns
Total System	200 microns

      d. Time Between Coatings
         1. A minimum of 12 hours time is required before additional coats may be applied to the prime coat.
         2. Two hours for the intermediate coat.
         3. Two hours for the finish coat.
   2. System B
      a. Metals subject to normal indoor or outdoor exposure, except as specified for buildings and not subject to chemical attack.
      b. All surfaces shall be free of dirt, dust, grease, or other foreign matter before coating. Surfaces shall be cleaned in accordance with paragraph 3.04. Weld surfaces and rough edges shall be ground and weld splatter removed.
      c. Coating application shall be in strict conformance with the manufacturer's recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application each coat. Coating thickness shall be:

Component	Minimum Film Thickness
Primer	50 microns
Intermediate Coat	50 microns
Finish Coat	50 microns
Total System	150 microns

   3. System C
      a. Metals submerged or intermediately submerged in water or corrosive liquid.
      b. All metal surfaces shall be sandblasted in accordance with paragraph 3.04, Near White Blast Cleaning using proper abrasive to achieve 50 to 75 microns anchor pattern. Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed, and welds neutralized with thinner.
      c. Coating application shall be in strict conformance with the manufacturer's recommendations. All sharp edges, nuts, bolts or other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application of each coat. Coating thicknesses shall be:

Component	Minimum Film Thickness
Primer	50 microns

Finish Coats (two or more)	400 microns
Total System	450 microns

4. System D
   a. For interior and exterior metal not painted under Systems A, B, and C.
   b. Ferrous metals shall be prepared as specified for System B and galvanized surfaces shall be washed with solvent thinner as recommended by the paint manufacturer.
   c. Each coat shall be applied to a minimum dry film thickness of 50 microns.
   d. Each coat shall be completely dry before the next coat is applied.

C. Paint Schedule
1. The following schedule shall indicate the coating system to be used. All surfaces shall be painted except those deleted herein and the Engineer shall select the colours.
2. Process Piping Colour Code
   a. All exposed pipe, including tubing, valves, couplings, fittings, flanges, galvanized pipe, and polyvinyl chloride pipe, shall be identified by colour code to show its function.
   b. Painted surfaces shall be colour coded in accordance with the coding schedule. Adhesively applied colour bands of an approved tape type shall be used on plastic and any other pipe not readily susceptible to painted finish.
   c. Piping which is not painted shall be provided with 300 mm wide colour bands every 3.5 m and each change of direction.
   d. Labels and arrows showing direction of flow shall be installed on all piping every 3.5 m and at each change of direction of the piping.
   e. Where not shown or otherwise required by applicable codes and regulations colours and labels shall conform to the following or as selected by the Engineer.

Item	BS 4800	Colour Description
Raw sewage	10 B 17	Stone
	14 C 39	(with Dark Green Bands)
Effluent, supernatants and liquors	14 E 39	Medium Green
Final Effluent	14 E 51	Light Green
Potable water	18 E 51	Sky Blue
Air	00 E 55	White
Chlorine	10 E 53	Yellow with danger bands
Gas (methane)	24 O 51	Orange
Electrical conduits	06 E 51	Orange

Danger bands are to be provided on specified pipelines and at valves and comprise danger symbol diagonal stripes on yellow background 150 mm wide.

3. All plant and equipment shall be painted to the colours detailed below unless otherwise instructed by the Engineer.

Item		BS 4800	Colour Description
Baseplates and mounting stools	}	00 A 05	Light Grey
Steel handrails, walkways & steel Supporting structures	}		
Fuel storage tanks		06 C 39	Mid Brown
Diesel engines		06 D 43	Light Orange
Screw pumps	}	00 E 53	Black
Non Potable Water Tanks	}		Light Green
Coupling & Fly wheels	}	04 E 53	Red
Drive shafting	}		
Valve handwheels	}		
Lifting equipment's, including rails	}		

Item	BS 4800	Colour Description
Beams, bogies, gantry girders crab, block and control cabin		
Centrifugal pumps Gearboxes	08 E 51	Mid Yellow
Transformers Control, switchgear, distribution & mimic panels	18 E 51	Sky Blue
Motors Alternators All other exposed metalwork	18 E 53	Mid Blue
Shafts and coupling guards Aluminium handrailing		Self Colour
Exhaust pipes		Polished Aluminium

D. General Coating System
1. The following list shall indicate the coating system.
2. Piping shall be defined as all pipe, valves, fittings, supports, operating systems and guides.
3. Mechanical equipment shall include all drives, motor control panels, and all other electrical equipment requiring a protective coating.
4. The colours of mechanical equipment shall be as given above.

	Item	System	Colour
a.	Pump Station Wet Wells:		
	All exposed mechanical equipment	A	*
	All submerged mechanical equipment And piping	C	Black
b.	Pump Station Dry Wells and Motor Rooms:		
	All mechanical equipment and piping	B	*
	Offices/Store/Workshops all exposed metal	B	*
c.	Miscellaneous:		
	All miscellaneous interior exposed metal surfaces	B	*
	All miscellaneous exterior exposed metal surfaces	A	*
	All submerged metal surfaces	C	Black
	All chambers containing piping	A	*
	Bridge crossing pipework	A	*
	Bridge structural members	A	Black

- Colour per equipment or pipe colour code schedules.

END OF SECTION 09870

Section 09900

Architectural Painting

Part 1 General

1.01 Description

A. Provide all labour, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in Contract Documents and as specified herein.

B. The principle work of this Section includes, but may not be limited to, field painting and finishing of all items of Works, both internally and externally with exception to those items identified in Sections 03350 and 09870 hereof.

C. Painting work shall be executed by an approved specialist Sub-Contractor.

D. Contractor shall examine other Sections of the Specifications for the various other trades and shall thoroughly familiarize himself with all such items and surfaces to be included in this work which are not included in other Sections.

E. The term "paint" as used herein, includes paints, enamels, stains, varnishes, lacquers, sealers, fillers and other types of coatings whether used as primers, intermediate or finish coats.

F. Refer to the schedule of finishes on the Drawings for a list of the areas and surfaces to be painted together with the each painting system, surface preparation, textures and lustre (sheen) required for the various surfaces.

1.02 Shop Painted Items

A. Shop Primed Items: certain items of work are specified to be shop primed under other individual sections with finish painting specified in this Section.

B. Shop Finished Items: certain items of work are specified under individual Sections to be shop finished and do not require finish painting in the field.

1.03 Submittals

A. Manufacturer's Data
   1. Manufacturer's specifications and installation instructions for paint materials and systems.
   2. Certifications.
   3. Verification of mil thickness specified.
   4 Other data to show compliance with these Specifications.

B. Detailed Painting Schedule:
   1. "Detailed Painting Schedule" prepared on the basis of:
      a. Surfaces.
      b. Types of paint materials.
      c. Types of primers and sealers.

d. Number of coats.

2. List the brand name of the product of the manufacturer for each use.

C. Samples

1. Samples as hereinafter listed.
   a. Sample Boards:
      1. Colour chips on 300 x 300mm hardboard, with colour, texture and sheen applied to simulate actual conditions.
      2. Resubmit sample boards as necessary for selection by the Engineer.
   b. Sample Areas:
      1. Using selected 300x300mm sample boards as a guide prepare a mock-up area and finish partial areas as directed by the Engineer for final approval of colour, texture and sheen.
      2. Approved areas shall serve as the standard for workmanship, appearance and materials for similar areas throughout the project.
2. Sample submittal shall be for colour, sheen and texture only.
3. Compliance with all other requirements is the exclusive responsibility of the Contractor.

D Paint

Five litres of each type of paint and colour used shall be provided for touch up purposes and shall be handed over to the Employer at the end of the maintenance period.

1.04 Quality Assurance

A. Where manufacturer makes more than one grade of any material specified, the applicator shall use the highest grade of each type, whether or not the material is mentioned by trade name in these specifications.

B. Include on labels of all containers the manufacturers name, the product name and number, the colour and the batch number.

C. All work shall conform to Contract Documents and Section 01400 hereof.

D. Set up mock-ups to enable the Engineer to approve/select colours and finish quality.

E. Guarantee all exterior paintwork to be weather resistant for a period of 10 years.

1.05 Environmental Conditions

A. Do not apply paint in rain, fog or mist; when the air is dust laden; when the relative humidity exceeds 85 percent; or when temperature of the surfaces to be painted and the surrounding atmosphere is below $10^{o}C$ for water thinned coatings and $7^{o}C$ for other coatings.

B. Paints, other than water-thinned coatings, shall be applied only to surfaces that are completely free of surface moisture as determined by sight, touch and moisture meter, as specified.

C. Maintain temperatures at a minimum of $16^{o}C$ during painting and drying periods.

D. During period of inclement weather, painting may be continued if areas and surfaces to be painted are enclosed, artificial heat is supplied and temperature and humidity conditions prescribed above are maintained.

E. Where the paint manufacturer's specifications or instruction differ from the above specifications, the more stringent requirements shall apply to this work.

1.06 Delivery, Storage and Handling

A. All materials shall be delivered in manufacturer's original sealed containers, bearing the manufacturer's standard label, indicating type and colour. Materials shall be delivered in sufficient quantities in advance of the time needed in order that work will not be delayed in any way.

B. Materials shall be stored in designated spaces in a manner which meets the requirements of applicable code and fire regulations. When not in use, such spaces shall be kept locked and inaccessible to those not employed under this Section. Each space shall be provided with a fire extinguisher of carbon dioxide or dry chemical type bearing the label of the National Board of Fire Underwriter's or approved equal and tag of recent inspection.

1.07 Protection

A. Place paint or solvent soaked rags, waste or other materials which might constitute a fire hazard in metal containers and remove from premises at the close of each day's work. Take every precaution to avoid damage by fire.

B. Protect the work of all other trades against damage, marking or injury by suitable covering during the progress of the painting and finishing work. Repair any damage done. Re-finish any work made necessary by defective workmanship or materials, or carelessness as directed by the Engineer.

Part 2 Products

2.01 General

A. No claims as to the suitability of any material specified or the Contractor's inability to produce first class work with these materials will be considered unless such claims are made in writing and submitted in sufficient time, prior to the execution of the work, so as not to cause delays.

B. Provide only absolutely pure linseed oil, turpentine, shellac, and other like materials that are of the highest quality with identifying labels intact and seals unbroken. Use no thinners other than those specified by the manufacturer. Use only primers and undercoats that are suitable for each surface to be covered and that are compatible with the finish coat required.

C. Use products of the same manufacturer for succeeding coats. Where shop primed materials are to be finished painted and/or prime coat materials are by a different manufacturer than the finish coat materials, confirm compatibility of the primers with the manufacturer of the finish coat paints.

2.02 Materials

A. Knotting shall be a solution of shellac or other resin in alcohol, pigmented with aluminium or other pigments to be applied on knots in wood before primer complying with BS 1336.

B. Stoppers or fillers shall be of the following type:
   1. For plasterwork - a water-based, powder type and can be mixed with emulsion paint.
   2. For concrete or blockwork - cement based material similar to the background and shall be finished with a similar texture.

C. Raw, refined and boiled linseed oils shall comply with BS 6900.

D. White Spirit shall comply with BS 245.

E. Primers shall be as follows:
   1. Plaster and concrete surfaces: alkali resistant primer obtained from the maker of undercoat and finishing coat.
   2. Alkaline surfaces: special primers obtained from the maker of undercoat and finishing coats.
   3. Bituminous surfaces to be finished with oil paint: special primer recommended by the maker of undercoat and finishing coats.
   4. Iron and steel work: red oxide priming paint complying with BS 2523.
   5. External galvanized steelwork: apply a wash coat for the pre-treatment of new galvanized surfaces.
   6. Internal woodwork: approved leadless white or light grey primary paint, compatible with undercoat and finishing coats and obtained from the same maker.
   7. External woodwork: ready mixed aluminium primary paint to comply with BS 4756.
   8. Hardwood: special ready mixed primer obtained from the maker of the undercoat and finishing coats.

F. Acrylic emulsion paint shall be high build vinyl copolymer type with minimum solid content of 50 percent. Thinner, if recommended, shall be from the same manufacturer.

G. Oil paints shall be oil based alkyd enamel paint of flat or silk finish with minimum solid content of 45 percent. Thinner, if recommended, shall be from the same manufacturer.

H. Oil alkyd based enamel paint for external galvanized steel work shall be air drying type with undercoat based on a thixotropic alkyd resin. Apply two coats of oil alkyd resin based gloss enamel paint.

I. Teak oil shall be of an approved brand and applied in accordance with manufacturer's instructions.

J. Varnish shall be of an approved brand.

K. Textured paint shall be acrylic-copolymer emulsion based paint suitable for outdoor use. Provide a weather-resistant finish upon drying.

2.03 Compatibility of Coatings

A. Paints applied in the shop and in the field shall be mutually compatible.

B. Shop drawings for fabricated items shall indicate manufacturer and type of shop coat to be applied.

C. Applicator shall determine that the materials specified in the painting schedule are compatible with shop coats to which these materials are to be applied.

D. Any condition which may require a change in the Specifications shall be brought to Engineer's attention before proceeding with the work. Failure to do so shall be construed as acceptance of the paints specified and the Contractor shall correct at his own expense, any defects in his work resulting from the use of such materials. No claim concerning the unsuitability of any material specified or his ability to produce first class work with same will be entertained.

2.04 Colours

A All colours shall be mixed in accordance with manufacturer's instructions. Colours shall be pure, non-fading pigments, mildew proof, sun proof, finely ground in approved medium. Colours used on concrete, wallboard surfaces (as applicable), shall be lime-proof. All materials shall be subject to the Engineer's approval.

Part 3 Execution

3.01 Condition of Surfaces

A The Contractor shall examine the substrata and adjoining construction, and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 General

A. Inspect all surfaces in regard to their suitability to receive a finish.

B. In the event that imperfections due to materials or workmanship appear on any surfaces after the application of paint or coating, the cost of any correction shall be borne by the Contractor.

C. Remove hardware, switch-plates, trim for mechanical work, lighting fixtures and similar items placed prior to painting. Set aside and re-fix on completion of painting work.

D. Protect items where not practicable to remove and upon completion of painting work remove protection.

E. Clean all surfaces to be painted as required to remove dust and dirt. Sand as necessary to properly prepare surfaces to receive paint or natural finish.

F. Before applying succeeding coats, (minimum 2) primers and undercoats shall be completely integral and shall perform the function for which they are specified.

G. Properly prepare and touch up all scratches, abrasions or other disfigurements.

H. Remove any foreign matter before proceeding with the following coat.

I. All spot-priming or spot-coating shall be feather-edged into adjacent coatings to produce a smooth and level surface.

J. Do not apply the last and final coats until after other trades whose operations would be detrimental to finish painting have finished with their work in the area to be painted, and the areas have been released for painting by the Engineer.

K. Comply with the manufacturer's instructions, Engineer's requirements and the following recommendations for the preparation of the listed type of surfaces wherever applicable. Field samples shall be prepared for each different type or colour of paint for Engineer's approval prior to proceeding with the work.
   1. Plaster, Concrete and Blockwork
      a. All splashes of plaster, mortar etc. shall be removed from plastered, concrete surfaces by scraping.
      b. All holes, cracks, etc. shall be stopped and the whole of the surfaces will be brushed down to remove dust and loose material.
      c. Plastered surfaces shall receive two coats of linseed oil putty complying with BS 544 well worked in and spread over the entire surface and to be sanded down to give a completely smooth and even surface.
      d. All traces of mould oil shall be removed from concrete surfaces by scrubbing with water and detergent and rinsing with clean water to remove all detergent.
      e. When efflorescence has occurred or is suspected, painting shall be postponed for a period as required by the Engineer.
   2. Gypsum Board
      a. Minor imperfections in gypsum board to be painted shall be filled with the same filler used for jointing the gypsum board.
      b. Whole of the surface shall be brushed down to remove dust.
   3. Hardboard
      a. All dirt and grease shall be removed from the surface.
      b. After priming all nail holes and other imperfections shall be stopped.
   4. Plywood
      a. Surfaces of work to be painted shall be primed, filled as required with a filler, rubbed and dusted down and a second coat of primer applied.
      b. After final priming all imperfections shall be stoppered, rubbed down and brushed off.
   5. Woodwork to be Painted
      a. Before fixing woodwork, all surfaces which will be visible after fixing shall be rubbed. All knots and resin pockets shall be coated with knotting.
      b. After priming and fixing, all nail holes and other imperfections shall be stopped. Whole surfaces shall be rubbed down and all dust brushed off.
   6. Woodwork to receive a clear finish
      a. All holes and other imperfections in surfaces to receive a clear finish shall be stopped.
      b. Whole surface shall be rubbed down and all dust brushed off.

3.03 Paint Application

A. General
   1 All materials shall be used strictly in accordance with manufacturer's instructions and to the approval of the Engineer.
   2 Recommended dry film thickness is 75-125 microns/coat or as recommended by the manufacturer.
   3 Contents of all cans and containers must be properly and thoroughly studied before and during use and stirred as and when necessary.
   4 Paint shall be applied by a brush, roller or spray in accordance with the manufacturer's instructions.
   5 All materials when brushed shall be evenly applied with brushes best suited for the type of material being applied. When using a roller, the covers shall be carpet, velvet back or high pile sheet wool best suited for material and texture selected by the Engineer.
   6 Sprayed paint shall be uniformly applied with suitable equipment.

7 Spread all materials evenly and smoothly without runs, sags or other defects.
8 Make edges of paint adjoining other materials or colours sharp and clean, without overlapping.
9 Allow sufficient time between coats to ensure proper drying.
10 Sand between coats with fine glass-paper or rub surfaces with pumice stone where required in accordance with manufacturer's directions to produce an even, smooth finish.
11 "Exposed surfaces" shall mean all areas visible when all permanent or built-in fixtures, grilles, access panels, mechanical and electrical equipment housings, ducts and conduits, are in place in all areas specified or scheduled to be painted.
12 Access panels and similar items in painted areas shall be painted to match the areas in which they occur unless otherwise specified in the schedules.
13 Paint the back sides of access panels, removable or hinged covers.
14 Do not paint nameplates on equipment.
15 Wherever steel or other metal parts are shown to be built into and concealed by masonry construction, the Contractor shall paint all such work same as herein specified for exposed parts.
17. Co-ordinate the work with all related trades, so that all finish painting of concealed parts is completed before such work commences.
18. Do not finish paint exposed parts until after completion of works.
19. Do not thin the textured paint excessively. Strictly follow the manufacturer's instructions in this regard.

B. All coatings shall be allowed to dry before application of succeeding coats. All undercoats of oil paints and clear finishes shall be rubbed down to a smooth surface with abrasive paper. All dust must be removed before succeeding coat is applied.

C. Each succeeding coat of priming and undercoats shall be sufficiently different in colour as to be readily distinguishable.

D. No painting shall be applied to surfaces affected by wet, damp or other unsuitable conditions. External painting work shall not be carried out during inclement weather. Textured paint shall be applied with a perforated roller or as recommended by the manufacturer.

3.04 Protection

A. Protection of Wet Surfaces: suitable precautions shall be taken to protect surfaces which are still wet by means of screens, barricades and "wet paint" signs.

B. Protection to Other Trades
1. Contractor shall ensure that work of other trades are protected from damage and soiling from paint materials.
2. Movable objects like furniture, equipment, fittings shall be moved, protected and replaced upon completion of an area.
3. All surface fixed ironmongery, fittings, etc., shall be removed before painting and re-fixed on completion.

3.05 Cleanliness

A. All brushes tools, etc, shall be kept in a clean condition.

B. Painting shall not be carried out in the vicinity of other operations which might raise dust.

C. Do not waste any liquids, slop washings etc. into gullies, manholes, sinks, basins, WCs or any other sanitary fittings.

D. Suitable receptacles shall be provided by the Contractor to receive such liquids and slop washings.

E. All flammable residues shall be removed from the site.

3.06 Clean Up

A. On completion of the work, thoroughly clean the areas affected by painting works.

B. Remove all paint splashes and smears and surplus construction materials and debris resulting from the work and dispose of same legally off the site.

C. Carry out touch-up paint work after all equipment has been commissioned bit before the building is handed over to the Employer.

END OF SECTION 09900

DIVISION 10.

SPECIALITIES

Section 10160

Toilet and Shower Partitions

Part 1 General

1.01 Description

The work included in this section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with toilet and shower partitions.

1.02 Submittals

A Manufacturer's specifications and installation instructions.

B Detailed shop drawings showing plans, elevations, and details, including specified items and interface with other work.

C Two samples of each item of hardware and two 300 mm square samples of a door corner.

Part 2 Products

2.01 General

Toilet partitions, shower compartments, shower seats, and locker benches shall be POLY-MAR HD solid 25 mm thick plastic as manufactured by Santana Products Company, or an approved equal by Capitol Partitions, Inc., or by Columbia Partitions. Colour shall be equal to Santana's "desert beige."

2.02 Materials

Panels, doors, pilasters, screens, and benches shall be fabricated from polymer resins under high pressure forming a single-component section that is:

1. Waterproof.
2. Corrosion-proof.
3. Impact-resistant.
4. Non-absorbent.
5. Has a self-lubricating Plastic-Glaze 280 surface that resists marking with pens, pencils, lipsticks, and other writing or marking implements.

2.03 Partitions, Pilasters And Screens

Partitions shall be 25 mm thick, with edges machined to a radius of 6 mm and with sharp corners removed. Dimension shall be as shown on drawings. Pilasters shall have 75 mm high stainless steel shoes attached by theft-resistant stainless steel sex bolts.

2.04 Hardware

A Hinges, door latches, door strikes, and wall brackets shall be stainless steel, US32.

B Fasteners, shoes, and curtain hooks shall be stainless steel.

C Headrail and shower curtain extrusions shall be Alloy 6061-T6 anti-grip with mill finish.

D Door pulls, doorstops, and bumper/hooks shall be Zamac, US26 finish.

2.05 Shower Compartments

A Receptors shall be precast 1-piece terrazzo 150 mm high, made of white cement with black and white marble chips.

B Receptor shoulders shall be rabbeted to receive panels.

C Brass drain shall be cast integrally and shall provide for a caulked lead connection, not less than 25 mm deep to a 50 mm pipe.

D Removable steel strainer plate with US26 finish.

2.06 Benches

A Shower compartment and locker room benches shall be seamless solid plastic as specified for partitions.

B Each 500 mm section of benches shall have a minimum load-bearing capacity of 136 kg.

C Hardware and fittings shall be stainless steel, US26 finish.

Part 3 Execution

3.01 Installation

A Install partitions, compartments, and benches in accordance with approved shop drawings and manufacturer's instructions.

3.02 Clean-Up

Finished surfaces shall be cleaned using materials and methods recommended by the plastics manufacturer.

END OF SECTION 10160

Section 10210

Louvres and Vents

Part 1 General

1.01 Summary

This Section includes furnishing and installation of fixed metal wall louvres and motorized dampers.

1.02 Definitions

Refer to AMCA Publication 501-85 for definitions of terms for metal louvres not otherwise defined in this section or referenced standards.

1.03 System Performance Requirements

A Design, engineer, fabricate, and install exterior metal wall louvres to withstand the effects of loads and stresses from wind and normal thermal movement, noise or metal fatigue caused by louvre blade rattle or flutter, without evidencing permanent deformation of louver components including blades, frames, and supports, or permanent damage to fasteners and anchors.

B Wind load uniform pressure of 1.2 kN/sqm acting inwards or outwards.

C Normal thermal movement is defined as that resulting from the maximum change (range) in ambient temperature. Base design calculations on actual surface temperatures of metals due to both solar heat gain and night time sky heat loss.

D Air Performance, Water Penetration, and Air Leakage Ratings. Provide louvres complying with performance requirements indicated as demonstrated by testing manufacturers stock units of height and width indicated, according to AMCA 500.

1.04 Submittals

A Product data for each product indicated.

B Shop drawings including:
1. Plans, elevations, sections.
2. Details showing profiles, angles, spacing of louvre blades.
3. Unit dimensions related to wall openings and construction.
4. Free areas for each size indicated.
5. Profiles of frames at jambs, heads and sills.
6. Structural computations.
7. Material properties.
8. Other information needed for structural analysis which has been prepared by, or under the supervision of a qualified professional engineer.

C Samples for initial selection purposes in form of manufacturer's colour charts showing full range of colours available for those units with factory-applied colour finishes. Samples for verification purposes of each type of metal finish required, prepared on 150 mm square metal samples of same thickness and alloy indicated for final unit of Work. Where finishes involve normal colour and texture variations, include sample sets showing full range of variations expected.

D Product test reports evidencing compliance of units with performance requirements indicated.

1.05 Quality Assurance

A Obtain louvres from a single source where alike in one or more respects with regard to type, design and factory-applied colour finish.

B Qualify welding processes and welding operators in accordance with AWS D1.2 and AWS D1.3. Certify that each welder employed in unit of Work of this section has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. Testing for recertification is the Contractor's responsibility.

C Comply with SMACNA "Architectural Sheet Metal Manual" recommendations for fabrication, construction details, and installation procedures.

1.06 Project Conditions

A Field Measurements
1. Check actual louvre openings by accurate field measurements before fabrication.
2. Show recorded measurements on final shop drawings.
3. Coordinate fabrication schedule with construction progress to avoid delay of the Work.
4. Where field measurements cannot be made without delaying the Work, guarantee opening dimensions and proceed with fabrication of louvers and vents without field measurements.
5. Coordinate wall construction to ensure that actual opening dimensions correspond to guaranteed dimensions.

Part 2 Products

2.01 Materials

A Aluminium sheet shall be ASTM B 209, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer to produce required finish.

B Aluminium extrusions shall be ASTM B 221, Alloy 6063-T5 or T-52.

C Fasteners shall be same basic metal and alloy as fastened metal, unless otherwise indicated. Do not use metals which are corrosive or incompatible with materials joined. Use types, gages, and lengths to suit unit installation conditions. Use Phillips flat-head machine screws for exposed fasteners, unless otherwise indicated.

D Anchors and inserts shall be of type, size, and material required for type of loading and

installation indicated. Use nonferrous metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or expansion bolt devices for drilled-in-place anchors.

2.02 Fabrication

A Fabricate louvers and vents to comply with requirements indicated for design, dimensions, materials, joinery, and performance.

B Preassemble louvers in shop to minimize field splicing and assembly and disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Include supports, anchorages, and accessories required for complete assembly.

C Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.

D Fabricate frames, including integral sills, to fit in openings of size indicated with allowances made for fabrication and installation tolerances of louvers, adjoining construction, and perimeter sealant joints.

E Provide vertical mullions of type and at spacings indicated but not further apart than recommended by manufacturer, or 1.8 m on centre, whichever is less. At horizontal joints between louver units provide horizontal mullions except where continuous vertical assemblies are indicated.

F. Join frame members to one another and to fixed louver blades with fillet welds, concealed from view, unless otherwise indicated, or size of louver assembly makes bolted connections between frame members necessary.

2.03 Fixed Extruded Aluminium Wall Louvres

A Horizontal drainable fixed blade louvers shall be of extruded aluminium frames and louver blades designed to collect and drain water to exterior at sill by means of gutters in front edges of blades and of channels in jambs and mullions. They shall comply with the following requirements:

1. Louver depth: 150 mm, unless otherwise indicated.
2. Frame thickness: 3.2 mm, unless otherwise indicated.
3. Louver blade thickness: 3.2 mm, unless otherwise indicated.
4. Louver blade angle: $37^1/_2$ degrees, unless otherwise indicated.
5. Determined by testing units 1.2 m wide by 1.2 m high per AMCA Standard 500 the louver free area shall be not less than 50 percent of total surface area; the static pressure loss not more than 37.4 N/m^2 at an airflow of 5 m/s free area intake velocity; and water penetration not more than 0.015 kg/sqm of free area at an airflow of 6 m/s free area velocity when tested for 15 minutes.

2.04 Finishes, General

A Comply with NAAMM "Metal Finishes Manual" for recommendations relative to application and designations of finishes. Finish louvers after assembly.

2.05 Aluminium Finishes

A Finish designations prefixed by "AA" conform to the system established by the Aluminium Association for designating aluminium finishes. Class I colour anodized finish shall be:
1. AA-M12C22A42/A44
2. Mechanical Finish: as fabricated, no specular.
3. Chemical Finish: etched, Medium Matte.
4. Anodic Coating: Class II Architectural, film thicker than 0.7 mil with integral colour or electrolytically deposited colour. Complying with AAMA 606.1 or AAMA 608.1.
5. Colour: As selected by Owner from within standard industry colours and colour density range.

2.06 Control Dampers

A Provide automatic or hand operated control dampers and motorized dampers as required. Construction shall be:
1. Damper frame: minimum of 16 gauge galvanized steel.
2. Damper blades: minimum of 16 gauge galvanized steel, 150 mm wide.
3. Control shaft: minimum of 12 mm zinc-plated.
4. Parallel or opposed blade design as recommended by manufacturer.
5. Leakage not to exceed 3.6 m3/m2 of damper area at a differential pressure of one kN/m^2.
6. Seals: inflatable seal blade edging with flexible metal compression seal.
7. Bearings: melded synthetic.
8. Finish: mill galvanized.

2.07 Damper Motors

A Size each damper motor with sufficient power to provide 2-position action as required:
1. Provide permanent split-capacitor or shaded pole type motors with gear trains completely oil-immersed and sealed.
2. Equip spring-return, single phase, motors, where indicated on the Drawings or in operational sequence, with integral spiral-spring mechanism.
3. Furnish entire spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
4. Equip motors for outdoor locations and for outside air intakes with "O ring" gaskets designed to make motors completely weather-proof.
5. Furnish non-spring return motors for dampers larger than 2.3 sqm and for valves larger than 60 mm breakaway torque rating of 34 Nm. Size spring-return motors for running torque rating of 17 Nm, and breakaway torque rating of 17 Nm.

2.08 Limit Switches

A Control dampers shall be provided with limit switches to verify damper open position.
1. Operating force: 0.45 Nm.
2. Single pole, double throw (SPDT).
3. Enclosure: NEMA 4X.

4. Design: side rotary with adjustable plunger and cam-tracking.
5. Minimum operating temperature capability: -12°C to 121°C.

Part 3 Execution

3.01 Preparation

Coordinate setting drawings, diagrams, templates, instructions and directions for installation of anchorages which are to be embedded in concrete or masonry construction. Coordinate delivery of such items to the work site.

3.02 Installation

A Locate and place louvre units plumb, level, and in proper alignment with adjacent work. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

B Form closely fitted joints with exposed connections accurately located and secured. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

C Provide cathodic barrier between concrete and aluminium. Protect galvanized and nonferrous metal surfaces from corrosion or galvanic action by application of a heavy coating of bituminous paint on surfaces which will be in contact with concrete, masonry, or dissimilar metals.

D Repair finishes damaged by cutting, welding, soldering, and grinding operations require for fitting and jointing. Restore finishes so there is no evidence of corrective work. Return items which cannot be refinished in field to shop. Make required alterations and refinish entire unit, or provide new units.

E Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses where required to make louver joints weathertight. Comply with Section 07920, applied during installation of louver.

3.03 Adjusting and Protection

A Protect louvers from damage of any kind during construction period including use of temporary protective coverings where needed and approved by louver manufacturer. Remove protective covering at time of Substantial Completion. Repair or replace louvers damaged during installation and construction to the satisfaction of Engineer. Clean and touch-up minor abrasions in finishes with air-dried coating that matches colour and gloss of, and is compatible with, factory-applied finish coating.

3.04 Cleaning

A Periodically clean exposed surfaces of louvers which are not protected by temporary covering. Remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning. Before final inspection, clean exposed surfaces with water and with a mild soap or detergent not harmful to finishes. Rinse thoroughly and dry surface.

END OF SECTION 10210

Section 10270

Access Flooring

Part 1 General

1.01 Description

Provide access (raised) flooring as shown on the drawings and as specified herein.

1.02 Submittals

A. Shop drawings shall indicate panel layout, railings, steps, ramps and other components and shall detail components of:
   1. Assembly
   2. Bracing
   3. Anchoring methods
   4. Edge details
   5. Interface with other construction.
   6. Identify pedestal locations.

B Samples of floor panels and support system components, finishes, trim and colours.

C Construct a job mock-up including two panels and six pedestals.

D Test reports from an independent laboratory verifying compliance with specified performance levels.

E Underfloor support structure design certified by a licensed structural engineer.

Part 2 Products

2.01 Manufacturers

A Product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer's approval.

B Access floor system shall be an approved equal to "Series 800 all Steel Access Floor System" as manufactured by Tate Access Floors, Inc.

C System Components
   1. Floor panels shall consist of a steel top sheet welded to a formed steel bottom pan and painted inside and outside with an approved epoxy paint.
   2. Understructure system to be supplied shall be "Stringerless - Gravity Held Panels" with standard Tate pedestal compartments corresponding to the Series "800 all Steel Access Floor System", with the following system performance requirements:
      a. each standard pedestal shall provide a 2300 kg axial load without permanent deformation.

b. panels shall be capable of supporting a concentrated load of 454 kg, placed on 645 sq mm area at any location on the panel with a maximum top surface deflection of 2 mm. Permanent set under this load shall not exceed 0.25 mm.
c. Ultimate strength of the floor system shall provide a loading capacity of 950 kg without failure.
d. Local and overall surface deformation shall not exceed 1 mm when subjected to 75 mm dia x 46 mm wide hard plastic wheel at 136 kg on the caster for 10 cycles over the same path and 150 mm dia x 38 mm corde hard neoprene wheel at 181 kg on the wheel for 10,000 passes over the same path.
e. Panels and supporting understructure shall withstand without failure an impact load any where in the panel of 45.4 kg dropped from a height of 900 mm onto a 645 sqmm area.

3. Finish surface of floor panels with "Modular Panel Mate Carpet Tile" from Tate.
4. Provide manufacturer's standard air flow panels, handrails, closure plates, plenum dividers, cove base, access holes and service outlets as required and indicated on the Drawings.
5. Provide 10 sqm floor panels, 1.5 sqm of understructure system and 2 panel lifting devices as spares.

Part 3 Execution

3.01 Environmental Conditions

A During the installation of the access flooring system, the room temperature shall be not less than 15^{o}C. Begin installation after the completion of other work which requires wet-applied materials and remove debris and dust. Ensure that new concrete is dry.

B Coatings, such as sealer, hardener, paint, or other materials which would prevent proper adhesion, shall be removed by grinding or scraping before applying adhesive. Test for adhesion by applying dabs of adhesive to various locations in the area to receive pedestals and leave approximately 24 hours. If the adhesive peels off easily, allow the new floor to continue to dry and again work the coated floors.

C Coordinate installation with other trades for under-floor smoke detection, under-floor fire extinguishing systems, wiring, conduit, etc.

3.02 Installation

Install the floor system and accessories according to manufacturer's recommendations to ensure a rigid, firm installation, free of vibration, rocking, and other unacceptable performance. Provide additional pedestals where grid is disrupted by columns, walls, and cutouts that impair strength of system. Verify that panels are interchangeable and fit snugly but do not bind when placed in alternate positions. Provide positive continuing electrical grounding of entire floor assembly. Accurately scribe and fit plenum fascia to subfloor.

3.03 Cleaning, Protection, and Final Adjustments

After completion of the installation, vacuum clean the entire system. Protect area with 9 kg kraft paper sealed to prevent tearing until acceptance of the building by the Employer. Before equipment is moved across the floor, the floor shall be protected by 12 mm plywood.

END OF SECTION 10270

Section 10400

Identifying Devices

Part 1 General

1.01 Description

Provide identifying devices as indicated on the drawings and specified herein.

1.02 Submittals

A Shop drawings shall indicate:
1. Size
2. Mounting
3. Letterstyle
4. Size
5. Spacing
6. Colors

B One sample sign for each approved sign category with manufacturer's available colors and lettering styles.

Part 2 Products

2.01 Manufacturers

The product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer’s approval.

2.02 Interior/Exterior Signs

Identifying devices shall be of the type and material as shown on the drawing. For purposes of establishing a standard of quality those of the Seton Name Plate Corporation may be used. All lettering shall be in English and the local language to the approval of the Employer.

2.03 Building Identification Signs

Building identification signs shall be as shown on the Drawings.

Part 3 Execution

3.01 Installation

Install all signage in accordance with the manufacturer's recommendations and approved shop drawings.

END OF SECTION 10400

Section 10520

Fire Protection Specialties

Part 1 General

1.01 Description

Furnish all labour, materials, equipment and appurtenances required to install fire extinguishers as specified herein or as shown on the Drawings.

1.02 Submittals

A Manufacturer's literature, or catalogue cuts to Engineer for approval

B Shop drawings showing schedule of fire extinguishers required for each building indicating installation details for specified fire extinguishers.

1.03 Quality Assurance

Provide portable fire extinguishers and accessories by a single company. Portable fire extinguishers shall be U.L. listed and shall bear U.L. "Listing Mark" for type, rating, and classification of extinguishers indicated.

Part 2 Products

2.01 General

Portable fire extinguishers shall be ABC Dry powder Fire Extinguishers

2.02 Manufacturers

A The product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer’s approval.

B Fire extinguishers shall be as manufactured by Larsons' Manufacturing Company, J.L. Industries, Potter-Roomer or approved equal.

C All fire extinguishers shall be furnished complete with a 6-year annual inspection and a service maintenance contract six years after acceptance by the Owner.

Part 3 Execution

3.01 Installation

A Install fire extinguishers units in locations indicated, or as directed by the Engineer or the Employer, at heights to comply with applicable regulations of governing authorities.

B Securely fasten mounting brackets to structure or substrate, square and plumb, to comply with manufacturer's instructions.
C Check extinguishers for proper charge and operation.
D Remove and replace damaged, defective or undercharged units.

END OF SECTION 10520

Section 10670

Storage Equipment

Part 1 General

1.01 Description

Provide miscellaneous storage equipment and accessories as indicated on the drawings and as specified herein.

1.02 Submittals

Provide product specification data on all storage equipment specified herein.

Part 2 Products

2.01 Manufacturers

A The product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer's approval.

B For the purposes of establishing a minimum standard of quality and workmanship, the products of Lyon Metal Products, Inc. (LMPI).

C Equipment numbers indicated on drawings are keyed to corresponding equipment numbers.

Part 3 Execution

3.01 Installation

A Shelvings, racks, benches and related accessories shall be assembled and installed at locations shown on the drawings, in accordance with the manufacturers' recommendations. Assemblies shall be level, rigid and plumb.

END OF SECTION 10670

Section 10800

Toilet Accessories

Part 1 General

1.01 Description

Provide toilet accessories as indicated on the drawings and specified herein.

1.02 Submittals

A Manufacturer's technical data and installation instructions for each toilet accessory.

B Provide shop drawings, templates, instructions and directions for installation of anchorage devices in other work.

1.03 Quality Assurance

A Provide products of the same manufacture for each type of accessory unit and for units exposed in the same areas.

B Provide locks where indicated, with the same keying for each type of accessory unit in the project wherever possible. Furnish 2 keys for each lock.

Part 2 Products

2.01 Manufacturers

Product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer's approval.

Part 3 Execution

3.01 Installation

A Use concealed fastening wherever possible.

B Provide anchors, bolts, and other necessary anchorages, and attach accessories securely to walls and partitions in locations as shown or directed.

C Install concealed mounting devices and fasteners fabricated of the same material as the accessories, or of galvanized steel, as recommended by manufacturer.

D Install exposed mounting devices and fasteners finished to match the accessories.

E Provide theft-resistant fasteners for accessory mountings.

F Secure toilet room accessories in accordance with the manufacturer's instructions for each item and each type of substrate construction.

END OF SECTION 10800

DIVISION 11.

MECHANICAL EQUIPMENT

Section 11000

General Requirements

Part 1 - General

1.01 General

A. The Contractor shall furnish all equipment, materials and labour required to complete the Work, in all respects, and install the equipment as shown on the drawings and/or as hereinafter specified. The numbering system employed in these Specifications is used throughout the Contract Documents.

B. When references to the following capitalized abbreviations are made in these specifications, they refer to specifications, standards, or methods of the respective national or international associations. It implies that other national standards or internationally accepted standards which ensure an equal or higher quality than the standards mentioned will be accepted. The Contractor shall submit any explanatory material upon request of the Engineer concerning the standards in conformity to which his goods will be manufactured

- ISO International Standardization Organization
- IEC International Electrotechnical Commission
- JIS Japanese Industrial Standards
- JEC Standard of the Japan Electrical Committee
- JEM The Standard of Japan Electrical Manufacturers' Association
- BS British Standards
- AWWA American Water Works Association

1.02 Maintenance of Equipment

The Contractor before operation shall provide all equipment and appurtenances installed with proper oil and lubricants. All new equipment shall be maintained and operated by the Contractor for testing purposes, until the Work is completed and accepted by the Engineer and the Employer.

1.03 Storage of Materials

Materials shall be so stored as to insure the preservation of their quality and fitness for the Work. When considered necessary, they shall be placed on wooden platforms or other hard, clean surfaces, and not on the ground and/or they shall be placed under cover. Stored materials shall be located so as to facilitate prompt inspection.

1.04 Shop Drawings and Operating and Maintenance Data

A. The Contract drawings are diagrammatic and show the general layout of the complete construction work. Locations of equipment, inserts, anchors, motors, panels, conduits, stub-ups, fittings, fixtures, air, water, power and process inlets, unless specifically dimensioned on the Drawings, shall be determined to suit field conditions encountered, and the Contractor shall be responsible for ensuring clearance between pipes, equipment, and similar appurtenances, without extra cost to the Employer. The Contractor shall review the Drawings and Specifications of other trades and shall include the mechanical work shown thereon that will be required for installation. The Contractor shall be responsible for preparing and submitting to the Engineer for review, all general arrangement drawings

showing the inter-relationship with the civil construction work and with all mechanical, electrical and instrumentation equipment to be installed. Should there be a need to deviate from the Contract drawings and Specifications, the Contractor shall submit written details and reasons for all changes to the Engineer for approval before making such changes. All extra costs to make the changes will be borne by the Contractor. In the event of varying interpretations of the Contract Documents, the Engineer's interpretation shall govern.

B. Prior to fabrication, the Contractor shall prepare the general arrangement drawings and shall obtain, from the manufacturer, shop drawings for all equipment. Shop drawings shall include fabrication, assembly, foundation and unit support drawings, installation drawings, and wiring diagrams together with detailed specifications and data covering materials used, power drive assembly, parts, devices, and other accessories forming a part of the equipment to be furnished. The Contractor shall submit certified performance or certified test curves, as specified for all pumps and blowers furnished under this Contract. The Contractor shall notify the Engineer at least three (3) weeks prior to all testing should the Engineer elect to witness the tests. The Contractor shall submit general arrangement and shop drawings and material lists for approval as specified in applicable Sections and in conformance with the requirements of Section 01300 and the Particular Specifications.

C. Before commencing the fabrication of equipment and materials, the Contractor shall review Tender document and submit the following information in five (5) prints or copied of all shop erection drawings and schedules required for the work for approval by the Engineer. Such drawings shall show of equipment exact locations, dimensions and materials of major parts. The Contractor shall make any correction as directed by the Engineer, and resubmit five (5) corrected copies, as necessary

1. Shop drawings and/or catalogue information and cuts.

2. Manufacture's specifications, parts list, suggested spare parts list, and equipment drawings.

3. Complete lubrication, maintenance, and operating instructions, including initial start-up instructions.

4. Other technical, installation, and maintenance data as applicable.

D. All information submitted shall be specifically for the equipment to be installed in the project and all extraneous sheets shall be removed or deleted from catalogues and other pre-printed materials.

E. Shop drawings on any piece of equipment will not be acceptable until all information listed in 1 through 4 above, has been submitted where applicable.

1.05 Preparation of Operation and Maintenance Manuals

Written operation and maintenance manuals, including both comprehensive and unit operation manuals as required, shall be prepared and submitted by the Contractor in English as directed by the Engineer at the time before commissioning.

1.06 Test and Inspection by Authorities

As regards equipment of which test and inspection by authorities are required, the results of the test and inspection of the equipment shall be submitted to the Engineer.

1.07 Documents to be Submitted by the Contractor

Materials stated below shall be included in the contents to be submitted by the Contractor:

1. Approval Stage before Implementation of the Work

(1) Work Starting Report
(within 30 days from the commencement date, 5 copies)

(2) List of Documents to be submitted
(within 30 days from the commencement date, 5 copies)

(3) Vender List
(within 30 days from the commencement date, 5 copies)

(4) General Flow Diagram
(within 60 days from the commencement date, 5 copies)

(5) General Flow Diagram together with the Calculation Sheet
(within 90 days from the commencement date, 5 copies)

(6) General Layout Drawings
(within 60 days from the commencement date, 5 copies)

(7) Detail Layout Drawings
(within 90 days from the commencement date, 5 copies)

(8) Equipment Foundation Drawings
(within 90 days from the commencement date, 5 copies)

(9) Equipment Assembly Drawings
(within 90 days from the commencement date, 5 copies)

(10) Piping Drawings
(within 90 days from the commencement date, 5 copies)

(11) Piping Support Drawings
(within 90 days from the commencement date, 5 copies)

(12) Equipment Drawings (Structure, function, materials and dimensions shall be shown)
(within 90 days from the commencement date, 5 copies)

(13) Performance Curve
(The Contractor shall furnish the expected performance curve for all equipment, and submit them without delay when requested by the Engineer)

(14) List of Equipment Weight
(within 90 days from the commencement date, 5 copies)

(15) Utility List
(within 90 days from the commencement date, 5 copies)

(16) Spare Parts List
(within 90 days from the commencement date, 5 copies)

(17) Tool List
(within 90 days from the commencement date, 5 copies)

(18) Lubrication List
(within 90 days from the commencement date, 5 copies)

(19) Motor List
(within 45 days from the commencement date, 5 copies)

(20) Test and Inspection Specifications
(within 90 days from the commencement date, 5 copies)

2. Completion Stage

(1) Test and Inspection Record

The Contractor shall submit three (3) copies of the Factory Inspection Record, the Installation Inspection Record and the Test Run Record before final payment after the day of work completion。

(2) Work Record

The Contractor shall submit the work record in form instructed by the Engineer with instructed number of copies by the instructed date.

(3) Photograph

The Contractor shall submit three (3) copies of photographs taken along with work progress with the negative films before final payment after the date of work completion. Photographs shall be coloured and fixed in albums. Size of photographs shall be instructed by the Engineer.

1.08 Materials

Materials to be used for manufacturing and installation of the equipment herein specified shall be selected from the best available for the purpose of use considering the strength, durability, and on the basis of the best current engineering practice.
Materials shall meet the allowing requirements:

1. New, unused and of first quality,

2. Free from defects,

3. Suitable for the application and not overstressed mechanically or electrically.
Typical materials to be specified under these specifications shall conform to the requirements of the specifications set forth in the latest applicable Standards as mentioned below:

(1) Steel plate:

Rolled steel for general structure, BS EN 10025, JIS G3101 or equivalent.

(2) Pipe and Tube:

Carbon steel pipe for ordinary piping, JIS G3452 or equivalent.
Carbon steel pipe for pressure service, JIS G3454 or equivalent.
Galvanized steel pipe for water service, Hot-dip galvanized to 610g/m^2, JIS G3442 or equivalent.
Stainless steel pipe, BS 3605-92, JIS G3459 or equivalent.
Ductile iron pipes, centrifugal cast for water works, JIS G5526 or equivalent.

(3) Alloy Steel for Structural Use

Carbon steel for machine structural use, JIS G4051 or equivalent.

(4) Stainless Steel

Stainless steel bar, JIS G4303 or equivalent.
Hot rolled stainless steel sheet and plate, JIS G4304 or equivalent.
Cold rolled stainless steel and plate, JIS G4305 or equivalent.
Hot rolled stainless steel strip, JIS G4306 or equivalent
Cold rolled stainless steel strip, JIS G4307 or equivalent.
Stainless steel wire rod, JIS G4308 or equivalent.
Stainless steel wire, JIS G4309 or equivalent.

(5) Casting

Grey iron casting, JIS G5501 or equivalent.
Spheroidal graphite iron casting, JIS G5502 or equivalent.

1.09 Finish

Surface requiring painting or coating for corrosion protection shall be smooth, free from sharp edge, burrs and projections, and shall have all welds ground smooth and all edges and corners of structural members rounded. Finished members shall be true to line and free from twists, bends and open joints.

1.10 Name Plates

Equipment nameplates shall be engraved or stamped on metal plate and fastened to the equipment in an accessible location. Nameplates shall indicate;

1. Name of manufacturer,
2. Type of unit and model number,
3. Serial number, and
4. Rated capacity, voltage, or other pertinent information.

1.11 Installation

A. Installation of Equipment

The Contractor shall make arrangement with the Engineer as to the installation location of

equipment. Each equipment shall be precisely installed in such a manner that the supervision and operation for it are easy, safe, reasonable and efficient.

At all dangerous places as may be required by the Engineer, the handrail, protection fence, notice of danger and the like shall be provided for safety.

The Contractor shall provide foundation for all equipment specified herein.

All packing materials, rust, dirt, grit and other foreign matters shall be removed.

Bolts and screws shall be tightened firmly and uniformly, but care shall be taken not to overstress the threads.

(1) Setting

Extreme care shall be exercised in handling equipment to avoid dropping, bumping or dragging. In hoisting, special lifting eyes shall be used where provided. In case of no lifting eyes, equipment shall be lifted by hooks or wire attached to proper place in safety ways.

(2) Foundation Finish

The Contractor shall finish concrete foundation for equipment. The Contractor shall submit shop drawings of foundation finish including finishing materials to the Engineer for approval.

The foundation constructed including any core holes shall be completed to lines and levels required with concrete and reinforcement as necessary. After alignment, level and plumb are checked, the said foundation shall be given mortar finishing unless otherwise specified.

(3) Checking and Installation Test

All equipment after installation shall be checked by the Contractor for correct positioning, alignment, fixing and all such items which may affect the satisfactory operation thereof.
Before start-up, the following items of work shall be done.

(a) Removing all packing materials, tape, wood spacers and the like,

(b) Checking lubricant levels, and topping up if necessary,

(c) Rotating shaft and other moving parts to check for clearance and free turning,

(d) Checking right direction moving and rotating of shaft and other moving parts.

(e) All other necessary preparation for start-up.

The Contractor shall submit checking and installation test report after they finished the test. The test report form shall be made by the Contractor and approved by the Engineer.

(4) Individual Function Test

Individual function test of all equipment shall be executed under non-loaded and

loaded condition after checking and installation test. Continuous test operation shall be performed after completion of this test.

B. Piping

All pipes to be specified under this specification shall be installed so as to complete the system. The piping shall include all necessary pipes, valves, supports, necessary appurtenances, and shall be robust construction to function perfectly.

Flow meters, pressure meters, valves, insulation, etc. shall be installed without any instruction in drawings and specifications, if the Contractor judges they are requisite for the system. Even though there is no instruction in the contract documents, equipment and appurtenances judged by the Engineer to be installed shall be installed by the Contractor immediately without compensation upon the instruction by the Engineer.

Earth work, chipping work, boring of structures and other work required for the piping shall be included in the scope of this Contract. Holes, openings and other chipped part including damaged part resulted from piping work shall be backfilled, refilled, repaired and finished perfectly.

All piping under these specifications shall be installed to the required lines and grades and as closely as possible to walls, ceilings, columns and other structural parts to occupy the minimum of space. The Contractor shall conform to the following requirements.

(1) All pipes shall be sound and clean before installation.

(2) Piping shall run parallel or at right angle to wall, unless noted otherwise.

(3) All piping shall have a sufficient number of joints to allow convenient removal of piping.

(4) Pipe installed shall not cause stress or strain in the line.

(5) All piping shall be rigidly supported from the structures by approved hangers, inserts or supports with adequate provisions for expansion and construction.

(6) All pipes, after installation, shall be coloured according to each function. The colour shall be approved by the Engineer.

(7) All pipes shall have necessary drain trap to be approved by the Engineer.

(8) The gap between all pipe surface and concrete structure shall be perfectly sealed and finished when they pass through the concrete structure.

(9) Insulation work and necessary piping shall be included in the scope of this contract.

Especially, the insulation work shall be applied on following piping system:

(a) Blower line

(10) Thickness of stainless steel pipes shall not be less than the thickness shown below.

Minimum Thickness of Stainless Steel Pipes

Pipe dia. (mm)	Thickness (mm)	Pipe dia. (mm)	Thickness (mm)	Pipe dia. (mm)	Thickness (mm)
6	1.0	50	2.8	250	4.0
8	1.5	65	3.0	300	4.5
10	1.5	80	3.0	350	4.5
15	2.0	90	3.0	400	5.0
20	2.0	100	3.0	450	5.0
25	2.8	125	3.0	500	5.5
32	2.8	150	3.0	600	6.5
40	2.8	200	4.0	700	8.0

(11) Unless otherwise specified, the type of gate valve shall be outside screw type.

(12) Expansion joints and/or flexible joints shall be provided for the following piping systems in order to prevent then from destruction.

(a) Piping to be installed between different pipe support conditions, i.e., underground piping after passing through the concrete structure and the like.
(b) Piping to be installed between adjoining structures, i.e., piping passing through the expansion joints of concrete structure and the like.
(c) Piping having expansion and contraction caused by temperature change, i.e., air piping, steam piping, etc.

Pipe supports shall be provided before and behind of said expansion joints and flexible joints.

C. Accessories

All the equipment shall be equipped with accessories required for operation and maintenance. When additional or special accessories are indicated in the specifications, they shall be mounted or supplied as specified.

1.12 Shop Inspection

A. The Contractor shall provide the materials, personnel and temporary materials necessary for the tests, inspections and the completion tests described hereunder, and shall make necessary arrangements so that the tests and inspections can be performed promptly and smoothly at the cost of the Contractor.
.

B. Shop inspection shall be performed on major equipment before shipment. The Engineer will designate such major equipment and inspection items to be inspected. The shop inspection shall be performed under witness of the Engineer in principle. Test and/or inspection shall include, but not limited to the items listed in the Table below

No.	EQUIPMENT	TEST/INSPECTION	WITNESS	RECORD
1	Lifting Pump (One for each)	Performance test	yes	yes
		Dimension	yes	yes
		Hydrostatic test	no	yes
		Material	no	yes
2	Motor for Lift Pump (One for each)	Temperature rise	no	yes
		Winding resistance	no	yes
		Efficiency	no	yes
		Withstand voltage	no	yes
3	Blower	Performance test	no	yes
		Material	no	yes
4	Motor for Blower	Temperature rise	no	yes
		Winding resistance	no	yes
		Efficiency	no	yes
		Withstand Voltage	no	yes
5	Reactor Tank Mixer(One for each)	Performance test	yes	yes
		Material	no	yes
		Dimension	yes	yes
6	Air Diffuser (One for each)	Performance test	yes	yes
		Material	no	yes
		Dimension	yes	yes
7	Clarifier	Performance test	no	yes
		Material	no	yes
		Dimension	no	yes
8	Sludge Dewatering Unit	No-load running test	yes	yes
		Material	yes	yes
		Dimension	yes	yes
9	Pipes	Material	no	yes
10	Valves	Hydrostatic test	no	yes
		Dimension	no	yes
		Material	no	yes
11	Other pumps	Performance test	no	yes
12	Crane	Dimension	no	yes
		Function	no	yes
13	Gate and Weir	Dimension	no	yes
		Material	no	yes
14	Compressor	Performance test	no	yes
15	Tank	Dimension	no	yes
16	Hopper	Dimension	no	yes

C. During the shop test and inspection, the Contractor shall perform an operational test at the factory under simulated field operating conditions, if required.

Equipment and materials for Plant shall be inspected and tested in accordance with the Manufacturer's Standards.

1.13 Coating and Painting

All equipment shall be finished with protective coating. Coating shall conform to the coating schedule defined in accordance with service condition of the equipment and piping is specified hereafter.

1. Surface Preparation

All oil, paraffin, grease and dirt shall be removed from the surfaces to be painted, using solvents and or other means. All weld splatter, slag, burrs, loose rusted mill scale and other foreign substances shall be removed by shot, sand blasting, wiring disk grinder, scraper, sand paper, or other means according to the grade of the surface preparation on the metal.

2. Painting Schedule

The painting systems for the various items of Plant shall comply with the minimum requirements shown the following table, in general.

Area	Equipment to be applied	Coating and painting schedule
Indoor	Equipment and materials which are not immersed in the water	One coat of anti-corrosive primer Four coats of polyurethane resin type or chlorinated rubber type paint or equivalent
Outdoor	Equipment and materials which are not immersed in the water	One coat of anti-corrosive primer Four coats of polyurethane resin type or chlorinated rubber type paint or equivalent
Corrosive atmospheric area	Equipment and materials which are not immersed in water but in corrosive area	One coat of anti-corrosive primer Three coats of epoxy resin type paint or equivalent
Submerged in water area	Equipment and materials which are immersed in the water	One coat of anti-corrosive primer Three coats of epoxy resin type paint or equivalent

3. Colour coding

The equipment and piping in plants and pump stations shall be colour-painted according to the colour scheme shown in the table below. Paint colour for the equipment which is not mentioned in the table shall be subject to the Engineer's approval. The Contractor shall provide arrows indicating the direction of flow and the name of the liquid or gas on the pipe. The contractor shall submit drawings showing the location and colour (black or white) of the arrows for the Engineer's approval. Interval of the arrows shall not exceed 20 meters.
Stand pipes for reclaimed water (treated effluent) system shall have a clear signage indication "only for non-potable use".

Table showing Colour Scheme

Equipment	Colour (BS 1710)	Code (BS 480D)
Control, distribution switch boards		
External surface	Grey	10 A 03
Internal surface	White	00 E 55
Overhead Cranes and Lifting Equipment	Yellow	08 E 51
Pump and Machinery	Grey	10 A 03
Sewage Pipes	Grey with Red	10 A 03 04 E 53
Liquors	Grey with Red	10 A 03 14 D 55
Sludge pipes with bands as follows:	Brown	04 C 39
Activated Sludge	White	00 E 55
Raw Sludge	Blue	18 E 53
Digested Sludge	Red	04 E 53
Sludge Gas	Yellow	08 E 51
Compressed Air Pipes	Green	14 D 55
Fuel Gas Pipes	Orange	06 E 55
Potable Water Supply	Blue	18 D 45
Washwater (Reclaimed water)	Black	00 E 53

1.14 Motors

A. Materials, Workmanship and Test

Motors shall comply with the requirements of MS, ISO, JES, JEM, or JIS as applicable.

The Contractor shall be responsible for the selection of motor output to prevent the overload, even if specified in the specification, considering manufacturer's standard, manufacturing condition, efficiency of the equipment.

The Contractor shall submit the power calculation sheets if the power is different from the specification, and reflect that to the related work.

The number of poles of motors for the pumps and the blowers shall be four (4) or more unless otherwise specified or approved by the Engineer.

B. Low Tension Motor

Low-tension motor shall comply with the following specifications for motors from 0.1kW through 400kW except where specified otherwise.

(1) Type

The motor shall be of squirrel cage, induction, direct starting or reduced voltage starting or reduced voltage starting type.

(2) Power Source

The motor shall be rated for 415V, 3-phase, 50Hz operation.

(3) Insulation

The motor shall be provided with class F of the said standards or equal insulation.

(4) Enclosing and protective features

The motor shall be drip-proof for indoor use, totally enclosed fan-cooled for outdoor use and explosion-proof for inflammable gas ambience.

(5) Speed

The speed shall be 1,500RPM maximum, unless otherwise specified.

C. Single-phase Motor

The single-phase motor shall comply with the following specifications except where specified otherwise:

(1) Type

The motor shall be of split-phase induction type or capacitor-start induction type.

(2) Power source

The motor shall be rated for 240V, 50Hz operation.

(3) Insulation

The motor shall be provided with the class F or equal insulation.

(4) Enclosing and protective features

The motor shall be drip-proof for indoor use, totally enclosed fan-cooled for outdoor use and explosion-proof for inflammable gas ambience.

(5) Speed

The speed shall be 1,500RPM maximum unless otherwise specified.

1.15 Pipes

All pipes, fittings, bolts, nuts, jointing materials and appurtenances for piping under these specifications shall be manufactured in compliance with the standards mentioned below, or approved equivalent.

1. Material

(1) Steel Pipes

Steel pipes with a diameter of 500mm or longer.

(a) Applicable Standard

a. JIS G3457 Arc Welded Carbon Steel Pipe for Ordinary Use
b. JIS B2311 Steel Butt-Welding Pipe Fittings for Ordinary Use
d. JIS B2313 Steel Plate Butt-Welding Pipe Fittings

(b) Joint

The steel pipes shall be jointed with flanges unless otherwise specified.

(2) Small Steel Pipe

Steel pipes with a diameter of 500mm or smaller.

(a) Applicable Standard

a. JIS G3442 Galvanized Steel Pipes for Water Service
b. JIS G3452 Carbon Steel Pipes for Ordinary Piping
c. JIS B2301 Screwed Type Malleable Cast Iron Pipe Fittings
d. JIS B2311 Steel Butt-Welding Pipe Fittings for Ordinary Use

(b) Joint

Steel pipes shall be jointed with flanges, and screwed couplings, 25mm in diameter and smaller.

(c) Coatings

Exterior surface of the pipe, JIS G3452 Carbon Steel Pipes for Ordinary Piping, and of the fitting, JIS B2311 Steel Butt-Welding Pipe Fittings for Ordinary Use, shall be coated with manufacturer's standard coating materials.

(3) Polyvinyl Chloride Pipes

(a) Applicable Standard

a. JIS K6741 Unplasticized Polyvinyl Chloride (uPVC) Pipes
b. JIS K6743 Unplasticized Polyvinyl Chloride Pipe (uPVC) Fittings for Waterworks

(b) Joint

The pipe shall be jointed with flanges or sockets.

(4) Polyethylene Pipes

(a) Applicable Standard

a. JIS K6761 Polyethylene Pipes for General Purposes
b. JIS K6763 Polyethylene Pipe Fittings for Water Works

(b) Joint

The pipe shall be jointed with sleeve joint or other way acceptable to the Engineer.

(5) Ductile Iron Pipes

(a) Applicable Standard

a. JIS G5526 Ductile Iron Pipes
b. JIS G5527 Ductile Iron Fittings

(6) Stainless Steel Pipes

(a) Applicable Standard

a. JIS G3459 Stainless Steel Pipes

2. Application

Application		Diameter	Material	JIS Code	References
Sewage		Dia 200 - 3,000mm	RC Pipe (Internal: sulphur resistant lining)		Gravity Pipe
		Dia 75 - 1,500mm	Ductile Iron Pipe	DCIP	Pressure Pipe
		More than Dia 1,500mm	Steel Pipe with Paint Coating (Internal: epoxy coating, Outside: polyobilen rapping)	STW400	Pressure Pipe
		Less than Dia 75mm	Stainless Steel Pipe	SUS-TP (Sch 10S)	
Sludge		Dia 75 - 1,500mm	Ductile Iron Pipe	DCIP	
Aeration Pipe		More than Dia 350mm	Galvanized Steel Pipe or Arc Welded Carbon Steel Pipe or Stainless Steel Pipe	SGPW or STPY or SUS-TP (Sch 10S)	
High Pressure Air		Less than Dia 100mm	Steel Pipe for Pressurized Air or Copper Tube	STPG or Cu-Tube	
Skimming Oil		Less than Dia 300mm	Stainless Steel Pipe	SUS-TP (Sch 10S)	
Utility Water		Dia 40 - 350mm	Galvanized Steel Pipe	SGPW	
Drinking Water		Dia 15 - 150mm	Shock-Resistant Unplasticized Polyvinyl Chloride Pipe	HIVP	
Chemical	PAC	Dia 13 - 150mm	Shock-Resistant Unplasticized Polyvinyl Chloride Pipe	HIVP	

Application		Diameter	Material	JIS Code	References
	Polymer	Dia 13 - 150mm	Shock-Resistant Unplasticized Polyvinyl Chloride Pipe	HIVP	
	Caustic Soda	Dia 13 - 150mm	Stainless Steel Pipe	SUS-TP (Sch 10S)	
	Sodium Hypochlorite	Dia 13 - 150mm	Shock-Resistant Unplasticized Polyvinyl Chloride Pipe	HIVP	
Digested Gas Pipe		Dia 15 - 350mm	Stainless Steel Pipe	SUS-TP (Sch 20S)	
Deodorization Duct Pipe		Dia 15 - 400mm	FRP Pipe		
Stormwater		Dia 200 - 1,500mm	RC Pipe		Gravity pipe

Note: 1) Sewage: Built in pipe shall be SUS. Piping around pumps shall be Ductile Iron Pipe or Stainless Steel Pipe.
2) Sludge: Ditto
3) Aeration Pipe: Built in pipe shall be SUS.
4) Utility Water: Built in pipe shall be SUS.

above table, the Contractor shall obtain approval from the Employer or the Engineer.

3. Pipe Installation

(1) The piping shall be installed on route and layout as shown on the contract drawings, in general. The Contractor shall prepare the detailed construction and fabrication piping drawings, following up with the requirements mentioned below.

(a) Piping shall be arranged neatly and run the route near the floor level in general. Contractor shall consider the space for future pipe installation work.

(b) Inspection and maintenance space for the piping shall be considered.

(c) Contractor shall design the walkways for the operator and maintenance worker to access easily for operation monitor, inspection and maintenance.

(d) The piping must be easily disassembled and removed for test and inspection if required.

(e) The supports for piping and valves shall not be taken from the equipment to avoid damage to the equipment, in general.

(2) Piping support.

(a) Piping support shall be designed so as to be rigid structure together with pipe and support. Support of heavy valves, etc. shall be designed to support such equipment independently as possible.

(b) Interval between supports on straight piping shall be within 3m. However, in case of air piping only installed, the interval between supports of air piping

shall be within 4m for air pipe size 350mm ~ 600mm dia, and for air pipe size over 650mm dia to be within 5m.

(3) Flexible tube and expansion joints

(a) In piping made of cast iron and steel, the flexible tube shall be inserted at the joints of building wall, if required.

(b) The expansion joints shall be used on the piping that cause large expansion and shrinkage due to the thermal change, in order to reduce the piping stress.

(4) Piping pass through the wall

(a) Insert pipe where piping run through the wall, shall be supplied by the Contractor under his obligations for mechanical works. Where the water-proof required, the water-stop-plates shall be installed to avoid leakage.

(b) The concrete mortar shall be filled to the clearance at the place where piping run through the wall hole, after installation of piping. For protection against water leakage, waterproof–mortar shall be filled in to both sides of wall. If required the flanges shall be provided at both sides of the wall for easy maintenance.

(c) In the fire protection area, the wall passing clearance shall be filled with non–combustible materials.

(5) If required, vent valves and/or drain valves shall be provided on the piping where the air or drains are accumulated, at such place as top of piping or bottom of piping.

(6) Piping shall be installed in order not to cause stress. For the bending and cutting of the piping, care shall be taken without crack, stress, damage on the piping. After the fabrication of piping, foreign materials such as soil, sand shall be removed and cleaned from inside of the piping.

(7) The piping shall have any slope to waste water easily by gravity, if required. Also sampling connection shall be installed on the piping, if required.

1.16 Valves

Gate valves, Butterfly valves, etc. under these specifications shall be manufactured in compliance with the standards mentioned below or equivalent.

1. Gate Valves

JIS B2031: Cast Iron Valves (10K, Flanged Outside Screw Type Gate Valve)

2. Butterfly Valves

JWWA B114. Butterfly Valves for Waterworks

Butterfly valve shall have flange ends. Valve seats shall be mounted in valve bodies unless otherwise specified.

3. Swing Type Check Valve

JIS B2031: Cast Iron Valves (10K, Flanged Swing Check Valve)

4. Diaphragm Valves

Diaphragm valves shall be fabricated of cast iron with diaphragm of neoprene rubber or equivalent suitable materials. The valves shall be of flanged ends.

5. Knife Gate Valve

JIS B2031 or equivalent

1.17 Flanges

All flanges on equipment and appurtenances under these specifications shall be manufactured in compliance with following standards or equivalent.

PN10 Flange: BS4504 Basic Dimensions of Ferrous Materials Pipe Flanges

1.18 Steel Work

Before starting manufacture, material and construction shall be approved by the Engineer..

(1) Handrails

Handrails shall have a height and a pitch as shown in the drawings.

(2) Inspection platform

(a) The platform shall have a width of 900 mm minimum.

(b) The material of the floor of the platform shall be checkered plates having a thickness of t = 4.5 mm minimum.

(3) Staircase

(a) The staircase shall have a slope of 45° with respect to the horizontal direction.

(b) The riser shall have a height of 200 to 230 mm and this height shall be equal for all risers.

(c) The tread shall have a depth of 220 to 300 mm and this depth shall be equal for all treads. Bending at each end of the tread shall be 30 mm minimum.

(d) The staircase and the landing shall have a width of 900 mm minimum, the same as that of the inspection platform.

The material of the floor shall be checkered plates having a thickness of t = 4.5 mm minimum. To prevent deflection, the floor shall be reinforced with angle steel of 40 x 40 x 3 mm minimum.

(e) If the building where the staircase is to be installed has a height in excess of 5m, a landing shall be provided for each 5m maximum. The tread shall have a width of 1,200 mm minimum.

(4) Covers

Covers shall be provided in the places shown on the drawing or any other places deemed necessary.

(5) Withstand load and removal weight

(a) Withstand load

Each cover shall be constructed to be safe and withstand the supposed load sufficiently.

(b) Removal load
Each cover shall have, or shall be divisible to have, a weight of less than 16 kg, as a rule, which can be removed by a single worker.

(6) Others

This steel works shall include all necessary steel works for the maintenance of the plant like as covers, manholes, stages walkways, handrails, steps, ladders, etc. even if not shown on the drawings and shall be designed, furnished, installed an adjusted by the Contractor.

1.19 Reduction Gears

A. Reduction gear under these specifications shall be of cycle type reduction gear or equivalent.

B. The cycloid type reduction gear shall be fully enclosed in an oil tight casing. Mechanism of this reduction gear shall be of a combination of a planet gear and a fixed-internal sun gear. Wear resistance parts shall be in rolling contact. The reduction gear shall consist of casing, ring gear housing, low speed and high-speed shafts, low speed shaft roller and shaft pin, and cycloid discs. The cycloid disc namely planet gear shall have cycloidal-shaped teeth, and the sun gear circular pin teeth. The torque transmitting components of the gear shall be made of high carbon chromium bearing steel. The lubrication shall be in accordance with current practice of manufacturer.

1.20 Lubrication

The Contractor shall provide lubricants required for testing and commissioning. The Contract shall also provide lubricants, in the stock of the Employee, required for the first charge after the commissioning.

1.21 Anchor Bolts and Nuts

Equipment suppliers shall furnish anchor bolts, nuts, washers, and sleeves of adequate design as required for proper anchorage of the bases and bedplates to the concrete bases.

Anchor bolts, together with templates or setting drawings, shall be delivered sufficiently early to permit setting the anchor bolts when the structural concrete is placed.

Anchor bolts and nuts using under submerged or intermittently submerged, or contact with corrosive gas shall be made of stainless steel.

1.22 Safety Guards

Belt or chain drives, fan blades, couplings, exposed shafts and other moving or rotating parts on all sides shall be covered with safety guards conforming to all local safety codes and regulations. Guards shall be designed for easy installation and removal, complete with necessary supports, accessories, and fasteners. Materials of guards which installed at corrosive area shall be of stainless steel and other area use shall be of galvanized steel. Guards shall be designed for outdoor locations to prevent entrance of rain and dripping water.

1.23 Test Run

The test run shall be conducted by the Contractor prior to the turnover of the Work to the Employer.

Refer to Section 01650 hereof.

1.24 Training

Training for operators should be conducted as stipulated in Section 01670 hereof.

1.25 Spare Parts and Maintenance Tool

A. The Contractor shall furnish sufficient spare parts for one (1) year operation in accordance with the manufacturer's recommendation.

B. The set of general manual tools to be used for daily maintenance of equipment shall be furnished. In addition to special tools shall be separately provided as required by manufacturer.

1.26 Manufacturer's Experiences

Unless specifically named in the specifications, a Manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than three (3) years. The Contractor shall submit the delivery record of the same type of equipment during the past three (3) years to the Engineer for approval.

END OF SECTION 11000

Section 11100

Pumping Equipment : Submersible Sewage Pump

Part 1 - General

1.01 General

This pump shall be used to discharge the sewage held in the pipe gallery, etc. It shall be constructed to be sturdy to endure continuous operation in water. It shall have the minimum bore diameter of 50 mm.
The pump shall be constructed to produce less vibration and noise and operate smoothly, and especially, shall not produce harmful phenomenon of cavitation.

1.02 Design Conditions

(1) The influent water shall be sewage which has been collected in the floor drain pit of the pipe gallery, etc.

(2) It shall be permitted for no-discharge operation.

Part 2 - Products

2.01 Fabrication

Drive unit

The motor to be used with the pump shall be a submersible motor.

Main body

(1) Casing

The casing shall be made of good quality of cast iron considering the mechanical strength to internal pressure, vibration, etc. as well as the resistance to corrosion and wear. The casing shall be constructed for easy disassembly and assembly.

(a) Removable type

The casing discharge flange shall be of slide type, and when mounting the pump, shall be connected positively along the discharge bend flange surface.

(b) Stationary type

A support stand shall be provided at the underside of the casing, and the pump shall be installed on the floor inside the pit.

(2) Impeller

The impeller shall be a stout product of good quality and shall be sturdy to ingress of solids.

The impeller shall be constructed with a minimum number of blades and well in balance, and the surface shall be finished smooth.

(3) Main shaft

The main shaft is an extension of the motor shaft. It shall be strong enough to the transmission torque and torsional vibration.

(4) Shaft sealing equipment

The shaft sealing portion shall consist of mechanical seals and it shall be a two-stage structure with oil sealed in an intermediate portion to prevent foreign substances from ingress into the motor whether the motor in operation or at stop. It shall be constructed for easy replacement of seals, etc.

(5) Bearing

The bearing installed in the motor shall bear the weight of rotary portions and the hydraulic thrust. It shall be constructed to endure a long time of continuous operation and be capable of smooth self-lubrication.

(6) Flange

Flanges for piping connection shall be in accordance with JIS 10K or equivalent.

2.02 Materials

(a)	Casing	: Cast iron
(b)	Impeller	: Cast iron
(c)	Main shaft	: Stainless steel

2.03 Protection Equipment

(1) A thermal switch to detect abnormal temperature, etc. shall be built in.

(2) A water pocket room to prevent oil and water from ingress into the motor section shall be provided, if necessary.

2.04 Accessories (per Unit)

(a)	Submerged cable (up to terminal box)	x 1 set
(b)	Lifting chain	x 1 set
(c)	Pump removable equipment (in the case of removable type)	x 1 set
(d)	Foundation bolt and nut	x 1 set
(e)	Compound pressure gauge (diaphragm type)	x 1 set
(f)	Automatic air vent valve (if necessary)	x 1 set

(g) Power cable terminal box x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11100

Section 11101

Pumping Equipment: Submersible Sludge Pump

Part 1 - General

1.01 General

The submersible sludge pump shall be used for sludge transfer and shall be constructed to be sturdy to endure continuous operation in the sludge. Also, it shall be constructed to operate smoothly with less vibration and noise, as well as produce no harmful cavitation.

1.02 Design Conditions

(1) Operating conditions

This pump shall be able to operate on no-discharge operation basis.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

The motor to be used with this pump shall be a submersible motor.

(2) Main body

(a) Casing

1) The casing shall be a product of good quality cast iron considering mechanical strength against internal pressure, vibration, etc. as well as corrosion and wear.

2) The casing shall be constructed to be easy to disassemble and reassemble, and in the case of disassembly, to be taken out upward with the impeller mounted on the main shaft.

(b) Impeller

The impeller shall be a strong product of good quality and shall be sturdy against ingress of solids. Moreover, the impeller shall be a screw type non-clogging single vane type and be sufficiently balanced and the surface finished smooth.

(b) Main shaft

The main shaft is an extension of the motor shaft and shall be sufficiently strong to the transmitted torque and torsional vibration.

(c) Shaft sealing device

The shaft sealing portion shall use mechanical seals and shall have two-stage construction with oil sealed in between to prevent ingress of foreign substances into the motor irrespective of the pump being in operation or at stop.

(e) Bearing

The bearing installed in the motor shall support the weight of the rotating portions and the thrust, and shall be constructed to endure continuous operation for a long time and be able to be self-lubricated smooth.

(f) Flange

The flange for piping connection shall be in accordance with JIS10K or equivalent.

2.02 Materials

Materials shall be as follows.

(a) Casing : Cast iron

(b) Impeller : Cast iron or equivalent

(c) Main shaft : Stainless steel

2.03 Protection Equipment

(1) A thermal switch to detect abnormal temperature rises shall be built in.

(2) The pump shall be provided with a submersion detector for detection and indication of submersion, if necessary.

2.04 Accessories (per Unit)

(a)	Submersible cable (up to terminal box)	x 1 set
(b)	Lifting chain (Stainless steel)	x 1 set
(c)	Pump removal equipment (in case of removable type)	x 1 set
(d)	Foundation bolt and nut	x 1 set
(e)	Compound pressure gauge (diaphragm type)	x 1 set
(f)	Automatic air vent valve (if necessary)	x 1 set
(g)	Power cable terminal box	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11101

Section 11102

Pumping Equipment: Submersible Sand Pump

Part 1 - General

1.01 General

This pump shall be used to discharge the grit held in the grit chamber, etc. It shall be constructed to be sturdy to endure continuous operation in water. It shall have the minimum bore diameter of 50 mm.
The pump shall be constructed to produce less vibration and noise and operate smoothly, and especially, shall not produce harmful phenomenon of cavitation.

1.02 Design Conditions

(1) The influent water shall be grit which has been collected in the grit chamber, etc.

(2) It shall be permitted for no-discharge operation.

Part 2 - Products

2.01 Fabrication

Drive unit

(1) The motor to be used with the pump shall be a submersible motor.

Main body

(2) Casing

The casing shall be made of good quality of cast iron considering the mechanical strength to internal pressure, vibration, etc. as well as the resistance to corrosion and wear.
The casing shall be constructed for easy disassembly and assembly.

(a) Removable type

The casing discharge flange shall be of slide type, and when mounting the pump, shall be connected positively along the discharge bend flange surface.

(b) Stationary type

A support stand shall be provided at the underside of the casing, and the pump shall be installed on the floor inside the pit.

(3) Impeller

The impeller shall be a stout product of good quality and shall be sturdy to ingress of solids.

The impeller shall be constructed with a minimum number of blades and well in balance, and the surface shall be finished smooth.

(4) Main shaft

The main shaft is an extension of the motor shaft. It shall be strong enough to the transmission torque and torsional vibration.

(5) Shaft sealing equipment

The shaft sealing portion shall consist of mechanical seals and it shall be a two-stage structure with oil sealed in an intermediate portion to prevent foreign substances from ingress into the motor whether the motor in operation or at stop. It shall be constructed for easy replacement of seals, etc.

(6) Bearing

The bearing installed in the motor shall bear the weight of rotary portions and the hydraulic thrust. It shall be constructed to endure a long time of continuous operation and be capable of smooth self-lubrication.

(7) Flange

Flanges for piping connection shall be in accordance with JIS10K or equivalent.

2.02 Materials

(a)	Casing	:	Cast iron
(b)	Impeller	:	Cast iron or equivalent
(c)	Main shaft	:	Stainless steel

2.03 Protection Equipment

(1) A thermal switch to detect abnormal temperature, etc. shall be built in.

(2) A water pocket room to prevent oil and water from ingress into the motor section shall be provided, if necessary.

2.04 Accessories (per Unit)

(a)	Submerged cable (up to terminal box)	x 1 set
(b)	Lifting chain	x 1 set
(c)	Pump removable equipment (in the case of removable type)	x 1 set
(d)	Foundation bolt and nut	x 1 set
(e)	Compound pressure gauge (diaphragm type)	x 1 set
(f)	Automatic air vent valve (if necessary)	x 1 set
(g)	Power cable terminal box	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11102

Section 11103

Pumping Equipment: Non-clog Type Sludge Pump

Part 1 - General

1.01 General

This pump shall be installed for the transfer of the sludge.

1.02 Design Conditions

(1) The impeller shall be screw type having a non-clogging single vane.

(2) It shall be permitted for no-discharge operation during the discharge valve start-up time (within 30 seconds).

(3) The pump suction side shall require no hand hole.

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) The pump casing shall be volute type. It shall be made of good quality of cast iron free from blowhole and have smooth cast surface. It shall be sturdy and have a wall thickness with ample allowance to shock, wear, corrosion and piping load.

(2) The impeller shall be shaped to pass solids of foreign substances without trouble. It shall be well in balance and not produce abnormal vibration during operation.

(3) The portion at which the main shaft penetrates through the shell shall be provided with a stuffing box.
The shaft seal water system shall be gland packing system, water spray mechanical seal system or no-water spray mechanical seal system.

(4) The bearing shall have been constructed best suited to loads. It shall have a sufficient supporting capacity, and shall be durable because of complete lubrication and freedom from overheating, etc. It shall have a sufficient capacity to axial thrusts as well.

(5) The motor specifications shall be totally enclosed fan-cooled type and of continuous rating.

(6) The pump flange shall be JIS 10K or equivalent.

2.02 Materials

(a) Casing : Cast iron

(b) Impeller : Cast iron

(c) Suction cover : Cast iron

(d) Main shaft : Carbon steel (with stainless steel sleeve)

2.03 Accessories (per Unit)

(a) Common base	x 1 set
(b) V-belt (in the case of pulley drive)	x 1 set
(c) V-pulley (in the case of pulley drive)	x 1 set
(d) Coupling (in the case of the motor direct coupling)	x 1 set
(e) Belt cover or coupling cover	x 1 set
(f) Pressure gauge (diaphragm type) (compound pressure gauge if necessary)	x 1 set
(g) Foundation bolt and nut	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11103

Section 11104

Pumping Equipment: Progressive Cavity Pump

Part 1 - General

1.01 General

This pump shall be a progressing cavity pump used to supply sludge at a constant rate to the coagulation-mixing tank or the dewatering unit.

1.02 Design Conditions

This pump shall be constructed to have stable performance to sludge of water content 95 to 98%, to be free from clogging with sludge and not to cause overloading of the motor.

Part 2 -Products

2.01 Fabrication

(1) The pump casing shall have smooth cast surfaces and be sturdy and shall have wall thickness having an adequate allowance for shock, wear, corrosion and piping loads.

(2) The rotor shall be one-axis eccentric screw type and shall not cause vibration during operation.

(3) The portion of the shell where the main shaft penetrates through shall be provided with a stuffing box and the shaft sealing equipment shall be a gland packing or mechanical system.

(4) To facilitate replacement of the stator, the pump shall be constructed to permit removal of suction casing and discharge casing and the piping and replacement space shall be determined.

(5) The bearing shall have been constructed to have an adequate supporting capacity to the load. Because of complete lubrication, it shall be free from overheating, etc. Moreover, it shall have an adequate allowance for axial thrust.

(6) The motor specifications shall be totally enclosed fan-cooled type, and of continuous rating.

2.02 Materials

(a)	Common base	: Cast iron or rolled steel
(b)	Casing	: Cast iron
(c)	Rotor	: Alloy tool steel + hard chrome-plating or Stainless steel + hard chrome-plating or equivalent

(d) Stator : Synthetic rubber

(e) Shaft : Stainless steel

2.03 Accessories (per Unit)

(a) Safety cover x 1 set

(b) Common base x 1 set

(c) Pressure gauge (diaphragm type) x 1 unit

(d) Foundation bolt and nut x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11104

Section 11105

Pumping Equipment: Diaphragm Pump

Part 1 - General

1.01 General

The diaphragm pump shall be used for the automatic proportional injection of polyaluminium chloride into the sludge dewatering unit. It shall be a diaphragm type automatic stroke length controlled positive displacement pump.

1.02 Design Conditions

This pump shall be corrosion resisting to polyaluminium chloride.
As to the injection rate, the expected maximum and minimum limits shall be calculated and this pump shall be designed for the injection in that range.

Part 2 - Products

2.01 Fabrication

(1) This pump shall consist of two components, pump main body and drive unit.

(2) The pump main body shall be of positive displacement type using diaphragms. The discharge portion shall contain a ball check valve and shall be constructed to be easy to check and disassemble.

(3) The drive motor shall be a universal constant-speed rotation type, and stroke length control shall be automatic with a servo unit.

(4) On the pump discharge line, an accumulator for pulsation prevention shall be provided, and to prevent any abnormally high pressure resulting from pipe clogging, a safety valve shall be provided as an accessory.

2.02 Materials

(a) Pump main body case	:	Rolled steel, cast iron or PVC (polyvinyl chloride),liquid end PVC or corrosion resisting material
(b) Diaphragm	:	Teflon or equivalent
(c) Ball valve	:	Ceramic or equivalent
(d) Common base	:	Cast iron or rolled steel

2.03 Protection Equipment

(1) Mechanical protection equipment

Safety valve

2.04 Accessories (per Unit)

(a)	Servo unit	x 1 set
(b)	Foundation bolt and nut	x 1 set
(c)	Accumulator	x 1
(d)	Safety valve	x 1
(e)	Diaphragm type pressure gauge (including master valve)	x 1
(f)	Common base	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11105

Section 11107

Pumping Equipment: Centrifugal Pump

Part 1 -General

1.01 General

This pump shall be a single-stage or multistage volute pump for elevated water tank storage, filter cloth washing water, compression, etc.

1.02 Design Conditions

(1) The pump shall have wall thickness having an adequate allowance for shock, wear and corrosion.

(2) The pump shall be constructed to produce no vibration and noise during operation and endure continuous operation for a long time sufficiently.

(3) The motor specifications shall be totally enclosed fan-cooled type and of continuous rating.

Part 2 - Products

2.01 Materials

(a) Casing :Cast iron

(b) Impeller :Cast iron or bronze casting

(c) Main shaft :Carbon steel with stainless steel sleeve or stainless steel shaft

2.02 Accessories (per Unit)

(a) Coupling cover x 1 set

(b) Common base x 1 set

(c) Pressure gauge or compound pressure gauge x 1 set

(d) Foundation bolt and nut x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11107

Section 11108

Pumping Equipment: Dry Well Installation Submersible Sewage Pump

Part 1-General

1.01 General

This pump shall be used to discharge the sewage held in the pump well, etc. It shall be constructed to be sturdy to endure continuous operation on dry well. The pump shall be constructed to produce less vibration and noise and operate smoothly, and especially, shall not produce harmful phenomenon of cavitation.

1.02 Design Conditions

(1) The influent water is pass it the screen shall be sewage which has been capable of removing screenings of garbage, fibre, sticks, etc.

(2) It shall be permitted for no-discharge operation.

Part 2-Products

2.01 Fabrication

Drive unit

The motor to be used with the pump shall be an induction motor of dry type.

Main body

(1) Casing

The casing shall be made of good quality of cast iron considering the mechanical strength to internal pressure, vibration, etc. as well as the resistance to corrosion and wear.
The casing shall be constructed for easy disassembly and assembly.

(2) Impeller

The impeller shall be a stout product of good quality and shall be sturdy to ingress of solids.
The impeller shall be constructed with a minimum number of blades and well in balance, and the surface shall be finished smooth.

(3) Main shaft

The main shaft is an extension of the motor shaft. It shall be strong enough to the transmission torque and torsional vibration.

(4) Shaft sealing equipment

The shaft sealing portion shall consist of mechanical seals and it shall be a two-stage structure with oil sealed in an intermediate portion to prevent foreign substances from ingress into the motor whether the motor in operation or at stop. It shall be constructed for easy replacement of seals, etc.

(5) Bearing

The bearing installed in the motor shall bear the weight of rotary portions and the hydraulic thrust. It shall be constructed to endure a long time of continuous operation and be capable of smooth self-lubrication.

(6) Flange

Flanges for piping connection shall be in accordance with JIS 10K or equivalent.

2.02 Materials

Materials shall be as follows.

(a)	Casing	: Cast iron
(b)	Impeller	: Cast iron or equivalent
(c)	Main shaft	: Stainless steel
(d)	Motor frame	: Cast iron

2.03 Protection Equipment

(1) A thermal switch to detect abnormal temperature, etc. shall be built in.

2.04 Accessories (per Unit)

(a) 10m Water tight rubber insulated flexible cable	1 set
(b) Lifting chain	1 set
(c) Foundation bolt and nut	1 set
(d) Compound pressure gauge (diaphragm type)	1 set
(e) Automatic air vent valve (if necessary)	1 set
(f) Power cable terminal	1 set
(g) Suction	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11108

Section 11121

Valve: Motor Driven Gate Valve

Part 1 - General

1.01 General

This valve shall be installed at the sewage discharge pipe-line and/or the sludge withdrawal pipe-line of pumps to stop and/or to control the flow automatically.
This valve shall be composed of open/close valve and electric actuators.

1.02 Design Condition

(1) Sizes shown are nominal pipe diameter, unless otherwise noted.

(2) Operators shall be sized based on the maximum expected torque recommended by valve manufacturer.

(3) Gate valves shall be provided to isolate supply and return services to each piece of equipment or appliance without disturbing the piping systems. The valves shall be located to be easily accessible to operator of equipment.

Part 2 - Products

2.01 Fabrication

(1) Gate valve

(a) Gate valves shall comply with the requirements of Section 11120.

(2) Electrical actuators

(a) Actuators shall be suitable for operation on 415 volts, 50 Hertz, 3 phase power supply and shall incorporate into a single integral unit a squirrel cage motor, reduction gearbox, limit and torque switch mechanism..

(b) Actuators shall be made of cast iron or other equal approved material.

(c) Actuators shall be mounted on the valves. Actuators shall be sized to guarantee complete opening/closing of the valves at the maximum and minimum pressure head.

(d) Actuators shall have a linear displacement rates of 200mm and more than per minute with clockwise rotation indicated by an arrow the hand-wheel for closing.

(e) The electrical motor shall be capable of operating the actuator over its full travel for two continuous opening and closing cycles or with a time rating of 15 minutes whichever is the longer, at an average load of at least 33% of maximum torque. The motor shall be Class E or other equal approved class and shall be air cooled, specifically designed for actuator operation.

(f) Motor for actuators shall be suitable for operation on a 415V, 50sicles, 3-phase power supply.

(g) All gears shall be designed for 100% overload and all single moving parts shall have adequate lubrication. The actuator gearbox shall be of the totally enclosed oil bath lubricated type or enclosed grease lubricated type.

(h) Provision shall be made for manual operation of valve. When in manual operation, power shall be automatically disconnected from motor. Likewise, the manual hand-wheel shall automatically disengaged and remain stationary when the motor is connected.

(i) Manually operation shall be instantly available when power operation ceases or fails and transition from manual to power operation shall produce no shock or movement.

(j) Position limit and torque are to be provided to indicate extreme valve positions and for over-load protection.

(k) The actuator shall include digital local position indicator to monitor the valve position to show whether the valve is fully open, fully close or in some intermediate position.

2.02 Materials

(1) Valve

(a) Body : Cast Iron or equivalent

(b) Disc : Cast Iron or equivalent

(c) Stem : Stainless Steel or equivalent

(d) Seat : Bronze casting or equivalent

(2) Electrical actuator

(a) Body : Cast Iron or equivalent

2.03 Accessories (per Unit)

(a) Bolts and Nuts : 1 set

Part 3 – Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11121

Section 11122

Valve: Butterfly Valve

Part 1 - General

1.01 General

This valve shall be installed at the pipe-line to seal the water and to adjust the flow.

1.02 Design Condition

(1) Valves shall be suitable for throttling operations and for infrequent operation after periods of inactivity.

Part 2 - Products

2.01 Fabrication

(1) Butterfly valves shall comply with JWWA B114 or equivalent.

(2) The body of the valve shall be made from cast iron or ductile iron.

(3) Valves shall have fabricated steel, cast iron or ductile iron discs with a resilient rubber sealing ring.

(4) Valve stem, shall be if stainless steel designed for both torsion and shearing stresses when the valve is operated with permanently self-lubricated shaft stub bearing, sized to withstand bearing loads.

(5) Butterfly valves shall be provided with hand-wheels and rack and pinion gearing operation. The valves shall be open by turning the hand-wheel in an anticlockwise direction. The direction of valve opening and closing shall be marked on the hand-wheel casting.

(6) The valves shall be designed to hold the disc in any intermediate position between fully opened and fully closed without creeping or fluttering by manual or electric operation.

2.02 Materials

(a) Body : Carbon steel or Cast iron or equivalent

(b) Disc : Carbon steel or Cast iron or equivalent

(c) Stem : Stainless Steel or equivalent

(d) Seat : Rubber or equivalent

2.03 **Accessories** (per Unit)

(a) Bolts and Nuts : 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11122

Section 11123

Valve: Motor Driven Butterfly Valve

Part 1 - General

1. General

This valve shall be installed at the pipe-line to seal the water and to adjust the flow.

2. Design Condition

(1) Valves shall be suitable for throttling operations and for infrequent operation after periods of inactivity.

Part 2 - Products

2.01 Fabrication

(1) Butterfly valves shall comply with the requirement of Section 11122.

(2) Stuffing box shall be provided at the actuator end of shaft and be arranged such that the O-rings can be replaced without removing the actuator.

(3) Electrical actuator shall be complied with the requirement of Section 11121.

2.02 Materials

A Valve

(a) Body : Carbon steel or Cast iron or equivalent

(b) Disc : Carbon steel or Cast iron or equivalent

(c) Stem : Stainless Steel or equivalent

(d) Seat : Rubber or equivalent

B Electrical Actuator

(a) Body : Cast iron or equivalent

2.03 **Accessories** (per Unit)

(a) Bolts and Nuts : 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11123

Section 11125

Valve: Motor Driven Eccentric Valve

Part 1 - General

1.01 General

This valve shall be installed at the sludge drawing pipe line, and shall be capable of opening and closing in the automatic operation of the pump.

1.02 Design Condition

(1) Size shown is nominal pipe diameter, unless otherwise noted.

(2) Operators shall be sized based on the expected maximum torque recommended by valve manufactures.

(3) The valves shall have an opening area more than 80% of the whole area in fully opening.

(4) The valves shall be adjustable and replaceable without the removal from the connected pipes.

Part 2 - Products

2.01 Fabrication

(1) Eccentric valves shall be of the non-lubricated type with Rubber resilient faced disc.

(2) The valve bodies shall be cast iron or ductile iron and shall be fitted with corrosion resistant seats.

(3) All valves shall have a rated working pressure of maximum 0.3MPa unless otherwise stated.

(4) The disc face to body seat interference shall be adjustable with the valve closed and without taking the valve out of service.

(5) Electrical actuator shall be complied with the requirement of Section 11120. However, the time for fully opening and closing shall be 20 to 40 seconds.

2.02 Materials

(a) Body : Cast Iron or Ductile iron

(b) Disc : Cast Iron or Ductile iron

(c) Body seat : Corrosion resistant material

(d) Disc seat : Rubber

(f) Stem : Stainless steel or Cast iron with rubber lining

2.03 Accessories (per Unit)

(a) Bolts and Nuts : 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11125

Section 11126

Valve: Telescopic Valve

Part 1 - General

1.01 General

This valve shall be installed at the digester to discharge scum and to control the water level, and composed of a sheath tube, approach tube, manual operated actuator, etc.

1.02 Design Condition

(1) This valves shall be capable of being operated manually with an operating torque not exceeding about 250N at the handwheel.

(2) This valves shall provide sufficient strength to operate at the maximum working pressure. In addition, this apparatus shall provide excellent corrosion resistance.

(3) This valves shall be of the cylindrical type.

Part 2 - Products

2.01 Fabrication

(1) The sheath tube shall be made of cast iron or equivalent, and it shall have enough size to receive the approach tube.

(2) The approach tube shall be made of stainless, and shall be structured to facilitate the sludge flow.

(3) The spindle shall be made of stainless and shall be a structure to move the approach tube up and down smoothly.

(4) The valves shall have the manual operated penstocks.

(5) The stand and the handwheel of the penstock shall be made of cast iron or equivalent. The handwheel shall be marked to indicate the direction of turning. The position indicator shall be provided with the stand or spindle cover.

2.02 Materials

(a) Sheath tube : Cast Iron or equivalent

(b) Approach tube : Stainless

(c) Spindle : Stainless

(d) Headstock : Cast iron

2.03 Accessories (per Unit)

(a) Bolts and Nuts : 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11126

Section 11127

Valve: Knife Gate Valve

Part 1 - General

1.01 General

This valve shall be installed at the sewage or sludge pipe-line.

1.02 Design Condition

(1) Sizes shown are nominal pipe diameter, unless otherwise noted.

(2) Operators shall be sized based on the maximum expected torque recommended by valve manufacturer.

(3) Knife gate valves shall be provided to isolate supply and return services to each piece of equipment or appliance without disturbing the piping systems. The valves shall be located to be easily accessible to operator of equipment.

(4) Knife gate valves shall not be installed with stem in the vertical down Position.

(5) Knife gate valves shall be provided complete with necessary operators, handwheels, chainwheels, operating nuts, chains, wrenches and other accessories required for the proper operation and system maintenance.

Part 2 - Products

2.01 Fabrication

(1) All knife gate valves shall be bonnetless, wafer type. Port areas shall be 100% of the full pipe area throughout the entire length. Flush port shall be located in the base of the valve and will be drilled, tapped and plugged.

(2) Knife gate valves shall be suitable for abrasive slurry application with bi-directional shutoff and comply with JIS B2031 or equivalent.

(3) Knife gate valves shall have cast iron bodies, stainless steel rising spindles, wedge gates with discs and seats. All sizes shall have two full port elastomer cartridge seats halves that shall be supported and compressed between flanges. The seat halves shall be steel reinforced moulded rubber and shall act as wiper blades to clean the gate as it strokes.

(4) The body shall be cast iron or fabricated steel. Packing box shall be of the inverted type, compressed by a weir cast into the valve body. Three layers of packing material shall be supplied as standard.

(5) The gate shall be of sufficient thickness to provide against permanent deformation at 1.2 times the rated working pressure. The gate shall be stainless steel 316. The stem shall be stainless steel 304 and shall have single pitch acme threads.

(6) All valves shall be capable of being operated by one man with an operating torque not exceeding 250N at the hand-wheel.

(7) All valves shall be close on a clockwise direction and the directions of opening and closing shall be cast on the hand-wheel. The valves shall be provided with open/shut position indicator.

(8) All valves shall have a rated working pressure of 0.98MPa unless otherwise stated.

(9) When valves are installed inaccessible positions, extension spindles, tee-keys, headstocks or chain-wheels shall be provided as the situation requires. Headstocks shall be clearly marked to indicate the opening and closing positions of valves.

2.02 Materials

(a) Body : Cast Iron or equivalent

(b) Gate : Stainless Steel 316

(c) Stem : Stainless Steel 304

(d) Seat : EPDM

2.03 Accessories (per Unit)

(a) Bolts and Nuts : 1 set

Part 3 – Valve Operator

3.01 Handwheel Operator

Knife gate valve size 3" to 12" are provided with standard handwheel mechanisms featuring cast handwheels, machined 304 stainless steel stem with yoke sleeves and thrust washers designed to produce maximum thrust with minimum torque. Rotating the handle clockwise shall push the threaded stem towards the valve body, closing the valve. Rotating the handle counter-clockwise pulls the gate out from the seats, opening the valve.

3.02 Pneumatic Actuator

Pneumatic actuator shall be single acting type consisting of either fail close spring or fall open spring. The actuator shall be of fiberglass reinforced epoxy resin. The actuator material shall be inert to most chemicals, hydraulic fluids, water and oil. It shall have temperature range up to 100 degree C and withstand maximum working pressure of 0.98MPa.

The actuator shall be self-lubricating for high cycle life and shall provide long term abrasion resistance under demanding operating conditions. The cylinder assembly shall be mounted on the valve body by means of a heavy duty fabricated topworks.

3.03 Electric Actuator

Electric actuators shall contain motor, gearing, manual over-ride, limit switches, torque switches, drive coupling, integral motor controls and mechanical dial position indicator. Actuator shall be capable of mounting in any position.

The motor shall be specifically designed for actuator service. The motor will be of the induction type with class F insulation and protected by means of thermal switches imbedded in the motor windings. Motor enclosure will be totally enclosed non-ventilated.

Motors will be capable of operating on 415 volt / 3 phase / 50 hertz power supply.

Actuator enclosure shall be IP55 (watertight). All external fasteners on the electric actuator will be stainless steel. Fasteners on limit switch and terminal compartments shall be captured to prevent loss while covers are removed.

All gearing shall be grease lubricated and designed to withstand the full stall torque of the motor.

Manual over-ride shall be by handwheel. Manual operation will be via power gearing to minimize required torque and facilitate easy change-over from motor to manual operation when actuator is under load. Return from manual to electric mode of operation will be automatic upon motor operation. A seized or inoperable motor shall not prevent manual operation.

Limit switches shall be furnished at each end of travel. Limit switch adjustment shall not be by manual operation. Limit switch drive shall be by countergear. Limit switches must be capable if quick adjustment requiring no more than five (5) turns of the limited switch adjustment spindle. One set of normally open and one set of normally closed contacts will be furnished at each end of travel where indicated. Contracts shall be silver and capable of reliably switching low voltage DC source form the control system.

Mechanically operated torque switches shall be furnished at each of travel. Torque switches will trip when the valve load exceeds the torque switch setting. The torque switch adjustment device must be calibrated directly in engineering units of torque.

All wiring shall be terminated at a plug and socket connector.

END OF SECTION 11127

Section 11130

Valve: Diaphragm Valve

Part 1 - General

1.01 General

This valve shall be installed at the water or chemical feeding pipe-line to seal and to adjust the flow.

1.02 Design Condition

(1) Valves shall be suitable for throttling operations and for infrequent operation after periods of inactivity.

Part 2 - Products

2.01 Fabrication:

(1) Handles showing direction of opening.
(2) All diaphragm valves shall be of flanged type.

2.02 Metallic diaphragm valves materials

(a)	Body	: Cast iron or Stainless steel or equivalent
(b)	Diaphragm	: Ethylene Propylene Rubber or equivalent
(d)	Bonnet	: Rubber or equivalent

2.03 Plastic diaphragm valves materials

(a)	Body	: PVC or equivalent
(b)	Diaphragm	: Ethylene Propylene Rubber or equivalent
(c)	Bonnet	: Glass filled polypropylene or equivalent

2.04 **Accessories** (per Unit)

(a)	Bolts and Nuts	: 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11130

Section 11131

Valve: Air Valve for Sewage

Part 1 - General

1.01 General

The valve shall be installed in a force main of sewage, etc, where heavy water with sludge or muds are found in a flow.

1.02 Design Condition

(1) The valve shall be installed under ground mostly outdoor.

Part 2 - Products

2.01 Fabrication

(1) Air valves shall comply with JWWA B114 or equivalent.

(2) The body of the valve shall be made from ductile iron.

(3) The valve has built-in isolation (bypass) ball valve for maintenance purpose.

(4) The nominal pressure is 0.74MPa (Test pressure is 1.75MPa).

(5) Air Ace is exclusively designed for use with sewerage water. The smaller air intake valve will avoid exhausting odor from the pipeline as well as to avoid spilling filthy water out of the valve. Odor filter unit is available. The unique internal structure avoid being affected by pulsatile flow.

2.02 Materials

(a) Body : Ductile iron. or equivalent

(b) Disc : Stainless Steel 316 with rubber lining or equivalent

(c) Float : Stainless Steel 316 or equivalent

(d) Drain Plug : Stainless Steel 304 or equivalent

(e) Valve Seal : Stainless Steel 316 or equivalent

(f) Bypass Valve : CACA06 or equivalent (Ball Valve)

2.03 **Accessories** (per Unit)

(a) Bolts and Nuts : 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11131

Section 11140

Gate: Manually Operated Cast Iron Gate

Part 1 - General

1.01 General

The cast iron gate shall be composed of the gate leaf, a spindle, an open-close device, etc. It shall be installed in the water treatment facility for the purpose of water sealing and influent flow adjustment. The gate shall be constructed to be watertight on four sides. It shall be opened and closed by manual operation. Its spindle shall be of outside screw type.

1.02 Design Conditions

(1) The gate leaf shall be made of cast iron of good quality free from cast blowhole. Strength calculations shall be made under the assumption that a water pressure of the indicated water level (lowest water level 5m with reference to the intake bottom) is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the gate shall be calculated from the water pressure and the load of self-weight including the spindle, etc.

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) The main portion of the gate leaf shall have the calculated wall thickness added with a corrosion allowance.

(2) Watertight sheet, wedge block, spindle connection bracket, etc. shall be provided. However, the spindle connection bracket may be cast integral with the gate leaf.

(3) Guide portions for gate leaf open-close shall be provided. The guide portion may be cast integral with the guide frame.

(4) The spindle shall be made from a stainless steel rod. It shall be able to move the gate leaf up and down smoothly and safely.

(5) If a pin is to be used in the connection between the gate leaf and the spindle, it shall be made of stainless steel.

(6) If a vibration-preventing metal is to be provided at an intermediate of the spindle length, it shall be made of cast iron or steel.

(7) Manual open-close device

(a) The open-close device shall be of horizontal handle type or gear type (bevel gear type, worm gear type).

(b) The stand and the hand wheel shall be made of cast iron. The hand wheel shall be marked to indicate the direction of turning. When the handle is turned counterclockwise, the gate leaf shall be opened.

(c) At the top of the open-close device, a spindle cover shall be mounted.

(d) To indicate the degree of opening, a clock type rotary opening-degree meter shall be provided in the case of gear type (bevel gear type, worm gear type), or an opening-degree meter shall be provided to the spindle cover or the stand in the case of the horizontal handle type. The opening-degree meter shall have a scale calibrated in mm and the major portions of the opening-degree meter shall be made of stainless steel.

2.02 Materials

Materials shall be as follows.

(a)	Gate leaf	: Cast iron
(b)	Guide frame	: Cast iron
(c)	Watertight sheet	: Bronze casting or stainless steel
(d)	Wedge	: Bronze casting + stainless steel or Cast iron
(e)	Spindle	: Stainless steel
(f)	Spindle cover	: Steel or stainless steel pipe

2.03 Accessories (per Unit)

(a)	Coupling for spindle	x 1 set
(b)	Foundation bolt and nut	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11140

Section 11141

Gate: Motor Driven Cast Iron Gate

Part 1 - General

1.01 General

The cast iron gate shall be composed of the gate leaf, a spindle, an open-close device, etc. It shall be installed in the water treatment facility for the purpose of water sealing and influent flow adjustment. The gate shall be constructed to be watertight on four sides. It shall be opened and closed by motor operation. Its spindle shall be of outside screw type.

1.02 Design Conditions

(1) The gate leaf shall be made of cast iron of good quality free from cast blowhole. Strength calculations shall be made under the assumption that a water pressure of the indicated water level (lowest water level 5m with reference to the intake bottom) is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the gate shall be calculated from the water pressure and the load of self-weight including the spindle, etc.

Part 2 - Products

2.01 Fabrication

(1) The main portion of the gate leaf shall have the calculated wall thickness added with a corrosion allowance.

(2) Watertight sheet, wedge block, spindle connection bracket, etc. shall be provided. However, the spindle connection bracket may be cast integral with the gate leaf.

(3) Guide portions for gate leaf open-close shall be provided.
The guide portion may be cast integral with the guide frame.

(4) The spindle shall be made from a stainless steel rod. It shall be able to move the gate leaf up and down smoothly and safely.

(5) If a pin is to be used in the connection between the gate leaf and the spindle, it shall be made of stainless steel.

(6) If a vibration-preventing metal is to be provided at an intermediate of the spindle length, it shall be made of cast iron or steel.

(7) Motor-driven open-close device

(a) A limit switch which operates positively at the position where the opening degree of the gate leaf is set shall be provided. The limit switch shall be adjustable.

(b) The mechanism of the motor-driven open-close device shall be such that if the torque applied to the motor abnormally increases during the open-close operation, the motor shall be stopped positively by the torque switch.

(c) The motor-driven open-close device shall be constructed such that if the gate is to be operated manually, the motor-driven circuit may be opened simply and positively and safety may be secured. This device shall be constructed to be returned manually to the motor-driven operation.

(d) The manual operation shall be done by means of a hand wheel.

(e) The opening-degree indicator shall be provided.

(f) Strength calculation of various portions shall be conducted considering safety to provide adequate strength with respect to the rated torque of the motor.

(g) The motor shall be a totally enclosed fan-cooled type and 15-minute (standard) rating provided with braking.

2.03 Materials

(a)	Gate leaf	: Cast iron
(b)	Guide frame	: Cast iron
(c)	Watertight sheet	: Bronze casting or stainless steel
(d)	Wedge block	: Bronze casting + stainless steel or Cast iron
(e)	Spindle	: Stainless steel
(f)	Spindle cover	: Steel pipe or stainless steel

2.04 Accessories (per Unit)

(a)	Coupling for spindle	x 1 set
(b)	Foundation bolt and nut	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11141

Section 11142

Gate: Motor Driven Steel Gate

Part 1 - General

1.01 General

The gate shall be composed of the gate leaf, a spindle, an open-close device, etc. It shall be installed in the water treatment facility for the purpose of water sealing and influent flow adjustment. The gate shall be constructed to be watertight on four sides. It shall be opened and closed by motor operation. Its spindle shall be of outside screw type.

1.02 Design Conditions

(1) The gate leaf shall be made of rolled steel. Strength calculations shall be made under the assumption that a water pressure of the indicated water level (lowest water level 5m with reference to the intake bottom) is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the gate shall be calculated from the water pressure and the load of self-weight including the spindle, etc.

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) The main portion of the gate leaf shall have the calculated wall thickness added with a corrosion allowance.

(2) Watertight sheet, wedge block, spindle connection bracket, etc. shall be provided. However, the spindle connection bracket may be cast integral with the gate leaf.

(3) Guide portions for gate leaf open-close shall be provided.

(4) The spindle shall be made from a stainless steel rod. It shall be able to move the gate leaf up and down smoothly and safely.

(5) If a pin is to be used in the connection between the gate leaf and the spindle, it shall be made of stainless steel.

(6) If a vibration-preventing metal is to be provided at an intermediate of the spindle length, it shall be made of cast iron or steel.

(7) Motor-driven open-close device

(a) A limit switch which operates positively at the position where the opening degree of the gate leaf is set shall be provided. The limit switch shall be adjustable.

(b) The mechanism of the motor-driven open-close device shall be such that if the torque applied to the motor abnormally increases during the open-close operation, the motor shall be stopped positively by the torque switch.

(c) The motor-driven open-close device shall be constructed such that if the gate is to be operated manually, the motor-driven circuit may be opened simply and positively and safety may be secured. This device shall be constructed to be returned manually to the motor-driven operation.

(d) The manual operation shall be done by means of a hand wheel.

(e) The opening-degree indicator shall be provided.

(f) Strength calculation of various portions shall be conducted considering safety to provide adequate strength with respect to the rated torque of the motor.

(g) The motor shall be a totally enclosed fan-cooled type and 15-minute (standard) rating provided with braking.

2.02 Materials

Materials shall be as follows.

(a)	Gate leaf	: Rolled steel
(b)	Guide frame	: Rolled steel
(c)	Spindle	: Stainless steel
(d)	Spindle cover	: Steel pipe or stainless steel

2.03 Accessories (per Unit)

(a)	Coupling for spindle	x 1 set
(b)	Foundation bolt and nut	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11142

Section 11143

Gate : Manually Operated Steel Gate

Part 1-General

1.01 General

The gate shall be composed of the gate leaf, a spindle, an open-close device, etc. It shall be installed in the water treatment facility for the purpose of water sealing and influent flow adjustment.

The gate shall be constructed to be watertight on four sides. It shall be opened and closed by manual operation. Its spindle shall be of outside screw type.

1.02 Design Conditions

(1) The gate leaf shall be made of rolled steel. Strength calculations shall be made under the assumption that a water pressure of the indicated water level (lowest water level 5m with reference to the intake bottom) is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the gate shall be calculated from the water pressure and the load of self-weight including the spindle, etc.

Part 2-Products

2.01 Fabrication

Fabrication shall be as follows.

(1) The main portion of the gate leaf shall have the calculated wall thickness added with a corrosion allowance.

(2) Watertight sheet, wedge block, spindle connection bracket, etc. shall be provided. However, the spindle connection bracket may be cast integral with the gate leaf.

(3) Guide portions for gate leaf open-close shall be provided.

(4) The spindle shall be made from a stainless steel rod. It shall be able to move the gate leaf up and down smoothly and safely.

(5) If a pin is to be used in the connection between the gate leaf and the spindle, it shall be made of stainless steel.

(6) If a vibration-preventing metal is to be provided at an intermediate of the spindle length, it shall be made of cast iron or steel.

(7) Manual open-close device

(a) The open-close device shall be of horizontal handle type or gear type (bevel gear type, worm gear type).

(b) The stand and the hand wheel shall be made of cast iron or steel. The hand wheel shall be marked to indicate the direction of turning. When the handle is turned counterclockwise, the gate leaf shall be opened.

(c) At the top of the open-close device, a spindle cover shall be mounted.

(d) To indicate the degree of opening, a clock type rotary opening-degree meter shall be provided in the case of gear type (bevel gear type, worm gear type), or an opening-degree meter shall be provided to the spindle cover or the stand in the case of the horizontal handle type. The opening-degree meter shall have a scale calibrated in mm and the major portions of the opening-degree meter shall be made of stainless steel.

2.02 Materials

Materials shall be as follows.

(a)	Gate leaf	: Rolled steel
(b)	Guide frame	: Rolled steel
(c)	Spindle	: Stainless steel
(d)	Spindle cover	: Steel pipe or stainless steel

2.03 Accessories (per Unit)

(a)	Coupling for spindle	x 1 set
(b)	Foundation bolt and nut	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11143

Section 11150

Weir: Fixed Weir Plate

Part 1 - General

1.01 General

The Fixed weir plate shall be installed in the water treatment facility for the purpose of equalization of influent flow. The Fixed weir plate shall be constructed to be concrete weir side.

1.02 Design Conditions

(1) The weir plate shall be made of stainless steel or FRP plate. Strength calculations shall be made under the assumption that a water pressure of the water level corresponding to the indicated lift head is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the weir plate shall be calculated from the water pressure and the load of self-weight, etc.

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) Regarding the specifications for the weir plate, the following requirements shall be observed.

(a) The weir plate shall be constructed to provide sufficient watertight.

(b) The weir plate shall be adjusted water level height (Approximately 20mm).

(c) The weir plate shall be made of stainless steel or FRP.

(d) Minimum thickness of weir plate shall be 4 mm.

2.02 Materials

(a) Weir plate : Stainless steel or FRP

2.03 **Accessories** (per Unit)

(a) Anchor bolt x 1 set

(b) Rubber packing x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11150

Section 11151

Weir: Adjustable Weir

Part 1 - General

1.01 General

The adjustable weir shall be composed of the adjustable weir leaf, a spindle, an open-close device, etc. It shall be installed in the water treatment facility for the purpose of water sealing and influent flow adjustment.
The adjustable weir shall be constructed to be watertight on three sides. It shall be opened and closed by manual operation. Its spindle shall be of outside screw type.

1.02 Design Conditions

(1) The weir leaf shall be made of cast iron of good quality free from cast blowhole. Strength calculations shall be made under the assumption that a water pressure of the water level corresponding to the indicated lift head is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the adjustable weir shall be calculated from the water pressure and the load of self-weight including the spindle, etc.

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) Regarding the specifications for the adjustable weir, the following requirements shall be observed.

(a) The adjustable weir shall be constructed to provide sufficient watertightness at each degree of opening.

(b) On each of three sides of the opening, a weir plate suited for flow measurement shall be provided.

(c) The watertight sheet shall be made of stainless steel or bronze casting. The adjustable weir shall be constructed to be watertight on three sides, as standard.

(2) The main portions of the weir leaf shall have the calculated wall thickness added with a corrosion allowance.

(3) Watertight sheet, weir plate, spindle connection bracket, etc. shall be provided. However, the spindle connection bracket may be cast integral with the weir leaf.

(4) Guide portions for weir leaf open-close shall be provided.
The guide portion may be cast integral with the guide frame.

(5) The spindle shall be made from a stainless steel rod. It shall be able to move the weir leaf up and down smoothly and safely.

(6) If a pin is to be used in the connection between the weir leaf and the spindle, it shall be made of stainless steel.

(7) If a vibration-preventing metal is to be provided at an intermediate of the spindle length, it shall be made of cast iron or steel.

(8) Manual Open-close Device

In accordance with Section 11140 Manually Operated Cast Iron Gate.

2.02 Materials

(a)	Weir leaf	: Cast iron
(b)	Guide frame	: Cast iron
(c)	Watertight sheet	
	- Weir leaf side	: Stainless steel or bronze casting
	- Guide frame side	: Stainless steel or bronze casting
(e)	Spindle	: Stainless steel
(f)	Spindle cover	: Steel pipe or stainless steel

2.03 Accessories (per Unit)

(a)	Coupling for spindle	x 1 set
(b)	Foundation bolt and nut	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11151

Section 11160

Hopper : Motor Driven Cut-gate Type

Part 1 - General

1.01 General

This hopper shall be provided to store, and further to discharge from the bottom, the object carried out of dewatering unit, etc. It shall be composed of hopper main body, frame, checking walkway, stairway, open-close gate, motor-driven open-close units, etc.

1.02 Design Condition

Prevention of arching phenomenon shall be considered. The hopper shall be manufactured to have a total capacity of nominal capacity (m^3) plus 5%.

Part 2- Products

2.01 Fabrication

(1) The hopper shall be a welded structure of steel plate and shape steel, and its frame shall be mounted firmly to the concrete foundation by means of foundation bolts.

(2) Open and close of the gate shall be made by cut-gate method. Driving method shall be hydraulic or pneumatic or motor driven.

(3) The hopper shall be able to indicate the weight by means of a load cell type weight detector. For each hopper, four detecting elements and an instrument panel (V/I converter, indicator) shall be provided as accessories. However, the instrument panel may be a composite with the local control panel.

(4) Under the hopper, a movable drain receiving trough shall be provided in a position not interfering with passage of the carrying vehicle. Drain pipes also shall be installed.

(5) In the case of a floor installation type hopper, an opening between the hopper and the foundation shall be covered with checkered steel plates.

(6) The local control panel shall be self-standing type.

2.02 Materials

(1) Main body, frame, walkway, stairway : Rolled steel

2.03 Protection Equipment

(1) Mechanical protection equipment

Speed reducer built-in torque limiter

(2) Electrical protection equipment

An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

2.04 Accessories (per Unit)

(1) Frame x 1 set

(2) Open-close device x 1 set

(3) Walkway, stairway (if necessary) x 1 set

(4) Foundation bolt and nut x 1 set

(5) Weight detector x 1 set

(6) Discharge side skirt (made of rubber or fabric vinyl) x 1 set

(7) Water cutting through x 1 set

(8) Oil (if necessary) x 1 can

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11160

Section 11170

Conveyor: Shaftless Screw Compactor

Part 1 - General

1.01 General

The shaftless screw compactor shall consist of a drive unit, a trough, a screw, compactor, etc. and shall be used to carry out screenings.

1.02 Design Conditions

(1) The strength of each portion of this compactor shall have an adequate safety factor.

(2) Even if the strength of each portion of this compactor is sufficient, it is necessary to consider the wall thickness of all portions that are subject to corrosion and wear.

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) Drive unit

(a) The power transmission from the motor shall be done through gears, etc.

(b) The gear shall be made of cast steel, cast iron or carbon steel, and in any case, gear teeth shall be cut by precision machining and the tooth surface shall be heat treated and have high wear resistance.

(c) The drive unit shall be constructed to be convenient for checking, servicing and oil supply.

(2) Trough

(a) The trough shall be made of stainless steel plates.

(b) The trough shall be provided with a nozzle for drainage.

(3) Screw

(a) The screw shall be made of special steel and shall be shaped for efficient discharge of the cake.

(b) The screw shall have sufficient strength to endure a long time of use.

2.02Materials

(a) Trough : Stainless steel

(b) Screw : Special steel
(c) Leg : Rolled steel

2.03 Protection Equipment

(1) Electrical protection equipment

Overcurrent detector for overload prevention (Electrical works)

2.04 Accessories

(a) Anchor bolt x 1 set

(b) Others required x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11170

Section 11171

Conveyor: Shaf-tless Screw Conveyor

Part 1 - General

1.01 General

The shaft-less screw conveyor shall be used for the transportation of screenings, sludge, etc. The shaft-less screw conveyor shall be composed of casing, shaft-less screw and drive unit, etc.

1.02 Design Condition

Each part of this equipment shall be designed with sufficient safety factor in strength.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

Cycloidal reduction gear or worm reduction gear, etc. shall be used for drive unit.

(2) Screw

The impeller of screw shall be a welded structure of stainless steel, and shall transport the screenings or sludge effectively.

(3) Casing

Cycloidal reduction gear or worm reduction gear, etc. shall be used as drive unit.

(a) The casing shall be made of stainless steel and shall be assembled firmly by welding or with bolts in order to endure the transport load.
(b) The casing shall be constructed such that it can be inspected easily with inspection holes provided in appropriate locations.

2.02 Material

(1) Casing : Stainless steel

(2) Screw : Stainless steel

2.03 Protection Equipment

(1) Mechanical protection

For the cyclodial reduction gear, a built in torque limiter shall be provided.

(2) Electrical protection

An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

2.04 Accessories (per Unit)

(1) Anchor bolts and nuts x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11171

Section 11190

Hoist : Geared Trolley Chain Block

Part 1 - General

1.01 General

The chain block shall be used for the carry-in and carry-out, installation, maintenance and check of equipment, apparatus and the materials required therefor installed in the building. It shall be of manual operation type and all of hoist and traverse motions shall be manually operated.

1.02 Design Condition

The chain block shall be manufactured to operate safely and accurately, as well as to be structurally durable and convenient for maintenance.

Part 2 - Products

2.01 Fabrication

(1) Hoist equipment

The hoist equipment shall be composed of a gear mechanism constructed with a combination of spur gears, a control mechanism, a hand chain wheel mechanism and a take-up mechanism. When the hand chain is manually operated, the force is transmitted to the gear mechanism which turns the load sheave to wind up the load chain.

(2) Load sheave

The load sheave to be used shall be a forged or cast one and shall be fabricated and treated so as to not cause damage to the load chain during winding.

(3) Load chain

The load chain to be used shall be made of galvanized steel or corrosion resistant material. It shall demonstrate excellent rust and corrosion resistance.

(4) Operating chains

For hoisting and traversing, separate chains shall be used. These chains shall be long enough to reach up to approximately 30 cm above the floor. Adequate consideration shall be given to ensure that they are free from bouncing, coming-off, etc. during operation.

(5) Hooks

The hook shall be a single-hook type and be provided with a safety lever.

(6) Traversing equipment (geared trolley)

When the hand chain mounted to the hand wheel is operated, the hand wheel is turned so that the spur gear mounted on the opposite side may drive half of the traverse wheels (on one side).

2.02 Materials

(1) Load chain : Galvanized steel or corrosion-resistant material

(2) Hand chain : Stainless steel or corrosion-resistant material

2.03 Protection Equipment

(1) Mechanical protection equipment

Braking equipment

When hand chain operation is stopped, the hoisting equipment shall be stopped at once by the mechanical braking mechanism.

2.04 Accessories (per Unit)

(1) Spare hook for re-hoisting (as necessary) x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11190

Section 11192

Hoist: Jib Crane

Part 1 - General

1.01 General

This equipment shall be used to lift the container, etc. and unload it on the lorry, etc. It shall be composed of a geared trolley chain block, a vertical post set, etc.

1.02 Design Condition

The jib crane shall be such that it can be operated safely and properly. It shall be durably constructed and provide easy maintenance.

Part 2 - Products

2.01 Fabrication

(1) The post shall be constructed such that it can be rotated manually even when the suspended geared trolley chain block lifts the load.

(2) The specification of the geared trolley chain block shall comply with section 11190 hereof.

2.02 Materials

(1) Vertical post : rolled steel or equivalent

(2) Geared trolley chain block : as per section11190

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11192

Section 11193

Hoist : Motorized Geared Trolley Chain Block

Part 1 - General

1.01 General

The motorized chain block shall be used for the carry-in and carry-out, installation, maintenance and check of equipment/apparatus installed in the building and required materials. It shall be of power drive operation and all hoist and traverse motions shall be operated by motor drive. Operation shall be initiated from the floor of the building by a hanging push start button.

1.02 Design Condition

The motorized chain block shall be manufactured to operate safely and accurately, as well as be structurally durable and convenient for maintenance.

Part 2 - Products

2.01 Fabrication

(1) Hoist equipment

The hoist equipment shall be composed of a gear mechanism constructed with a combination of spur gears or helical gears and a take-up mechanism. When the chain is operated by motor drive, the force is transmitted to the gear mechanism, which turns the load sheave to wind up the load chain.

(2) Load sheave

The load sheave to be used shall be a cast one and shall be fabricated and treated so as not to cause damage to the load chain during winding. In addition, it shall be strong enough to withstand the use of motor drive.

(3) Load chain

The load chain to be used shall be made of hardened steel or corrosion resistant material. It shall demonstrate excellent rust and corrosion resistance.

(4) Hooks

The hook shall be a single-hook type and be provided with a safety lever.

(5) Traversing equipment (geared trolley)

Via the motor for traversing, the spur gear or helical gear shall drive half of the traverse wheels (on one side).

2.02 Materials

(1) Load chain : Galvanized steel or corrosion-resistant material

2.03 Protection Equipment

(1) Braking equipment

When motor drive operation is stopped, the hoisting equipment shall be stopped at once by the mechanical braking mechanism.

(2) Protection equipment for over hoist

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11193

Section 11200

Lifting Device: Chemical Container Lifting Device

Part 1 - General

1.01 General

This lifting device shall be provided for loading chemical containers to be carried by a truck into the first floor of the sludge building and lowering spent containers from the first floor to the ground floor.

1.02 Design Condition

(1) This lifting device shall be designed to assure the safe and proper operation and fabricated from materials of high durability for maintainability.

Part 2 - Products

2.01 Fabrication

(1) The drive mechanism shall be of motor driven or oil hydraulic type in principle.

(2) The lifting device shall be of wire type or chain type that shall be fabricated from material of corrosion resistance and durability.

(3) The lifting device shall be provided with the floor where chemical containers can be stably placed and walls to prevent containers from dropping and structured of a sufficient size where chemical containers to be used can be easily lifted or lowered.

(4) The framework of the lifting device shall be fabricated from sufficiently rugged and durable materials to support the main body and its associated drive mechanism. The structure shall be also designed to withstand natural environment such as wind and earthquake (windbreak and aseismatic structure).

(5) A safety device shall be provided with mechanical and electrical interlocks designed, taking the safety of operators into account.

(6) The power control panel shall be capable of providing power to the drive mechanism, and controlling the stop operation of the main body according to the detection of the automatic stop position.

(7) The operating switch shall be of pushbutton type, and provided with lifting/lowering and emergency stop buttons at each one proper place on the ground and first floors.

(8) The lifting/lowering speed shall be generally limited to 10 meters/minute or less.

(9) For the lifting lowering operation, pressing the “UP” button shall enable the lifting device to be operated to the first floor and stop it automatically at the “Stop” position. Pressing the “DOWN” button shall enable it to be operated to the ground floor and stop at the “Stop” position. In case of emergency, pressing the “Emergency stop button”

shall enable the lifting device to stop immediately. The lifting device shall be operated up and down readily for an emergency case.

2.02 Materials

(a) Frame	: Rolled Steel
(b) Main body	: Rolled Steel
(c) Wire or chain	: Corrosion-resistant material
(d) Mounting bolts and nuts	: Stainless Steel

2.03 Accessories (per Unit)

(a) Bolts and Nuts	: 1 set
(b) Power control panel	: 1 set
(c) Operation switch	: 2 sets

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11200

Section 11220

Screen: Automatic Drum Screen

Part 1 - General

1.01 General

The automatic drum screen shall be composed of screen, screw conveyor, washing unit, dewatering unit and drive unit, etc. The automatic drum screen shall be used to block, remove, wash, and dewater the suspended solid or scum in the influent or sludge.

1.02 Design Condition

(1) This equipment shall be designed with sufficient safety factor in strength.

(2) This equipment shall be of integrated type and shall be constructed such that it can be installed easily.

(3) The difference of water level, the characteristics of suspended solid, and flow rate shall be considered in design.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

(a) Cycloidal reduction gear or worm reduction gear shall be used as drive unit. Drive unit shall transmit the power by means of gear transmission or direct connection with coupling.

(b) Gearbox shall be provided in case of gear transmission.

(c) Belt drive system may be acceptable.

(2) Screen

(a) The screen shall be made of cylindrical stainless steel. The screen shall have a smooth finish in order to prevent the attachment of screenings and shall be arranged with equal spacing.

(b) An electrical pole shall be installed in front of the screen in order to detect the overflow and control operation.

(3) Rake

(a) The rake shall be connected with the screw conveyor along the same axis and shall rotate with it. The raked screenings shall be scraped down into the screw conveyor by the scraper.

(b) The rake shall be constructed such that the screenings never remain on the screen

after raking.

(c) Water jet washing system may be used in place of rake in accordance with the manufacturer's standard. In such a case, provision of washing water supply system shall be included in the automatic drum screen system, in addition to the in-plant water supply system.

(4) Screw conveyor

(a) The impeller and shaft of the screw shall be a welded structure of stainless steel and shall endure the incurred stress.

(b) A dewatering device shall be provided at the upper portion of the screw conveyor. The dewatering device shall be sealed and shall have sufficient strength to endure the pressure of screenings and scum. The inspection hole and washing water pipe shall be provided for the dewatering device. The inspection hole shall permit easy inspection and the washing water pipe shall be used to wash the casing for filtrated liquid.

(5) Shaft and bearing

(a) The shaft of screw shall be made of stainless steel and shall have sufficient strength to endure the incurred stress.

(b) The submerged bearing shall be an oil-less enclosed pneumatic type. For a bearing installed above the water level, an automatic oiling device shall be provided.

(6) Washing unit

Washing nozzles shall be provided at the inlet of the screw conveyor in order to wash down the screening or scum with pressurized water.

(7) Chute

A stainless steel chute shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings or scum are blocked from being discharged.

2.02 Materials

(a) Screen : Stainless Steel

(b) Rake : Stainless Steel

(c) Screw conveyor : Stainless Steel

(d) Chute : Stainless Steel

2.03 Protection Equipment

(1) Mechanical protection

For cyclodial reduction gear, a built-in torque limiter shall be provided.

(2) Electrical protection

An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

2.04 Accessories (per Unit)

(c) Anchor bolts and nuts 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11220

Section 11221

Screen: Automatic Disc Screen

Part 1 - General

1.01 General

This screen shall be used for eliminating impurities and/or scum in sewage by continuous separation. This apparatus shall be composed of a casing, screen, scraper, drive unit, etc. It shall be of a structure to forcibly scrape off impurities and scum attached to the screen by turning the slit-worked surface of cylindrical screen by the drive unit.

1.02 Design Condition

(1) This apparatus shall provide excellent resistance to corrosion and wear, as the handled fluid is sewage or scum containing drainage.

Part 2 - Products

2.01 Fabrication

(1) Driving device

(a) The driving device shall be equipped with an adjustable speed cycloidal reducer or a planetary gear reducer. The screen driving method shall be either by means of a reducer coupled to the motor or by means of roller chains.

(b) The exposed sections of the reducer and chains shall be provided with covers.

(2) Casing

(a) The casing shall be of a watertight structure that permits overflow.

(b) The casing shall be made of rolled steel or stainless steel, and shall be provided with an inspection window as required, to permit inspection of the interior.

(3) Screen

(a) The screen shall be of a cylindrical type made of stainless steel, and shall be of a structure that rotates smoothly.

(b) The screen shaft shall be made of stainless steel and shall provide sufficient strength.

(4) Scraper

(a) The scraper shall be made of stainless steel, and it shall be capable of smoothly and efficiently scraping away impurities and scum attached to the screen.

(b) The blades of the scraper shall be made of a material grade that provides excellent durability and wear resistance.

2.02 Materials

(a) Casing : Rolled steel or Stainless steel

(b) Screen : Stainless steel or equivalent

(c) Scraper : Stainless steel or equivalent

2.03 Accessories (per Unit)

(a) Anchor bolts and nuts x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11221

Section 11222

Screen: Automatic Bar Screen

Part 1 - General

1.01 General

This equipment shall be composed of a main body frame, drive unit, rake, chain, shaft, sprocket and screen. It shall be used to block, continuously scrape, and discharge suspended solids in the influent sewage. The suspended solids shall be discharged into a container or conveyor.

1.02 Design Condition

(1) This equipment shall be designed with sufficient safety factor in strength.

(2) The standard speed of rake shall be approx. 2 - 3.6 m/min.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

(a) The reduction gear directly connected with motor shall be used for drive unit. Drive unit shall transmit the power by means of direct connection with shaft or gear chain.

(b) The reduction gear shall be installed at the external of frame cover.

(c) The drive steel roller chain shall be covered with a stainless steel cover. The cover shall be constructed such that it can be inspected and maintained easily.

(d) The sprocket wheel for the drive unit and the output shaft shall be made of cast iron.

(2) Frame

(a) The frame shall be made of rolled steel with epoxy coating or stainless steel. It shall be assembled sturdily by welding or with nuts and bolts. It shall be free from deviation or bending caused by welding.

(b) The guide rail for the chain, which attaches and transports the scraping rake, shall be installed on the side frame. The side frame shall be constructed such that it can scrape and discharge the screenings without blockage.

(c) The screw take up shall be installed at the upper portion of the frame, in order to stress the chain for scraping. The screw of screw take up shall be made of stainless steel.

(3) Cover, Chute and Apron

(a) The frame above the floor level shall be covered with a stainless steel cover to

prevent odour. A stainless steel plate shall be used for the cover.

(b) The cover shall be constructed such that it can be inspected and maintained easily. It shall be provided with front inspection door, etc. in order to carry-in and carry-out the rake or the chain for scraping. It shall have sufficient strength.

(c) A part of the cover shall be used as the chute. The chute shall be constructed such that the discharged screenings can be smoothly introduced into the container or conveyor.

(4) Chain for scraping, sprocket wheel

(a) The chain for scraping shall be bush roller sprocket chain, etc. The strength of chain shall be designed to safely endure unilateral loads. It shall be made of stainless steel.

(b) The sprocket wheel shall be made of wear resistance material such as stainless steel or the material equivalent or superior to cast iron. The material other than stainless steel shall be with induction hardening.

(c) The submergible bearing shall be with high wear resistance bush made of aluminium bronze or oil less bearing, etc. The submergible bearing shall be provided with sealing device to block surrounding sewage.

(5) Rake, Wiper

(a) The teeth which suit the spacing of bar screen shall be attached to the rake in order to scrape the screenings effectively. The rake shall be constructed such that it can drop the screenings completely with its reverse motion. The rake shall be shall be adjusted accurately.

(6) Screen

The vertical angle of the fine screen shall be 60 degrees.

2.02 Materials

(1) Frame : Rolled steel with epoxy coating or Stainless Steel

(2) Chain

(a) Roller chain for transmission of power: Stainless Steel

(b) Bushed roller chain for scraping: Special steel or Stainless steel

(3) Sprocket wheel

(a) For transmission of power : Carbon steel or Stainless steel casting or stainless steel

(b) For scraping: Stainless steel or Stainless steel casting or Stainless steel (with induction hardened tip)

(c) Shaft: Stainless steel

(d) Rake: Stainless steel

(e) Screen: Stainless steel

(f) Anchor bolt: Stainless steel

2.03 Protection Equipment

(1) Electrical protection

The over current detector with instantaneous element shall be provided in case the mechanical protection is not provided.

2.04 Accessories (per Unit)

(a) Anchor bolts and nuts x 1 set

(b) Cover against odour x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11222

Section 11223

Screen: Manually Operated Bar Screen

Part 1 - General

1.01 General

The screen shall be a bar screen of flat steel grid type and be installed to block refuse, garbage, fibres, sticks and other inclusions and coarse suspended substances.

1.02 Design Condition

(1) Strength calculations of the screen shall be conducted with consideration of the influent water flow, influent suspended solids and the difference of water level around the screen.

(2) For the strength of the screen, an adequate safety factor shall be taken.

Part 2 - Products

2.01 Fabrication

(1) The screen shall be constructed with flat steels. The steels, with spacers inserted to separate them at equal intervals, shall be tightened and assembled together by means of through-bolts, which have screws at both ends.

(2) The screen shall be mounted to the support shape steel by means of bolts. The support shape steel shall be fixed by means of anchor bolts at both ends to the water channel side wall.

2.02 Materials

(1) Screen: Rolled steel

(2) Other important portions in contact with water

(a) Spacer: stainless steel

(b) Pin, bolt, through-bolt, etc.: stainless steel

2.03 **Accessories** (per Unit)

(a) Anchor bolt x 1 set

(b) Rake for manual scraping x 1 set each

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11223

Section 11224

Screen: Wire Rope Driven Single Rake Type Screen

Part 1 - General

1.01 General

The wire rope driven single rake type screen shall consist of the frame, drive units, a rake wind-up system, a switching system, shafts and a fine screen. It shall be used for blocking suspended solids contained in the influent sewage water and scraping with the rake and carrying them out.

1.02 Design Conditions

(1) The strength of each portion of this screen shall have an adequate safety factor.

(2) Even if the strength of each portion of this screen is sufficient, it is necessary to consider the wall thickness of all portions that may be subject to corrosion and wear.

(3) The raking speed shall be about 6 m/min.

(4) The screen shall be constructed to have no problem of strength with respect to the influent flow of water, suspended solids, water level difference, etc.

Part 2 - Products

2.01 Fabrication

(1) Drive unit for winding and switching

(a) The drive unit shall use a motor-direct coupled cycle reducer or planetary gear reducer or worm gear reducer and the power transmission to the drive shaft shall be made using chains or gears. As the drive unit for switching, a power cylinder may be used.

(b) The gear as the power transmission gear shall be fabricated by precision machining and heat treated to endure wear sufficiently.

(c) The drive unit for winding shall be constructed not to be rotated reversely by the self-weight of the rake, etc. while not being operated.

(d) The winding drum shall be made of cast iron or steel.

(e) The shaft shall be a single-piece shaft having a sufficient strength and shall be sufficiently safe even when it receives both torsional and bending moments simultaneously.

(f) The bearing shall be constructed to be convenient for installation and repair and shall have a sufficient load capacity.

(g) The rope for raking and for switching shall be made of stainless steel. The rope diameter shall have an adequate allowance not to produce elongation due to the load.

(h) The motor for winding shall be a totally enclosed fan-cooled type and continuous rating provided with braking. In the case where the power cylinder is used as the drive unit for switching, the motor shall be a totally enclosed type and 30-minute rating provided with braking.

(i) For exposed rotating parts of the drive unit, a cover shall be provided, as necessary. In the case where a cover is provided for the motor portion in the outdoors, adequate care is needed for ventilation.

(2) Frame

(a) The frame shall be made of shape steel and steel plates. It shall be assembled firmly by welding and bolting and shall be constructed to be free from welding distortion, bending, etc.

(b) The frame shall support the drive unit for winding.

(c) The frame shall be provided with an apron to prevent screenings from falling between the top end of the screen and the chute. The thickness of the apron plate shall be sufficiently large to have an allowance for strength and corrosion.

(d) In order to check the drive unit provided on top of the frame, a ladder shall be provided.

(3) Chute

(a) The chute shall be constructed to discharge the screenings raked by the rake from the top end of the apron to the predetermined position without accumulation.

(b) Similarly to the case of the apron, the thickness of the chute plate shall be sufficiently large to have an allowance for strength and corrosion.

(4) Rake

(a) The rake shall consist of rake frame and rake plate and shall be constructed by welding of shape steel and steel plates.

(b) The rake shall be sturdy and constructed not to allow the screenings scraped to escape.

(5) Screen

(a) The screen shall be constructed with flat bars. The steels shall be removed of strains completely, then with spacers inserted to separate them at equal intervals, shall be tightened and assembled together by means of through-bolts which have screws at both ends.

(b) The screen shall be mounted to the support shape steel by means of bolts. The support shape steel shall be fixed by means of anchor bolts at both ends to the water channel side wall.

(6) Lubricating equipment

The lubricating system shall be a concentrated lubrication type, as a rule. Oil supply shall be made using a manual grease pump, and a necessary number of distribution valves shall be provided. In the case where a grease gun is used, the grease nipple shall be provided at a position easy to supply oil.

2.02 Materials

(a) Frame : Rolled steel

(b) Rope : Stainless steel

(c) Shaft : Carbon steel

(d) Rake : Rolled steel

(e) Screen : Rolled steel

2.03 Protection Equipment

(1) Mechanical protection equipment

Reducer built-in torque limiter for overload prevention

Limit switch for overwinding prevention

Limit switch for slack detection

(2) Electrical protection equipment

Overcurrent detector for overload prevention

2.04 Accessories

(a) Anchor bolt x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11224

Section 11225

Screen: Rotating Arm Single Rake Type

Part 1 - General

1.01 General

The Rotating Arm Single Rake Type shall consist of the main body frame, a drive unit, a rake, shafts, a screen, etc. It shall be used for blocking suspended substances contained in the influent sewage water and scraping with the single rake and carrying them onto the carry-out conveyor. This machine shall be constructed to have the drive unit and the rotating portion above the water surface.

1.02 Design Conditions

(1) The strength of each portion of this machine shall have an adequate safety factor.

(2) Even if the strength of each portion of this machine is sufficient, it is necessary to consider the wall thickness of all portions that may be subject to corrosion and weir.

(3) The screen shall be constructed to have no problem of strength with respect to the water level difference, influent suspended substances, influent water flow, etc.

(4) The raking speed shall be about 7.5 m/min maximum, as a rule.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

(a) The drive unit shall use a motor and a speed reducer, and the power transmission to the drive shaft shall be made using chains and gears or the rake shall be driven by direct coupling. If there is a possibility that the driving motor may be submerged, the submersible motor shall be used.

(b) The rake shall be moved up and down along roller guides.

(c) The motor shall be provided with brake.

(d) The inspection stand shall have a steel staircase and shall be constructed for easy climbing up and down. It shall be provided with steel handrails for safety.

(e) The inspection stand and the ladder treads shall be lined with checkered steel plate for floor.

(f) Around the rotating portion of the motor direct coupled speed reducer, a cover shall be provided as necessary.

(g) The main shaft shall have adequate strength and shall be sufficiently safe even when it receives both torsional and bending moments simultaneously.

(2) Frame

(a) The frame shall be made of shape steel and steel plates. It shall be assembled firmly by welding and bolting and shall be constructed to be free from welding distortion, bending, etc.

(b) The frame shall be provided with guide rails for the scraping rake. It shall be constructed and fabricated with adequate care for smooth scraping and discharging of screenings.

(c) The rake guide rail to be mounted to the frame shall have a groove in which the guide roller mounted to the rake moves rolling. It shall be installed on both side wall portions of the waterway.

(d) The rake guide shall be given adequate consideration to be free from attachment of screenings.

(3) Cover

(a) The upper portion of the frame shall be provided with a cover made of rolled steel.

(b) The cover shall be constructed for easy disassembly and reassembly, inspection, servicing, etc. and shall have adequate strength.

(4) Chute and apron

(a) The chute shall be constructed to discharge the screenings scraped by the rake from the top end of the apron to the predetermined position without accumulation.

(b) As to the chute and the apron, the thickness of the plate shall be sufficiently large to have an allowance for strength and corrosion.

(5) Rake

(a) At the end of the rake, claws shall be cut in conformity to the pitch of screen bars so that screenings may be scraped efficiently.

(b) The rake shall be specially sturdy and constructed not to allow the screenings scraped to escape.

(6) Screen

(a) The screen shall be constructed with flat bars. The steels shall be removed of strains completely, then with spacers inserted to separate them at equal intervals, shall be tightened and assembled together by means of through-bolts which have screws at both ends.

(b) The screen shall be mounted to the support shape steel by means of bolts. The support shape steel shall be fixed by means of anchor bolts at both ends to the water channel side wall.

(7) Lubricating equipment

The lubricating system shall be a concentrated lubrication type, as a rule. Oil supply shall be made using a manual grease pump, and a necessary number of distribution values shall be provided. In the case where a grease gun is used, the grease nipple shall be provided at a position easy to supply oil.

2.02 Materials

(a) Frame : Rolled steel

(b) Shaft : Carbon steel

(c) Rake : Rolled steel

(d) Roller : Cast iron or equivalent

(e) Screen : Rolled steel

2.03 Protection Equipment

(1) Electrical protection equipment

Overcurrent detector for overload prevention

(2) Mechanical protection equipment

Reducer built-in torque limiter for overload prevention

2.04 Accessories

(1) Anchor bolt x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11225

Section 11241

Grit Collector: Chain Drive V-Bucket Conveyor

Part 1 - General

1.01 General

The chain drive v-bucket conveyor shall consist of the main body frame, a drive unit, endless chains provided with v-buckets, shafts, sprockets, v-buckets and a washing system. It shall be used to scrape and carry the grit settled in the grit chamber continuously into the grit transportation container placed on the floor.

1.02 Design Conditions

(1) The strength of each portion of this conveyor shall have an adequate safety factor.

(2) Strength calculation of the chain shall be conducted on assumption that the total load is applied on one side.

(3) Even if the strength of each portion of this conveyor is sufficient, it is necessary to consider the wall thickness of all portions that are subject to corrosion and wear.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

(a) The drive unit shall use a motor-direct coupled cyclo reducer or planetary gear reducer and the power transmission to the drive shaft shall be made using steel roller chains.

(b) The reducer for the drive unit shall be placed outside the frame cover, and as necessary, check stands shall be provided around the reducer.

(c) A stainless steel plate cover shall be mounted to the reducer portion and exposed chain portions, and ventilation shall be considered.

(d) The sprocket on the output side of the drive unit shall be a product made by high precision machining and have high wear resistance.

(2) Frame

(a) The frame shall be made of shape steel and steel plates. It shall be assembled firmly by welding and bolting and shall be constructed to be free from welding distortion, bending, etc.

(b) The frame for the upper portion of the equipment shall be constructed by full consideration of the sand falling position, the overall strength and easiness of operation and maintenance.

(c) The frame for the upper portion of the equipment shall be provided with a steel plate cover.
(d) The check stand shall be constructed to have a steel ladder so that the person for checking can climb up and down easily and shall be provided with handrails for safety.

(e) The inside of the cover shall be free from grit adhesion.

(3) Chain and sprocket for raking

(a) The chain for raking shall be a bushed chain.

(b) The sprocket shall be made of a material with high wear resistance.

(c) Tensioning of the chain shall be done using a take-up.

(d) The number of submersible shafts to be mounted shall be three (3).

(4) V-bucket

(a) V-buckets for raking shall be mounted at approximately equal intervals along the entire length of the chain.

(b) The v-bucket shall be made of steel plates having a plate thickness with adequate allowance for wear and corrosion, and shall be constructed to be capable of efficient scraping and positive discharge of grit.

(c) The v-bucket, that is to travel on guide rails, shall be mounted with weir shoes to the portion that is to contact the rail.

(5) Chute

(a) The chute shall be provided inside the frame and shall be constructed to lead the grit into the transportation container without being spilled around while the v-bucket is in the raking, turning and discharging processes.

(b) The chute shall be made of steel plates, be provided with steel supports on the back surface, as necessary, to be free from distortion and shall be mounted firmly to the frame.

(c) The chute shall be mounted at an angle which shall be determined by careful consideration to prevent grit from accumulating inside the chute. The fall-out port shall comply with the grit transportation container.

(6) Guide rail

(a) The guide rail shall be provided on the bottom of the tank and on the inside wall of the tank.

(b) Any guide rail other than provided on the bottom of the tank shall have brackets provided on the inside wall of the tank, as necessary.

(7) Lubricating equipment

(a) For the bearing in each portion of the chain drive V-bucket conveyor, oil supply piping shall be provided.

(b) The lubricating system shall be a concentrated lubrication type, as a rule. Oil supply shall be made using a manual grease pump, and a necessary number of distribution valves shall be provided. In the case where a grease gun is used, the grease nipple shall be provided at a position easy to supply oil.

(8) V-bucket washing system

In order to discharge the scraped grit, etc. completely from the bucket, it shall be possible that the grit removal efficiency can be improved by washing the bucket by water spraying and also check and maintenance can be done positively.

2.02 Materials

(1) Frame : Rolled steel

(2) Chain

(a) Roller chain for power transmission : Special steel

(b) Bushed chain for scraping : Stainless steel

(3) Sprocket

(a) For power transmission : Carbon steel or cast iron

(b) For scraping : Stainless steel or cast iron

(4) Shaft : Carbon steel

(5) V-bucket : Rolled steel

2.03 Protection Equipment

(1) Electrical protection equipment

Overcurrent detector for overload prevention (electrical equipment work)

(2) Mechanical protection equipment

Speed reducer built-in torque limiter for overload prevention

2.04 Accessories

(a) V-bucket washing system x 1 set

(b) Anchor bolt x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11241

Section 11242

Grit Collector: Vortex Type

Part 1-General

1.01 General

The grit collector shall be complete with the following equipment, gear motor, gear head, air bell, propeller drive tube, etc., and shall be constructed taking the properties of the grit into consideration to scrape the grit satisfactorily.

1.02 Design Conditions

(1) This equipment shall be sufficiently safe with respect to the grit scraper load and the start-up load, shall be free from vibration, heat generation, abnormal noise, etc., and shall endure continuous operation.

(2) The various parts of the machine shall have adequate strengths and wall thickness to corrosion and wear.

Part 2-Products

2.01 Fabrication

(1) The grit collector which shall be used under water shall be made entirely of stainless steel which is corrosion resistant and wear resistant.

(2) The arrangement of grit collector size and shape shall be determined with adequate consideration to suit the shape of the grit chamber so that the grit collection may be done efficiently.

(3) This drive unit shall use a motor cyclo-reducer to transmit the power safely and positively.

2.02 Materials

(a)	Air bell	: Stainless steel
(b)	Drive Tube	: Stainless steel
(c)	Paddle and Paddle Hub	: Stainless steel
(d)	Foundation bolt and nut	: Stainless steel

2.03 Protection Equipment

(1) Mechanical protection equipment

Protection equipment for overload protection

(2) Electrical protection equipment
Over-current detector for overload protection (electrical equipment work)

2.04 Accessories

Anchor bolt 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11242

Section 11270

Grinder: In-pipeline Type

Part 1 - General

1.01 General

This grinder shall be composed of a casing, shafts, a commuting portion, a drive unit, etc. and shall be installed in the influent water channel or sludge piping to crush and finely cut the inclusions contained in the influent sewage.

1.02 Design Condition

(1) This machine shall crush and finely cut the inclusions contained in the sewage to those sizes which do not interfere with the operation of the sewage pump.

(2) The commuting portion shall be made of materials and in the construction to be less worn and endure a long time of use.

(3) For the strength of various portions, a sufficient safety factor shall be taken.

Part 2 - Products

2.01 Fabrication

(1) This machine shall be constructed so that the 2-shaft type rotary cutting portion is driven through a vertical motor direct-coupled type speed reducer.

(2) The casing shall be a cast iron product of good quality considering mechanical strength as well as corrosion and abrasion resistance.

(3) The cutting portion shall be made of special steel having excellent wear resistance and be constructed to permit easy replacement.

2.02 Materials

(a)	Casing	: Cast iron
(b)	Cutting portion	: Abrasion resistant material
(c)	Shaft	: Carbon steel or chromium-molybdenum steel or equivalent

2.03 Protection Equipment

(1) Electrical protection

(a) The over current detector shall be provided against overload. (Instantaneous function type)

(b) The reversible rotation shall be equipped for discharging in overload.

2.04 Accessories (per Unit)

(a) Foundation bolts and nuts x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11270

Section 11320

Air Compressor: Pressure-switch Type

Part 1 - General

1.01 General

This air compressor shall be provided with an air tank and used for air-operated valve, etc.

1.02 Design Condition

(1) The maximum pressure shall be 0.69 to 0.93 MPa. The control differential pressure shall be 0.15 MPa min. As a rule, the air compressor shall be a no-oil supply type.

Part 2 - Products

2.01 Fabrication

(1) The air compressor shall be a reciprocating type as a rule, and shall be driven by the crank shaft by motor direct-coupling or through V-belts and V-pulleys from the motor. In the case of the belt drive, front and back sides of the pulley shall be covered with a metal cover.

(2) The air tank shall be a horizontal cylindrical type and shall be provided with air inlet/outlet pipe mounting seats, pressure gauge mounting seats, drain pipe mounting seats, and other necessary apparatus.

2.02 Materials

(a) Air tank : Rolled steel

2.03 Protection Equipment

Safety valve and unloading device or pressure switch type

2.04 Accessories (per Unit)

(a) Unloading device or pressure switch x 1 set

(b) Suction silencer (with filter) x 1 set

(c) V-belt and V-pulley and their covers (belt-drive only) x 1 set

(d) Air tank x 1 set

(e) Pressure gauge x 1 set

(f) Safety valve x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11320

Section 11321

Air Dryer: Refrigerating Type

Part 1 - General

1.01 General

To obtain dry air, an air dryer shall be provided to remove humidity in the compressed air from the air compressor.

1.02 Design Condition

The air dryer shall have high efficiency for dehumidification, and shall be sturdily constructed to endure continuous operation.

Part 2 - Products

2.01 Fabrication

(1) The air dryer shall be of the refrigeration type.

(2) The air dryer shall be provided with mounting seats for air inlet and outlet pipes, pressure gauge, temperature meter, automatic drain trap and other required devices.

(3) The protection device shall be provided to keep the constant dew point even with variations in the compressed air volume.

(4) Air refrigeration shall be by direct refrigeration method.

(5) In principle, refrigeration of the refrigerant shall be adopted as the air cooling method. However, a water cooling method can be adopted for large-scale refrigeration.

(6) The motor shall be a totally enclosed fan-cooled type and of continuous rating.

2.02 Materials

(a) Shell of heat exchanger : Stainless steel

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11321

Section 11330

Clarifier: Center Driven Type

Part 1 - General

1.01 General

Clarifier shall be composed of drive unit, main shaft, feed well, steel bridge rake, scum skimmer, etc. The turning force shall be given from the drive unit through the main shaft to the rake arm so that the sludge on the clarifier bottom may be scraped by means of the rake mounted to the rake arm continuously to the sludge pit provided at the center of the clarifier. The scum generated on the water surface of the clarifier shall be collected by the scum blade mounted to the skimmer arm into the pipe skimmer for scum removal. In the center-driven suspension construction, the drive unit shall be installed on the bridge, and the main shaft and the rake arm shall be suspended from the bridge.

1.02 Design Conditions

(1) This equipment shall be safe sufficiently to the scraper load and startup time load, be free from vibration, heating, abnormal sound, etc. during operation, and shall withstand continuous operation.

(2) Each portion of the equipment shall have ample strength and wall thickness to corrosion and abrasion.

(3) The peripheral speed shall be about 2 to 3 m/min.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

(a) This unit shall be composed of motor, cycloidal reduction gear or planetary reduction gear or gear and chain, etc. and transmit the power safely and positively. The speed shall be reduced to the predetermined scraping speed. The main shaft shall be turned through coupling and bearing stand.

(b) The bearing shall be able to support the load of the scraper main body and the vibration due to turning sufficiently.

(c) The cover for the exposed chain shall be made of rolled steel plat with epoxy coating or stainless steel plate.

(2) Steel bridge

(a) The bridge shall be a welded structure and be provided with main beam, auxiliary beam, etc. It shall be sturdy.

(b) The walkway on the bridge surface shall be not less than 900mm in width. Around the central driving portion, an ample space for check, repair, etc. shall be provided and lined with checkered steel plates. For important portions, a check cover shall be provided and on both sides of the bridge, handrails shall be provided.

(3) Rake and rake arm

(a) The rake shall be mounted firmly to the rake arm. Rakes shall be overlapped each other not to leave areas where the sludge is not scraped.

(b) Under the rake, a replaceable adjusting blade shall be mounted and the clearance to the clarifier bottom shall be adjustable.

(c) The rake arm shall have two blades (auxiliary blades may be provided). It shall be constructed by steel material and shall have adequate strength to bending loads, etc.

(d) The clearance to the rake clarifier bottom surface shall be not more than about 50 mm at the mid point of the blade and rubber shall be mounted to the blade end.

(4) Feed well

(a) The feed well shall be mounted firmly to the clarifier wall by means of supports. It shall reduce the flow speed promptly and have large effect of straightening.

(b) The feed well shall be made of rolled steel with epoxy coating or stainless steel.

(c) Slots shall be cut at liquid level to permit escape of floating material. Slots shall be made with a baffle to prevent short circuiting.

(5) Main shaft and bearing

(a) The main shaft shall be suspended from the bearing stand and have a sufficient allowance for torsional loads. The bearing shall be a rolling bearing constructed to support thrust loads.

(6) Scum skimmer

(a) The skimmer arm shall be mounted firmly to the main shaft, and the scum blade shall pass above the pipe shimmer.

(b) The scum blade shall be of movable type and scum discharge to the pipe skimmer shall be smooth.

(c) The baffle plate shall be constructed to be suited to prevent scum from flowing out.

(d) The scum blade shall be constructed for efficient collection of scum considering undercurrents, etc.

(e) The pipe skimmer shall be of the manually operated slot type. For the details, refer to “Section11620 Oil Removal Equipment: Oil Skimmer”.

(7) Oil supply equipment

(a) The drive unit shall be constructed for easy oil supply and check.

(b) A grease nipple shall be provided at a position of easy oil supply.

(8) The motor specifications shall be outdoor totally-enclosed fan-cooled type and continuous rating.

2.02 Materials

(a)	Blade	: Rolled steel or equivalent
(b)	Submerged bolt and nut	: Stainless steel
(c)	Rake and rake arm	: Rolled steel
(d)	Main shaft	: Carbon steel pipe
(e)	Feed well	: Rolled steel with epoxy coating or stainless steel
(f)	Feed well support	: Rolled steel
(g)	Bridge	: Rolled steel
(h)	Handrail	: Steel pipe
(j)	Skimmer arm	: Rolled steel
(k)	Scum blade	: Rolled steel or equivalent
(l)	Baffle plate	: Rolled steel or equivalent
(m)	Bracket for baffle plate	: Rolled steel or equivalent

2.03 Protection Equipment

(1) Mechanical protection equipment

Protection equipment for overload protection

(2) Electrical protection equipment

Overcurrent detector for overload protection
(electrical equipment work)

2.04 Accessories

(a)	Anchor bolt	x 1 set
(b)	Drive unit and chain cover	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11330

Section 11331

Sludge Clarifier: Chain Flight Type

Part 1 - General

1.01 General

The sludge collector shall be a chain flight type and be installed for the purpose of scraping the settled sludge into the hopper provided by the side of the tank.
The sludge collector shall be constructed with endless chains having flights mounted at definite intervals. The endless chain shall be driven through sprockets on the drive shaft and idle shaft to move the flights along the rail surfaces on the tank bottom so that the sludge may be scraped into the sludge hopper.
In this construction, the scum generated on the water surface in the clarifier is scraped from the return side of the sludge collector so that it may flow into the scum skimmer.

1.02 Design Conditions

(1) Collector chain

(a) Type : Synthetic resin chain

(b) Pitch : About 150 to 200 mm

(c) Rupture strength : Guaranteed minimum :15 kN
: Average :20 kN

(2) Sprockets

(a) Pitch : About 150 to 200 mm

(3) Scraping speed

(a) Primary clarifier : About 0.6 m/min

(b) Secondary clarifier : About 0.3 m/min

(4) Collector flight mounting pitch : About 3 m

Part 2 - Products

2.01 Fabrication

(1) Drive unit

The drive unit shall be a horizontal cycloidal reduction gear or planetary reduction gear. Power shall be transmitted by chain transmission system and the speed shall be reduced to the predetermined sludge scraping speed. The transmission chain shall be arranged on the sprockets with the return side up, as a rule.
The drive chain which will be submerged in water shall be a stainless steel bushed chain or synthetic resin chain. Or, a chain tightener shall be provided, as necessary.

(2) Collector chain

The chain shall be a synthetic resin chain with high wear resistance and corrosion resistance. It shall be constructed easy to disassemble and adjustable in chain elongation.

(3) Sprockets

(a) For the sprockets for the drive chain, a special pin type wheel, shall be used considering wear.

(b) For the sprockets for the collector chain, a special pin type wheel, shall be used for the drive shaft considering abrasion, and a synthetic resin sheave type wheel with no tooth for the idle shaft.

(4) Collector flights

(a) Collector flight material shall be synthetic resin (fibre reinforced plastic, FRP).

(b) For each tank, rubber plates to scrape the sludge to the tank bottom surface shall be mounted at ends of two collector flights.

(c) Regarding wear shoes, adequate consideration shall be given to their mounting intervals, etc. and an adequate allowance for wear shall be provided, so that the collector flights may not contact the concrete wall, bearing stand, rail holder, etc. and the collector flight strength may not be damaged.

(5) Shaft

The mid portion of the drive shaft shall be made of stainless steel pipe. The idle shaft shall be made of stainless steel pipe and be a cantilever type shaft.

(6) Bearing

The bearing for drive shaft shall be made of synthetic resin.

(7) Adjustment of chain elongation

Adjustment of chain elongation shall be made by pulling off chain links, as a rule. The chain shall be installed such that the sludge may be scraped up to the end portion of the tank.

(8) Bottom rails

On the bottom surface of the tank, bottom rails (made of synthetic resin) to guide the collector flights shall be mounted.

(9) Guide rails

Return rails shall be mounted on the side-walls when returning after scraping. They shall be somewhat adjustable and have adequate strength. If there is a possibility of abnormal vibration, or the collector flight contacting the beam, scum skimmer, etc. and being broken, guide rails, etc. shall be provided even over the collector flights.

(10) Lubricating equipment

No oil supply type.

2.02 Materials

(1) Collector chain

(a) Chain main body : Synthetic resin

(b) Pin : Synthetic resin

(2) Shaft

(a) Drive shaft : Stainless steel

(b) Idle shaft : Stainless steel

(3) Bearing

(a) Drive shaft bearing : Synthetic resin

(4) Sprockets

(a) For drive chain : Stainless steel + synthetic resin

(b) For collector chain for drive shaft : Stainless steel + synthetic resin

(c) For collector chain for idle shaft : Synthetic resin

(5) Collector flights : Fibber reinforced plastic (FRP)

(6) Guide rails : Stainless steel

(7) Bottom rails : Synthetic resin or stainless steel

(8) Guide rail bracket : Rolled steel

(9) Wear shoes : Synthetic resin

(10) Anchor bolt and nut : Stainless steel

2.03 Protection Equipment

(1) Electrical protection equipment

Overcurrent detector for overload protection (electrical works)

(2) Mechanical protection equipment

Speed reducer built-in torque limiter for overload protection

2.04 Accessories

(a) Steel plate common base x 1 set

(b) Drive unit and chain cover x 1 set

(c) Mounting bolt and nut x 1 set

(d) Anchor bolt and nut x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11331

Section 11332

Sludge Clarifier: Chain Flight Sludge Collector

Part 1 - General

1.01 General

The chain flight sludge collector shall be a chain flight type and be installed for the purpose of scraping the settled sludge into the hopper provided in the grit chamber.
This collector shall be constructed with endless chains having flights mounted at definite intervals. The endless chain shall be driven through sprockets on the drive shaft and idle shaft to move the flights along the rail surfaces on the tank bottom so that the sludge may be scraped into the sludge hopper.
This collector shall be constructed such that the oil generated on the water surface in the grit chamber is scraped on the return side of the sludge collector and flows into the oil skimmer.

1.02 Design Conditions

(1) Collector chain

(a)	Type	:	Stainless steel bushed chain
(b)	Pitch	:	About 1520 mm
(c)	Attachment	:	For flight mounting

(2) Take-up

(a)	Adjustment	:	About 300 mm

(3) Scraping speed : About 0.6 m/min

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) Drive unit

The drive unit shall be a horizontal cycloidal reduction gear or planetary reduction gear. Power shall be transmitted by chain transmission system and the speed shall be reduced to the predetermined sludge scraping speed. The transmission chain shall be arranged on the sprockets with the return side up, as a rule. The drive chain which will be submerged in water shall be a stainless steel bushed chain. The cover for drive unit reducer and exposed chain portions shall be provided.

(2) Collector chain

The chain shall be a stainless steel bushed chain with high wear resistance and corrosion resistance. It shall have adequate strength and hardness.

(3) Sprockets

For the sprockets, a material with high wear resistance and corrosion resistance shall be used.

(4) Collector flights

(a) Collector flight shall be 150 mm wide and 60 mm thick, as standard. It shall be mounted with wear shoes with high wear resistance.

(b) Regarding wear shoes, adequate consideration shall be given to their mounting intervals, etc. and an adequate allowance for wear shall be provided, so that the collector flights may not contact the concrete wall, bearing stand, rail holder, etc. and the collector flight strength may not be damaged.

(5) Shaft

The drive shaft, the idle shaft, the take-up shaft, etc. shall have shaft diameters with adequate strength.

(6) Take-up

To allow adjustment of chain elongation and also to facilitate installation and adjustment of this machine, take-up shall be provided.

(7) Bottom rails

On the bottom surface of the tank, rails (15kg/m) to guide the collector flights shall be mounted.

(8) Guide rails

Return guide rails shall be mounted from the side wall. They shall be somewhat adjustable and have adequate strength.

(9) Lubricating equipment

The lubrication system shall be a concentrated lubrication type, as a rule. Oil supply shall be made using a manual grease pump, and a necessary number of distribution valves shall be provided. In the case where a grease gun is used, the grease nipple shall be provided at a portion easy to supply oil.

(10) The motor specifications shall be totally enclosed fan-cooled type and continuous rating.

2.02 Materials

Materials shall be as follows

(a) Collector chain : Stainless steel

(b) Shaft

- Drive shaft : Carbon steel

- Idle shaft and take-up shaft : Carbon steel

(c) Bearing : Cast iron

(d) Guide rail : Rolled steel

(e) Bottom rail : Rolled steel

2.03 Protection Equipment

(1) Mechanical protection equipment

Speed reducer built-in torque limiter for overload prevention

(2) Electrical protection equipment

Overcurrent detector for overload prevention (electrical equipment work)

2.04 Accessories

(a) Steel plate common base x 1 set

(b) Lubricating equipment x 1 set

(c) Chain cover x 1 set

(d) Mounting bolt and nut x 1 set

(e) Guide rail mounting bolt and nut x 1 set

(f) Anchor bolt and nut x 1 set

Part 3 – Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11332

Section 11333

Sludge Scraper: Centre Driven Column Type

Part 1-General

1.01 General

The sludge scraper to be used for a basin having a basin diameter in excess of 15m shall consist of a drive unit, a feed well, a steel bridge, a turning stand, rakes, a scum skimmer, etc. From the drive unit located at the centre, the driving torque shall be given to the rake arm mounted to the centre cage, so that the sludge on the basin bottom may be scraped by means of rakes mount to the rake arm continuously into the sludge pit provided at the centre of the basin. The scum produced on the water surface of the sedimentation basin shall be collected by means of scum blades mounted to the skimmer arm into the pipe skimmer, from which the sludge shall be discharged.

This sludge scraper shall be constructed as the centre-driven column type having the drive unit installed on the bridge.

1.02 Design Conditions

(1) This machine shall be sufficiently safe with respect to the sludge scraper load and the start-up load, shall be free from vibration, heat generation, abnormal noise, etc., and shall endure continuous operation.

(2) The various parts of the machine shall have adequate strengths and wall thickness to corrosion and wear.

(3) The peripheral speed shall be about 2 to 3 m/min.

Part 2-Products

2.01 Fabrication

(1) Drive unit

(a) This unit shall use a motor cyclo-reducer or planetary gear reducer or gears, chains, etc. to transmit the power safely and positively.

(b) The worm gear, the internal gear and the pinion shall be contained all in a casing.

(c) The internal gear, the turning stand, the cage, etc. shall be constructed to be easy to maintain and check.

(d) The cover for exposed chain portions shall be made of steel plates.

(2) Steel bridge

(a) The bridge shall be constructed by welding and shall be strong provided with main beams and auxiliary beams.

(b) The checking platform on the top surface of the bridge shall have a width not less than 900mm, shall have an ample space necessary for check, repair, etc. around the centre driving portion, and shall be lined with checkered plates. In essential portions, a checking cover shall be provided and on both sides of the bridge, hand rails shall be provided.

(3) Rake and rake arm

(a) The rake shall be mounted firmly to the rake arm, and rakes shall be overlapped with each other so that no unscraped area may remain.

(b) At the bottom of the rake, replaceable adjusting blades shall be mounted so that the clearance to the basin bottom may be adjusted. At the end of the blade, a rubber plate shall be mounted so that no unscraped sludge may remain on the basin bottom.

(c) The rake arm shall be of two-plate structure (auxiliary plates may be provided). It shall be constructed as a truss structure using steel materials, and shall have a sufficient strength to bending loads, etc.

(d) The clearance between the blade and the basin bottom shall be about 50 mm maximum at the central portion of the blade, and at the end of the blade, a rubber shall be mounted.

(4) Feed well

(a) The feed well shall be mounted firmly to the centre cage. It shall promptly reduce the stream speed and shall have a large stream rectifying effect.

(b) The feed well shall be made of rolled steel.

(c) A baffle-provided small window shall be provided to the feed well and the scum in the feed well shall be able to be removed through this window.

(5) Centre cage

(a) The centre cage shall hold the rake arm firmly

(b) The centre cage shall be made of steel materials or the like, shall be assembled as a truss structure which shall be sufficiently strong to torsional stress, etc.

(6) Scum skimmer

(a) The skimmer arm shall be mounted firmly to the centre cage or the rake arm, and the scum blade shall pass over or under the pipe shimmer.

(b) The scum blade shall be of movable type and shall be able to discharge the scum into the pipe skimmer smoothly.

(c) The baffle plate shall be constructed to be suited to prevent scum flow-out and shall be installed firmly by means of the support.

(d) The scum blade shall be constructed with consideration about undercurrents, etc. to be able to collect scum efficiently.

(e) The pipe skimmer shall be of the manually type.

(7) Oil supply equipment

(a) The drive unit shall be constructed for easy oil supply and check.

(b) The oil supply system shall be of centralized oiling type, in principle. A required number of distribution valves shall be provided. If a grease gun is to be used, grease nipples shall be provided at positions easy to oil supply.

(8) The motor specifications shall be totally-enclosed fan-cooled type and continuous rating.

2.02 Materials

(a) Blade	: Rolled steel or equivalent
(b) Submerged portion bolt and nut	; Stainless steel
(c) Rake and rake arm	: Rolled steel
(d) Centre cage	: Rolled steel
(e) Field well	: Rolled steel with epoxy coating or stainless steel
(f) Bridge	: Rolled steel
(g) Handrail	: Steel pipe
(h) Skimmer arm	: Rolled steel or equivalent
(i) Scum blade	: Rolled steel or equivalent
(j) Baffle plate	: Rolled steel or equivalent
(k) Baffle plate bracket	: Rolled steel or equivalent

2.03 Protection Equipment

(1) Mechanical protection equipment

Protection equipment for overload protection

(2) Electrical protection equipment

Over-current detector for overload protection (electrical equipment work)

2.04 Accessories

(a) Anchor bolt	1 set
(b) Safety cover	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11333

Section 11333

Sludge Scraper: Centre Driven Column Type

Part 1-General

1.01 General

The sludge scraper to be used for a basin having a basin diameter in excess of 15m shall consist of a drive unit, a feed well, a steel bridge, a turning stand, rakes, a scum skimmer, etc. From the drive unit located at the centre, the driving torque shall be given to the rake arm mounted to the centre cage, so that the sludge on the basin bottom may be scraped by means of rakes mount to the rake arm continuously into the sludge pit provided at the centre of the basin. The scum produced on the water surface of the sedimentation basin shall be collected by means of scum blades mounted to the skimmer arm into the pipe skimmer, from which the sludge shall be discharged.

This sludge scraper shall be constructed as the centre-driven column type having the drive unit installed on the bridge.

1.02 Design Conditions

(1) This machine shall be sufficiently safe with respect to the sludge scraper load and the start-up load, shall be free from vibration, heat generation, abnormal noise, etc., and shall endure continuous operation.

(2) The various parts of the machine shall have adequate strengths and wall thickness to corrosion and wear.

(3) The peripheral speed shall be about 2 to 3 m/min.

Part 2-Products

2.01 Fabrication

(1) Drive unit

(a) This unit shall use a motor cyclo-reducer or planetary gear reducer or gears, chains, etc. to transmit the power safely and positively.

(b) The worm gear, the internal gear and the pinion shall be contained all in a casing.

(c) The internal gear, the turning stand, the cage, etc. shall be constructed to be easy to maintain and check.

(d) The cover for exposed chain portions shall be made of steel plates.

(2) Steel bridge

(a) The bridge shall be constructed by welding and shall be strong provided with main beams and auxiliary beams.

(b) The checking platform on the top surface of the bridge shall have a width not less than 900mm, shall have an ample space necessary for check, repair, etc. around the centre driving portion, and shall be lined with checkered plates. In essential portions, a checking cover shall be provided and on both sides of the bridge, hand rails shall be provided.

(3) Rake and rake arm

(a) The rake shall be mounted firmly to the rake arm, and rakes shall be overlapped with each other so that no unscraped area may remain.

(b) At the bottom of the rake, replaceable adjusting blades shall be mounted so that the clearance to the basin bottom may be adjusted. At the end of the blade, a rubber plate shall be mounted so that no unscraped sludge may remain on the basin bottom.

(c) The rake arm shall be of two-plate structure (auxiliary plates may be provided). It shall be constructed as a truss structure using steel materials, and shall have a sufficient strength to bending loads, etc.

(d) The clearance between the blade and the basin bottom shall be about 50 mm maximum at the central portion of the blade, and at the end of the blade, a rubber shall be mounted.

(4) Feed well

(a) The feed well shall be mounted firmly to the centre cage. It shall promptly reduce the stream speed and shall have a large stream rectifying effect.

(b) The feed well shall be made of rolled steel.

(c) A baffle-provided small window shall be provided to the feed well and the scum in the feed well shall be able to be removed through this window.

(5) Centre cage

(a) The centre cage shall hold the rake arm firmly

(b) The centre cage shall be made of steel materials or the like, shall be assembled as a truss structure which shall be sufficiently strong to torsional stress, etc.

(6) Scum skimmer

(a) The skimmer arm shall be mounted firmly to the centre cage or the rake arm, and the scum blade shall pass over or under the pipe shimmer.

(b) The scum blade shall be of movable type and shall be able to discharge the scum into the pipe skimmer smoothly.

(c) The baffle plate shall be constructed to be suited to prevent scum flow-out and shall be installed firmly by means of the support.

(d) The scum blade shall be constructed with consideration about undercurrents, etc. to be able to collect scum efficiently.

(e) The pipe skimmer shall be of the manually type.

(7) Oil supply equipment

(a) The drive unit shall be constructed for easy oil supply and check.

(b) The oil supply system shall be of centralized oiling type, in principle. A required number of distribution valves shall be provided. If a grease gun is to be used, grease nipples shall be provided at positions easy to oil supply.

(8) The motor specifications shall be totally-enclosed fan-cooled type and continuous rating.

2.02 Materials

(a) Blade	: Rolled steel or equivalent
(b) Submerged portion bolt and nut	; Stainless steel
(c) Rake and rake arm	: Rolled steel
(d) Centre cage	: Rolled steel
(e) Field well	: Rolled steel with epoxy coating or stainless steel
(f) Bridge	: Rolled steel
(g) Handrail	: Steel pipe
(h) Skimmer arm	: Rolled steel or equivalent
(i) Scum blade	: Rolled steel or equivalent
(j) Baffle plate	: Rolled steel or equivalent
(k) Baffle plate bracket	: Rolled steel or equivalent

2.03 Protection Equipment

(1) Mechanical protection equipment

Protection equipment for overload protection

(2) Electrical protection equipment

Over-current detector for overload protection (electrical equipment work)

2.04 Accessories

(a) Anchor bolt	1 set
(b) Safety cover	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11333

Section 11350

Scum Skimmer: Linked Type Scum Skimmer

Part 1 - General

1.01 General

The linked type scum skimmer shall be installed in front of the overflow weir of the clarifier where the chain flight sludge collector is installed. It shall be constructed to discharge the scum produced on the water surface by making use of the traveling of the flight of the sludge collector.
This skimmer shall consist of a weir, a discharge way, driving and operating arm, bearings, etc.

1.02 Design Conditions

(1) This skimmer shall be designed with consideration to ensure that no trouble to the traveling of the sludge collector flight is produced.

(2) This skimmer shall be constructed to permit even discharging the scum manually.

(3) The weir float shall be constructed to move following the water level and allow the scum to be discharged always at a constant rate.

(4) This skimmer shall be constructed such that the scum may be allowed to flow out and stop.

Part 2 - Products

2.01 Fabrication

(1) Discharge way

(a) The discharge way shall be constructed as a trough type or pipe type and allow the scum to be discharged smoothly.

(2) Weir or skimming pipe

(a) The working portion of the weir or skimming pipe shall be constructed such that the weir or skimming pipe may be operated by a link mechanism so as to take in the scum in front of it.

(3) Driving and operating arms

(a) The scum skimmer shall be constructed to allow the driving number of times to be changed to increase or decrease by changing the number of strikers or rollers to be mounted to the flight according to the observed value of scum generation rate.

(b) The arm supporting bearing shall be of no-oil supply type.

2.02 Materials

(a)	Weir float	: Stainless steel
(b)	Discharge trough or skimming pipe	: Stainless steel
(c)	Driving and operating arm	: Stainless steel
(d)	Shaft	: Stainless steel
(d)	Bolt and nut	: Stainless steel

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11350

Section 11360

Aerator: Submersible Aerator

Part 1-General

1.01 General

The submersible aerator shall be installed on the bottom of the reaction tank for the purpose of aeration or agitation. It shall have two functions. One of them is to effectively convert into fine particles the air supplied from a blower by the agitation capability of the equipment so that the oxygen may be dissolved into the liquid to remove sewage components such as BOD, SS, etc. The other is to secure the flow velocity necessary for the mixing of sewage water and activated sludge. This aerator shall hold stable agitation or aeration effects for a long time and be constructed to be suited for maintenance.
This equipment shall consist of a drive unit, an impeller, a casing and others.

1.02 Design Conditions

(1) This aerator shall be capable of giving a necessary flow velocity and oxygen efficiently to the mixed liquor in the reaction tank by rotating the impeller.

(2) This aerator shall be constructed to be easy to operate and maintain and free from vibration and abnormal noise and to endure continuous operation for a long time.

(3) This aerator shall have the following performance.

(a) Aeration efficiency 1.5 kg-O_2/kWh min.

(b) Bottom flow velocity 0.1 m/s min.

(4) This aerator shall be serviceable for both functions of oxygen dissolution and agitation. It shall be free from clogging and be capable of anaerobic agitation and aerobic agitation.

Part 2-Products

2.01 Fabrication

This aerator shall consist mainly of a drive unit, an impeller, a casing, etc.

Construction of these components shall be as follows.

(1) Drive unit

(a) The drive unit shall consist of a submersible motor and a speed reducer and shall be constructed to be sufficiently endurable to continuous operation under the conditions of water pressure, sewage, etc.

(b) The sealing mechanism of double mechanical seal or seal set system shall be used, and irrespective of the machine in operation or at stop, it shall prevent ingress of foreign substances.

(2) Impeller

(a) The impeller shall be an axial flow type, sturdy product of good quality. It shall be well balanced and the surface finished smooth.

(b) The impeller shall be shaped to prevent adhesion of suspended substances, inclusions, etc. contained in the wastewater.

(c) The impeller shall have a highly efficient shape for maintaining the required agitation force and dispersing air bubbles over a wide range.

(3) Casing

(a) The casing shall be a product of good quality cast iron considering mechanical strength against internal pressure, vibration, etc. and corrosion and wear.

(b) The casing shall be constructed to be easy to disassemble and reassemble.

(c) Air supply to the inside of the casing shall be done through an air supply pipe (stainless steel pipe) also serviceable as a guide, or a flexible hose (heat resisting).

2.02 Materials

Materials shall be as follows.

(a) Impeller : Stainless steel

(b) Casing : Cast iron

(c) Shaft : Stainless steel, or chromium-molybdenum steel with stainless steel sleeve

(d)Lifting metal and chain : Stainless steel or cast iron

2.03 Protection Equipment

This aerator shall be provided with a temperature detector to detect abnormal temperatures of the motor and a submersion detector to detect submersion and shall be constructed to be capable of failure display.

2.04 Accessories

(a) Submersible cable(including terminal box) x 1 set

(b) Lifting metal and chain x 1 set

(c) Cable and chain support metal x 1 set

(d) Guide pipe or flexible hose x 1 set

(e) Foundation bolt and nut (for guide pipe) x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11360

Section 11370

Aeration Equipment: Air Diffuser（Panel type）

Part 1-General

1.01 General

This equipment shall have optimum functions to dissolve oxygen contained in air efficiently into the sewage in order for the effective removal of BOD, SS, etc. based on the oxidation ditch process. It shall be constructed to retain the stable diffusion effect for a long time and to be suited for easy maintenance.

1.02 Design Conditions

The diffuser shall be constructed with special polyurethane of panel type. It shall generate fine air bubbles from the pores having a high efficiency of oxygen dissolution. Also it shall have excellent shock resistance and durability and maintain the stable aeration performance for a long time.

Diffuser membrane shall be a type to prevent reverse flow of liquid to inside the membrane when aeration ceases.

Specification and design conditions

(a)	Application	: Aeration for sewage treatment
(b)	Gas-handled	: Air
(c)	Air pressure	: 69 kPa (7000 mmAq)
(d)	Diffuser specifications	
	Size	: L 3.5m x W 0.15m /panel
	Air flow quantity	: 30 to 60m^3/m^2-panel/h
	Oxygen dissolution efficiency	: 20 to 40％（Effective water depth 4.0 to 6.0m）
	Moisture ventilation resistance	: 9.0 to 11.0 kPa (20℃,65%RH)
	Pore diameter	: Applox.1,000μm（Diameter average）
(e)	Operation	: intermittent aeration

Part 2-Products

2.01 Fabrication

(1) Diffuser tube holder

The diffuser holder shall be made of stainless steel or synthetic resin. The diffusion holder shall be installed with adequate care about levelness so that the diffuser centreline may be set at the same water level.

(2) The riser pipe shall be a stainless steel pipe.

For the stabilization of the aeration tank diffuser, the header pipe and the diffuser tube holder shall be provided with stainless steel legs.

(3) The main valve for riser pipe shall be a butterfly valve (important portions made of stainless steel). The valve opening degree shall be adjusted in notch type (stepwise). The handle of the valve shall be constructed to be easily operated from the slab.

(4) The header pipe shall have an exhaust pipe and the valve which can drain out the condensation water easily.

2.02 Materials

(a) Diffuser : Special polyurethane
(b) Diffuser holder : Stainless steel
(c) Header pipe and riser pipe : Galvanized steel pipe
(d) Support frame : Mailed steel

2.03 Accessories (per Unit)

(a)	Frame	1 set
(b)	Mounting bolt and nut	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11370

Section 11371

Aeration Equipment: Air Diffuser（Disc type）

Part 1-General

1.01 General

This equipment shall have optimum functions to dissolve oxygen contained in air efficiently into the sewage in order for the effective removal of BOD, SS, etc. based on the oxidation ditch process. It shall be constructed to retain the stable diffusion effect for a long time and to be suited for easy maintenance.

1.02 Design Conditions

The diffuser shall be constructed with membrane rubber of disc type. It shall generate fine air bubbles from the pores having a high efficiency of oxygen dissolution. Also it shall have excellent shock resistance and durability and maintain the stable aeration performance for a long time.

Diffuser disc shall be a type to prevent reverse flow of liquid to inside the disc when aeration ceases.

(1) Specification and design conditions

(a)	Application	: Aeration for sewage treatment
(b)	Gas-handled	: Air
(c)	Air pressure	: 69 kPa (7000 mmAq)
(d)	Diffuser specifications	
	Diameter	: Applox. 300 mm
	Air flow quantity	: 5 to 7m^3/ h/piece
	Oxygen dissolution efficiency	: 20 to 40％（Effective water depth 4.0 to 6.0m）
	Moisture ventilation resistance	: Applox. 4.0 kPa (20℃,65%RH)
	Slit length	: Applox. 500 μ m
(e)	Operation	: intermittent aeration

Part 2-Products

2.01 Fabrication

(1) Diffuser holder
The diffuser holder shall be made of synthetic resin. The diffusion holder shall be installed with adequate care about levelness so that the diffuser centre line may be set at the same water level.

(2) The header pipe shall be a stainless steel pipe. For the stabilization of the aeration tank diffuser, the header pipe and the diffuser holder shall be provided with stainless steel legs.

(3) The main valve for header pipe shall be a butterfly valve (important portions made of stainless steel). The valve opening degree shall be adjusted in notch type (stepwise). The handle of the valve shall be constructed to be easily operated from the slab.

(4) The header pipe shall have an exhaust pipe and the valve which can drain out the condensation water easily.

2.02 Materials

(a) Diffuser	: Synthetic rubber
(b) Diffuser holder	: Synthetic resin
(c) Header pipe	: Galvanized steel pipe
(d)Frame stand	: Mailed steel

2.03 Accessories (per unit)

(a)	Frame stand	1 set
(b)	Mounting bolt and nut	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11371

Section 11390

Chemical Tank: Cylindrical Steel Tank

Part 1 - General

1.01 General

This tank shall be used for dissolving the polymer supplied by the polymer feeder to a constant concentration and feed the solution to the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, various level gauges, etc.

1.02 Design Condition

The capacity, dimensions, etc. shall comply with Particular Specification.

Part 2 - Products

2.01 Fabrication

(1) The tank shall be a welded structure of steel plate, as a rule, and the tank internal surface shall be painted with tar epoxy resin for corrosion resistance treatment.

(2) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.

(3) The tank shall be provided with necessary mounting seats for overflow pipe, etc.

(4) The motor-driven mixer shall be belt speed reducing type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the centre or at a position off the centre according as the tank being angular or circular.

(5) The mixer shall be protected by electrical prevention of dry operation.

(6) The tank shall be constructed to seal gas and splash from below at the area where the agitator shaft drive portion passes through.

2.02 Materials

(a)	Main body	: Rolled steel + internal surface tar epoxy painting or stainless steel
(b)	Mixer frame	: Rolled steel or stainless steel
(c)	Mixer shaft	: Stainless steel
(d)	Blade	: Stainless steel
(e)	Belt cover	: Rolled steel

2.03 Accessories (per Unit)

(a) Foundation bolt and nut x 1 set

(b) Air vent pipe x 1 set

(c) Mixer x 1 unit

(d) Direct reading level gauge x 1 unit

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11390

Section 11391

Chemical Tank: Polyethylene Tank

Part 1 - General

1.01 General

This tank shall be a vertical tank and shall be composed of tank main body, air exhaust pipe, electrical level gauge, direct reading level gauge, ladder, manhole, etc. It shall be used to store the coagulant.

1.02 Design Condition

The capacity shall comply with Particular Specification.

Part 2 - Products

2.01 Fabrication

(1) The tank shall be made of corrosion resistant material.

(2) The tank shall be constructed such that the coagulant can be directly fed from tank lorry.

(3) A manhole shall be provided to check the inside of tank.

(4) A weir against coagulant overflow shall be provided around the tank.

(5) A ladder shall be provided at the tank.

2.02 Materials

(a)	Main body	: Polyethylene
(b)	Ladder	: Rolled steel

2.03 **Accessories** (per Unit)

(c)	Foundation bolts and nuts	x 1 set
(d)	Air exhaust pipe	x 1 set
(e)	Manhole (approx. dia.500mm)	x 1 set
(f)	Air vent pipe	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11391

Section 11392

Chemical Tank: FRP Tank

Part 1 - General

1.01 General

This tank shall be a vertical tank and shall be composed of tank main body, air exhaust pipe, electrical level gauge, direct reading level gauge, ladder, manhole, etc. It shall be used to store the coagulant.

1.02 Design Condition

The capacity shall comply with Particular Specification.

Part 2 - Products

2.01 Fabrication

(1) The tank shall be made of corrosion resistant material.

(2) The tank shall be constructed such that the coagulant can be directly fed from tank lorry.

(3) A manhole shall be provided to check the inside of tank.

(4) A weir against coagulant overflow shall be provided around the tank.

(5) A ladder shall be provided at the tank.

2.02 Materials

(a)	Main body	: FRP
(b)	Ladder	: Rolled steel

2.03 **Accessories** (per Unit)

(a)	Foundation bolts and nuts	1 set
(b)	Air exhaust pipe	1 set
(c)	Manhole (approx. dia.500mm)	1 set
(d)	Air vent pipe	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11392

Section 11420

Chemical Feeder: Constant Chemical Feeder

Part 1 - General

1.01 General

This equipment shall be used for the continuous constant-rate supply of water and chemical for the preparation of a constant concentration in the polymer dissolution tank. It shall be composed of acceptance hopper, weighing device, feeder main body, adjustable speed drive unit, mixer, dry air supply device, feed water supply device, etc.

1.02 Design Condition

The maximum and minimum values of the quantity of chemical to be used shall be calculated, and the equipment shall be manufactured to supply for that calculated range with high precision. The specific gravity of chemical shall be 0.4 to 1.0.

Part 2 - Products

2.01 Fabrication

(1) The equipment shall be constructed to be resistant to factors affecting the supply precision even with variations in powder pressure in the hopper.

(2) The supply rate shall be adjustable through the adjustable speed reducer of the drive unit and the supply range shall be covered sufficiently.

(3) The equipment shall be constructed to inhibit powder outflow with flushing.

(4) The acceptance hopper shall have the total capacity of its effective capacity plus 5% minimum.

(5) A throw chute for chemical shall be provided.

(6) The equipment shall be constructed to be effective for humidity shutoff, and as a rule, dry air shall be supplied.

(7) The chemical throwing portion shall be constructed to inhibit lumps from forming.

2.02 Materials

(a) Acceptance hopper	: Stainless steel or PVC
(b) Weighing device (powder contact portion)	: Stainless steel or equivalent
(c) Mixer	: Stainless steel (important parts) or clear resin

2.03 Accessories (per Unit)

(a)	Common base	x 1 set
(b)	Feed water motor-driven ball valve	x 1 unit
(c)	Flow meter (area type or direct-reading type)	x 1 unit
(d)	Flow adjusting valve	x 1 unit
(e)	Dry air electromagnetic valve and manual valves	x 1 set
(f)	Air regulator, air mist separator, air filter	x 1 each
(g)	Feed water, dry air piping (machine side 1m)	x 1 set
(h)	Powder level gauge (if necessary)	x 1 unit

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11420

Section 11430

Distribution Tank: Rectangular Steel Tank

Part 1 - General

1.01 General

This tank shall be a rectangular type and shall be composed of the tank main body with pedestal, the fixed weir plate, pipe connections, etc. This tank shall be used to receive and distribute the waste water or the sludge.

1.02 Design Condition

The capacity, etc. shall be complied with the "Particular Specification".

Part 2 - Products

2.01 Fabrication

(1) The tank shall have sufficient strength and wall thickness to corrosion and abrasion.

(2) The tank shall be installed a fixed weir plate, to distribute the water.

(3) The tank shall be installed with connections for inlet pipe and outlet pipe and drainage pipe, etc.

2.02 Materials

(a)	Main body	: Rolled steel or equivalent
(b)	Fixed weir plate	: Rolled steel, stainless steel or equivalent
(c)	Bolts and nuts	: Stainless steel

2.03 Accessories (per Unit)

(a)	Foundation bolt and nut	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof

END OF SECTION 11430

Section 11450

Strainer: Automatic Backwashing Type

Part 1 – General

1.01 General

The automatic washing strainer shall be installed to remove inclusions contained in the secondary treated sewage supplied under pressure by the treated water pump.

1.02 Design Condition

(1) The mesh width of the strainer shall be about 35 mesh (0.4mm).

(2) The design pressure shall be 1.0 MPa.

Part 2 - Products

2.01 Fabrication

(1) The backwash portion shall be screen rotation type or backwash nozzle rotation type, and the rotating body shall be rotated through the speed reducer from the motor by the rotating shaft fixed at the upper bearing.

(2) The opening portion of the strainer shall be in a shape suited especially for removing fibrous substances.

(3) The casing shall be made of cast iron or rolled steel.

(4) Automatic washing in accordance with timer setting (variable) and differential pressure shall be possible.

(5) The automatic wash equipment shall be of self-washing type and the automatic valve shall be operated by an air cylinder or motor.

(6) The control panel shall be composed of an operation panel and a relay panel to control the interlocking circuit between the main body and the backwash valve. The operation panel and the relay panel may be constructed integral with each other.

(7) The connection flange shall be in accordance with JIS 10K or equivalent.

2.02 Materials

(a) Casing : Cast iron or rolled steel

(b) Strainer : Synthetic resin or stainless steel

(c) Shaft : If the shaft has a submerged sliding portion, it shall be made of stainless steel or provided with sleeve (stainless steel).

(d) Liquid contact portion bolt and nut: Stainless steel

2.03 Accessories (per Unit)

(a)	Automatic backwash equipment	x 1 set
(b)	Differential pressure switch	x 1 set
(c)	Pressure gauge (diaphragm type)	x 1 set
(d)	Backwash valve	x 1 set
(e)	Small piping around the equipment	x 1 set
(f)	Control panel (outdoor wall mounted type)	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof

END OF SECTION 11450

Section 11460

Sludge Thickener: Centre Driven Gravity Thickener

Part 1 - General

1.01 General

The gravity thickeners shall be composed of drive unit, main shaft, feed well, steel bridge rake, etc. The turning force shall be given from the drive unit through the main shaft to the rake arm so that the sludge on the thickener bottom may be scraped by means of the rake mounted to the rake arm continuously to the sludge pit provided at the centre of the thickener. In the centre-driven suspension construction, the drive unit shall be installed on the concrete slab of the tank.

1.02 Design Condition

(1) This equipment shall be safe sufficiently to the scraper load and start-up time load, be free from vibration, heating, abnormal sound, etc. during operation, and shall withstand continuous operation.

(2) Each portion of the equipment shall have ample strength and wall thickness to corrosion and abrasion.

(3) The peripheral speed shall be about 2 to 3 m/min.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

(a) This unit shall be composed of motor, cycloidal reduction gear or planetary reduction gear or gear and chain, etc. and transmit the power safely and positively. The speed shall be reduced to the predetermined scraping speed. The main shaft shall be turned through coupling and bearing stand.

(b) The bearing shall be able to support the load of the scraper main body and the vibration due to turning sufficiently.

(c) The cover for the exposed chain shall be made of steel plat with epoxy coating or stainless steel plate.

(2) Rake and rake arm

(a) The rake shall be mounted firmly to the rake arm. Rakes shall be overlapped each other not to leave areas where the sludge is not scraped.

(b) Under the rake, a replaceable adjusting blade shall be mounted and the clearance to the thickener bottom shall be adjustable.

(c) The rake arm shall have two blades (auxiliary blades may be provided). It shall be constructed by truss structure of steel material and shall have adequate strength to bending loads, etc.

(d) The clearance to the rake thickener bottom surface shall be not more than about 50 mm at the mid-point of the blade and rubber shall be mounted to the blade end.

(3) Feed well

(a) The feed well shall be mounted firmly to the thickener wall by means of supports. It shall reduce the flow speed promptly and have large effect of straightening.

(b) The feed well shall be made of stainless steel.

(c) The feed well shall be provided with a small window with baffle and the scum in the feed well shall be able to be discharged through the window.

(4) Main shaft and bearing

(a) The main shaft shall be suspended from the bearing stand and have a sufficient allowance for torsional loads. The bearing shall be a rolling bearing constructed to support thrust loads.

(5) Oil supply equipment

(a) The drive unit shall be constructed for easy oil supply and check.

(b) A grease nipple shall be provided at a position of easy oil supply.

(6) The motor specifications shall be outdoor totally-enclosed fan-cooled type and continuous rating.

2.02 Materials

(a) Blade : Rolled steel or equivalent

(b) Submerged bolt and nut : Stainless steel

(c) Rake and rake arm : Rolled steel

(d) Main shaft : Carbon steel pipe for pressure service or Carbon steel tube for machine structural purposes

(e) Feed well : Rolled steel with epoxy coating or stainless steel

(f) Feed well support : Rolled steel

(g) Baffle plate : Rolled steel or equivalent

(h) Bracket for baffle plate : Rolled steel or equivalent

2.03 Protection Equipment

(1) Mechanical protection equipment

Protection equipment for overload protection

(2) Electrical protection equipment

Overcurrent detector for overload protection
(Scope of electrical equipment work)

2.04 Accessories

(a) Anchor bolt x 1 set

(b) Drive unit and chain cover x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000.

END OF SECTION 11460

Section 11461

Sludge Thickener: Rotary Drum Thickener

Part 1 - General

1.01 General

This equipment shall be used to thicken the waste sludge continuously and shall be composed of thickener main body, cover, ancillaries, and control panel.

1.02 Design Condition

(1) This equipment shall be of continuous operation type.

(2) The performance of this equipment shall be as follows.

(a) Condition of sludge

Sludge type	: Waste sludge
Concentration	: 0.6% - 0.8%
SVI	: equal or less than 200

(b) Capacity

Thickened Sludge concentration	: equal or more than 4%
SS recovery rate	: 0.6% - 0.8%
Sludge feed rate	: Refer to Particular Specification

Part 2 – Products

2.01 Fabrication

(1) Main body
The main body of thickener shall consist of screen drum, polymer mixing tank, feed pipe, bearing, chute, safety device, drive unit, etc.

(2) Enclosure
The main body of thickener shall be enclosed. The enclosure shall be constructed such that the thickener can be inspected easily, while containing the mist of sludge and odour without leakage.

(3) Others
Any other apparatus and/or control system to operate the equipment meeting the required performance shall be provided and installed in accordance with the manufacturer's standard, including power supply and control panel for such apparatus system.

2.02 Materials

(a) Thickener main body : Stainless steel

(b) Polymer mixing tank : Stainless steel

(c) Chute : Stainless steel

2.03 Accessories (per Unit)

(a) Drive unit x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11461

Section 11500

Dewatering Unit: Screw Press Type

Part 1 - General

1.01 General

This apparatus shall be used for the continuous dewatering process of sewage sludge, and composed of a screw press main body, coagulation device and power control panel.

1.02 Design Condition

(1) The screw press which rotates at a normal low speed, and shall have sufficient strength against the cake pressure to be generated from the pushing pressure of the presser.

(2) Performance of this dewatering unit shall meet the following requirements:

(a) The sludge is mainly generated in the treatment process of the domestic sewer by an activated sludge method.

(b) Rate of inflow will be more than 30% of the capacity of the receiving sewage treatment plant.

(c) The sludge will be concentrated by either gravity or mechanical thickeners.

Part 2 - Products

2.01 Fabrication

This unit shall be composed of an outer cylinder-type screen, screw shaft, bearing, base, safety cover and trough, cleaning device, driving motor and local control panel.

(1) Screw press main body
The main body shall be composed of an outer cylinder-type screen and screw shaft, The outer cylinder-type screen shall be made of a perforated steel plate. The screw shaft shall be of an integrated construction composed of an inclined-shape shaft and screw impeller. In addition, a cone-shaped compressor shall be provided at the sludge-cake discharge section to give pushing pressure to the sludge cake.

(2) Base
The base, made of steel plate, shall be constructed as a common base for the screw press main body and the drive motor for unification so that it can withstand the mechanical force generated.

(3) Bearing
The bearing shall have sufficient strength to withstand continuous operation at a low load.

(4) Odour-protection cover and trough
The odour-protection cover shall be constructed to facilitate internal inspection and repair, and to ensure good sealing for prevention of moisture or odour leak to the

outside. The trough shall be of a construction to permit smooth drain of the filtrate, etc.

(5) Washing device
The cleaning device shall be provided with nozzles to wash this Unit while turning the outer cylinder-type screen after completion of each dewatering operation term. The device shall be of a simple construction to minimize nozzle plugging and to facilitate maintenance.

(6) Coagulation device
This device shall be provided to mix the coagulant efficiently with the forwarded sludge. The apparatus shall be constructed to forward the mixed sludge smoothly to the screw press main body. The coagulation device shall be equipped also with an agitator, etc. for mixing.

(7) In response to the characteristic of the contents being processed, rotation of the screw shaft at a low speed shall be possible concurrent to the variable speed. The motor shall be of a squirrel-cage three-phase induction motor, totally-enclosed type. Rating shall be of a continuous rating, and insulation shall be Class E or other equal approved class. Further, inverter drive shall be the standard, and inverter control unit shall be included in the device.

(8) Dewatering unit control panel
This panel shall provide power control, graphic indication and necessary instrumentation for the dewatering unit and related facilities consisting of coagulation device (coagulant and polymer), sludge feed pump and polymer feed pump. Graphic indication shall display the running and fault condition of the dewatering unit operation and also the operation condition of equipment in the related facilities. Where speed control is provided, variable speed drive with electromagnetic noise reduction filter shall be used and motor shall be of the type specified for inverter application. The panel and motor shall be subject to the Engineer's approval.

(9) Others
Any other apparatus and/or control system to operate the equipment meeting the required performance shall be provided and installed in accordance with the manufacturer's standard, including power supply and control panel for such apparatus system.

2.02 Materials

(a)	Outer cylinder	:	Stainless steel
(b)	Screen	:	Stainless steel
(c)	Screw shaft, impeller	:	Stainless steel
(d)	Frame base	:	Stainless steel
(e)	Cleaning pipe	:	Steel pipe
(f)	Odour-protection cover	:	Stainless steel, synthetic resin
(g)	Trough	:	Stainless steel
(h)	Cake chute	:	Stainless steel

(i) Dewatering unit control panel : Rolled steel

2.03 Protection Equipment

The driving motor shall be provided with a detection device for overload protection.

2.04 Accessories (per Unit)

(a) Fixing bolts and nuts x 1 lot

(b) Coagulation device x 1 unit

(c) Power control panel x 1 set

(d) Special overhaul tools (if necessary) x 1 set (common for all Units)

(e) Electromagnetic flow meter for chemical dosing (if necessary) x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11500

Section 11501

Dewatering Unit: Centrifugal Type

Part 1 - General

1.01 General

This dewatering unit shall be used for the continuous centrifugal dewatering treatment of the sewage sludge and shall be composed of the mechanical equipment of the centrifugal separator main body and accessory equipment necessary for operation.

1.02 Design Condition

The centrifugal separator shall be manufactured to rotate well even with high-speed operation and have adequate strength against centrifugal forces. Also adequate consideration for wear and corrosion resistance shall be given.

Part 2 - Products

2.01 Fabrication

(1) Centrifugal separator

This machine shall be composed of rotor, back drive device, bearing, base, casing, liquid feed pipe, driving motor control panel, etc.

(a) Rotor

The rotor shall be composed of bowl and screw, and the bowl shall be constructed to be properly adjustable in the height of the separated water weir. The screw blade end shall be made of a material having excellent wear resistance such as ceramic, tungsten carbide, surface hardened metal or the like.

(b) Back drive device

The back drive device shall be constructed to take the difference of rotation between the bowl and the screw smoothly and endure high-load continuous operation sufficiently. This device shall adopt electrical control, hydraulic oil control, or inverter control system, as standard and include accessories necessary for back drive control

(c) Casing

The casing shall be constructed for easy check and maintenance of the inside and shall also close well to prevent leakage of sludge mist and offensive doors to the outside. The cake discharge chute shall be made of stainless steel and for the connection to the cake discharge device, flexible joints shall be provided.

(d) Base and vibration isolator device

The base shall be made of stainless steel or cast iron and be constructed to endure mechanical vibration. Moreover, vibration isolation measures shall be taken sufficiently, for example, by mounting a vibration isolator device, etc. between the base and installation frame.

(e) Bearing

The bearing shall be durable enough to endure continuous high-speed load operation.

(f) Safety device

A safety device shall be installed to stop the operation of the dewatering unit in the event of abnormal loading caused by ingress of foreign substances into the inside of the rotor which produce a braking effect or in the event of abnormal vibration of the rotor.

(g) Liquid feed pipe

Structurally, it shall be possible to feed liquid into the inside of the rotor through a corrosion resistant pipe from the outside.

(h) Lubrication system

The lubrication system shall be as follows.
Main shaft (bearing box): Oil forced lubrication or grease-sealed, oil bath
Screw supporting portion bearing: Grease-sealed

(i) Drive unit

The drive unit shall have the capacity to rotate the main body up to the specified number of rotations and endure the load. The motor shall be inverter-driven, as standard. The inverter control unit shall be included in this equipment.

(2) Accessory equipment

(a) Soundproof cover

The soundproof cover shall be a folded structure of steel plate and shall be provided with a cover at the top and doors on right and left sides for internal check, repair, etc. The inside surface shall be applied with soundproof treatment.

(b) Washing device

After completion of dewatering operations, it shall be possible to wash the centrifugal separator inside, etc. with feed water.

(c) Lighting and ventilation devices

In the soundproof cover, lighting and air intake and exhaust devices shall be provided.

(d) Package internal piping

Considering sludge properties and properties of chemical, pipes of adequate bore diameter free from clogging shall be used. For the connection to the centrifugal separator main body, flexible joints, etc. shall be used for elastic connection. All pipelines and valves necessary for operation in the noise reducing package shall be included.

(3) Others

Any other apparatus and/or control system to operate the equipment meeting the required performance shall be provided and installed in accordance with the manufacturer's standard, including power supply and control panel for such apparatus system.

2.02 Materials

(1) Centrifugal dewatering unit

(a) Bowl : Stainless steel or equivalent

(b) Screw : Stainless steel or equivalent

(c) Chute : Stainless steel

(d) Base : Rolled steel or cast iron

(e) Soundproof cover (inside surface with lining of sound absorber) : Rolled steel

Any part subjected to wear shall be made of wear-resisting materials and ensure a long period of operation.

(2) Piping, etc.

(a) Sludge and separated water : Stainless steel

(b) Feed water : Steel pipe

2.03 Protection Equipment

Mechanical protection equipment

(a) Speed reducer built-in torque limiter

2.04 Accessories (per Unit)

(a)	Vibration isolator device	x 1 set
(b)	Lubricating device	x 1 set
(c)	Back drive device	x 1 set
(d)	Motor	x 1 set
(e)	V-belt, V-pulley, cover	x 1 set

(f) Soundproof cover (with sound absorber, lighting, ventilation) x 1 set

(g) Dewatered cake chute x 1 set

(h) Separated water chute x 1 set

(i) Separated water monitoring unit x 1 set

(j) Soundproof cover internal piping, valves, expansion pipes x 1 set

(k) Power Control Unit x 1 set

(l) Foundation bolt and nut x 1 set

(m) Special disassembly tool x 1 set (common for all units)

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11501

Section 11502

Dewatering Unit: Multi-Diskplate Screw Press Type

Part 1 - General

1.01 General

This apparatus shall be used for the continuous dewatering process of sewage sludge, and composed of a multi-diskplate screw press main body, coagulation device and power control panel.

1.02 Design Condition

(1) The multi-diskplate screw press which rotates at a normal low speed, and shall have sufficient strength against the cake pressure to be generated from the pushing pressure of the presser.

(2) Performance of this dewatering unit shall meet the following requirements:

(a) The sludge is mainly generated in the treatment process of the domestic sewer by an activated sludge method.

(b) Rate of inflow will be more than 50% of the capacity of the receiving sewage treatment plant.

(c) Multi-Diskplate Screw Press shall dewater directly thin sludge with its concentration at 0.2% at minimum, discharge sludge cake with its solids content at 15% at minimum and catch 90% to 95% solids fed. Therefore, sludge with its concentration at 0.2 to 0.4 % will be transferred from Oxidation Ditch by Waste. Sludge Pump, and be dewatered by means of a dewatering press, without any pre-thickening.

Part 2 - Products

2.01 Fabrication

This unit shall be composed of an outer cylinder-type screen, screw shaft, bearing, base, safety cover and trough, cleaning device, driving motor and local control panel.

(1) Screw press main body

The main body of Multi-Diskplate Screw Press shall have a drum being composed of accumulated rings and a screw going through inside the drum. Solids and liquid shall be separated by the pressure caused by the screw. Filtrated water shall be discharged from the first part of the drum, from the gaps between the accumulated rings. The accumulated rings shall be sorted into two types; moving rings and fixed rings. The internal diameter of the moving rings shall be smaller than the diameter of the screw so that the screw shall push the internal edges of the moving rings. The moving rings move continuously in the gaps between the fixed rings when the screw rotates, which shall clean the gaps and prevent clogging. The separated solids shall be discharged from the end of the drum.

(2) Base
The base plate, made of steel plate, shall be constructed as a common base for the screw press main body and the drive motor for unification so that it can withstand the mechanical force generated.

(3) Bearing
The bearing shall have sufficient strength to withstand continuous operation at a low load.

(4) Odour-protection cover and trough
The odour-protection cover shall be constructed to facilitate internal inspection and repair, and to ensure good sealing for prevention of moisture or odour leak to the outside. The trough shall be of a construction to permit smooth drain of the filtrate, etc.

(5) Washing device
The cleaning device shall be provided with nozzles to wash this Unit. The device shall be of a simple construction to minimize nozzle plugging and to facilitate maintenance.

(6) Coagulation device
This device shall be provided to mix the coagulant efficiently with the forwarded sludge. The apparatus shall be constructed to forward the mixed sludge smoothly to the screw press main body. The coagulation device shall be equipped also with an agitator, etc. for mixing.

(7) In response to the characteristic of the contents being processed, rotation of the screw shaft at a low speed shall be possible concurrent to the variable speed. The motor shall be of a squirrel-cage three-phase induction motor, totally-enclosed type. Rating shall be of a continuous rating, and insulation shall be Class F or other equal approved class. Further, inverter drive shall be the standard, and inverter control unit shall be included in the device.

(8) Dewatering unit control panel
This panel shall provide power control, graphic indication and necessary instrumentation for the dewatering unit and related facilities consisting of coagulation device (polymer), sludge feed pump and polymer feed pump. Graphic indication shall display the running and fault condition of the dewatering unit operation and also the operation condition of equipment in the related facilities. Where speed control is provided, variable speed drive with electromagnetic noise reduction filter shall be used and motor shall be of the type specified for inverter application. The panel and motor shall be subject to the Engineer's approval.

(9) Others
Any other apparatus and/or control system to operate the equipment meeting the required performance shall be provided and installed in accordance with the manufacturer's standard, including power supply and control panel for such apparatus system.

2.02 Materials

(a)	Screw and Shaft	:	Stainless steel or equivalent
(b)	Screen (Main parts)	:	Stainless steel
(c)	Flocculation Tank	:	Stainless steel

(d)	Frame base	:	Stainless steel or equivalent
(e)	Cleaning pipe	:	Stainless steel
(f)	Odour-protection cover	:	Stainless steel, synthetic resin
(g)	Trough	:	Stainless steel
(h)	Cake chute	:	Stainless steel
(i)	Dewatering unit control panel	:	Rolled steel or SPHC

2.03 Protection Equipment

The driving motor shall be provided with a detection device for overload protection.

2.04 Accessories (per Unit)

(a)	Fixing bolts and nuts	x	1 lot
(b)	Coagulation device	x	1 unit
(c)	Power control panel	x	1 set
(d)	Special overhaul tools	x	1 set (common for all Units)
(e)	Electromagnetic flow meter for chemical dosing (if necessary)	x	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11502

Section 11521

Odor-Control Equipment: FRP Centrifugal Fan

Part 1 - General

1.01 General

This fan shall be used to suck the odor gas.

1.02 Design Condition

(1) This fan shall be constructed to produce less vibration and noise and endure continuous operation on 24 hours per day basis.

(2) This fan shall be designed to have an adequate allowance for both air flow and wind pressure and shall meet the following conditions.

(a) Air flow: As specified under the set conditions of 30℃, 0.1MPa (1 atm) and 90% RH.

(b) Wind pressure: With a sufficient allowance to cover duct loss and deodorization equipment loss.

(c) Motor: With a sufficient allowance to prevent overloading under varying air temperature, relative humidity, etc.

Part 2 - Products

2.01 Fabrication

(1) This fan shall be a single-suction turbo fan. The impeller shall be made of corrosion-resisting material (FRP) and be well balanced in rotation to produce less noise and vibration and be highly efficient.

(2) The impeller shall have wall thickness having an allowance of strength enough to endure the specified wind pressure.

(3) The shaft shall be made of carbon steel and the sleeve used in the portion which comes into contact with the gas shall be made of FRP.

(4) The casing shall be made of corrosion-resisting material (FRP) and be constructed to be sturdy.

(5) The portion of the casing where the shaft penetrates through shall be sealed to prevent odor gas leakage.

(6) The fan motor shall be installed on the common base and be driven by V-belts.

(7) The suction side and the discharge side of the fan shall be provided with respective vibration-preventing joints.

(8) In the bottom portion of the casing, a water drain valve shall be provided and be piped to the destination of discharge.

(9) The common base shall be provided with an vibration isolator device (such as vibration isolator spring).

(10) The shaft shall be protected with a cover and the oil supply port of the bearing shall be separated sufficiently from the shaft.

(11) Motor specifications shall be totally-enclosed fan-cooled type and continuous rating.

2.02 Materials

(a)	Impeller	: Fiber reinforced plastic (FRP)
(b)	Shaft	: Carbon steel
(c)	Casing	: Fiber reinforced plastic (FRP)
(d)	Common base	: Rolled steel or cast iron

2.03 Accessories (per Unit)

(a)	Cover	x 1 set
(b)	Vibration isolator joint	x 1 set
(c)	Common base	x 1 set
(d)	Vibration isolator device	x 1 set
(e)	Manometer	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11521

Section 11600

Mixer: Submersible Propeller Mixer

Part 1 - General

1.01 General

This mixer shall be used to agitate the sewage or sludge, and shall be sturdily constructed to endure continuous operation in sewage.
The mixer shall be constructed to produce less vibration and noise, and to be operated smoothly.

1.02 Design Condition

This mixer shall be designed to endure continuous operation and intermittent operation by timer.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

Dry submergible-type induction motor shall be used for this mixer.

(2) Mixer main body

(a) Casing
The casing shall have adequate mechanical strength to endure the vibration. It shall be made of cast iron or stainless steel and shall be free from corrosion and wear. The casing shall be constructed such that it can be dismantled and assembled easily.

(b) Propeller
The propeller shall be made of sturdy material. It shall have required agitation capacity and shall be of an effective shape for agitation.

(c) Main shaft
The main shaft shall have the adequate strength to endure the transmitted torque and torque vibration.

(d) Shaft sealing unit
The shaft sealing unit shall be a mechanical system and shall seal the drive unit. The shaft sealing unit shall be constructed such that the mechanical seal can be replaced easily.

(e) Bearing
The bearing shall sustain the load from rotating parts and water thrust force. The bearing shall be sturdily constructed to endure continuous operation for long periods.

(3) Installation unit

The installation unit shall be composed of the guide bar, guide bracket, base, lifting post, handle and lifting chain. The horizontal installation angle shall be adjustable by rotating the guide bar.

2.02 Materials

(a) Casing	: Cast iron or Stainless steel
(b) Propeller	: Cast iron or Stainless steel
(c) Main shaft	: Stainless steel

2,03 Protection Equipment

A thermal switch shall be provided to detect extraordinary temperature rise.

2.04 Accessories (per Unit)

(a) Submergible cable (10m)	x 1 set
(b) Guide bar	x 1 set
(c) Guide bar bracket	x 1 set
(d) Bolts and nuts	x 1 set
(e) Lifting device	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11600

Section 11601

Mixer: Vertical Type Propeller Mixer

Part 1 - General

1.01 General

This mixer shall be used for mixing inside the sludge storage tank to prevent sludge settling.

1.02 Design Condition

(1) This mixer shall be manufactured to endure internal tank level variations sufficiently.

(2) This mixer shall be of fixed type, as a rule.

Part 2 - Products

2.01 Fabrication

(1) The drive unit shall be vertical speed reducer, direct-coupled type.

(2) Blades and main shaft shall have excellent corrosion resistance, and especially, the blade shall be constructed in the shape free from easy entangling with inclusions.

(3) Basically, this mixer shall be constructed to endure dry operation.

(4) Bolts to be used in the liquid contact portion shall be made of stainless steel and shall be provided with locking.

(5) Blades shall be provided in two stages.

(6) Structurally, the lower bearing shall be unnecessary.

2.02 Materials

(a) Main shaft : Stainless steel

(b) Blade : Stainless steel

2.03 **Accessories** (per Unit)

(a) Foundation bolt and nut x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11601

Section 11602

Mixer: Air Bubbling Pipe Unit

Part 1 - General

1.01 General

This air bubbling pipe unit shall be installed in the sludge holding tank to prevent sludge settlement.

1.02 Design Condition

The gas handled shall be air. This apparatus shall be of a structure that is capable of diffusing air uniformly in 49 to 69kPa pressure.

Part 2 - Products

2.01 Fabrication

All bubbling pipe shall be made of steel or PVC pipes and shall have holes to diffuse air. The specifications of holes and the arrangement of pipings shall be designed to diffuse air uniformly by manufacture.

2.02 Materials

(a)	Air pipe	: Steel pipe or PVC pipe or equivalent
(b)	Mater valve	: Bronze casting or equivalent
(c)	Constant flow valve	: Bronze casting or equivalent

2.03 **Accessories** (per Unit)

(a)	Attachment and fittings	x 1 lot

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11602

Section 11603

Mixer: OD Tank Submersible Propeller Mixer

Part 1-General

1.01 General

This equipment shall be used to dissolve oxygen into the mixed liquid in the oxidation ditch and also give a stream velocity necessary for agitation. This equipment shall consist of submersible propeller mixers.

1.02 Design Conditions

This equipment shall be free from vibration, heat generation, abnormal noise, etc. during operation and shall endure continuous operation.

Part 2-Products

2.01 Fabrication

(a) The submersible propeller mixer shall consist of a propeller, a submersible motor, a reducer, a lifting device, etc. and shall cause water streams to be generated in the oxidation ditch.

(b) The shaft sealing portion shall use mechanical seals and shall be constructed to be free from entry of foreign substances either during operation or at stop.

(c) The weight of rotating parts and the hydraulic thrust shall be borne with bearings which are built in the motor and constructed to endure continuous operation for a long time.

(d) The lifting device shall be constructed to allow easy mounting and dismounting of the submersible propeller mixer. The lifting chain block shall have an adequate allowance to the dead weight of the submersible propeller mixer.

(e) The lifting guide bars shall be provided with stoppers for positioning of the submersible propeller mixer.

(f) The lifting guide bars shall be constructed to be sufficiently strong to the reactive force during operation.

2.02 Materials

(a)	Propeller	: FRP
(b)	Shaft	: Stainless steel
(c)	Casing	: Cast iron
(d)	Bolt and nut	: Stainless steel
(e)	Guide bar	: Stainless steel
(f)	Lifting chain	: Stainless steel

2.03 Protection Equipment

Submersible Propeller Mixer

The drive unit shall have a built-in thermal switch for detecting abnormal temperature rise.

2.04 Accessories (per Unit)

(a)	Submersible cable (up to terminal box)	1 set
(b)	Lifting device (common for 2 submersible propeller mixers)	1 set
(c)	Foundation bolt	1 set
(d)	Terminal box	1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11603

Section 11610

Container: Container

Part 1 - General

1.01 General

This container shall be provided to store and transport the screenings and shall be mobile.

1.02 Design Condition

(1) The container shall be constructed such that it can be lifted and lowered by lifting equipment at any time.

(2) The container shall have sufficient strength and rigidity to endure the full-filled condition of screenings.

Part 2 - Products

2.01 Fabrication

(1) The container shall be square in principle and its bottom shall be a porous plate, etc. for drainage.

(2) The container shall be lifted individually.

(3) The handcart shall have casters with stopper for the manual removal with full-filled container.

2.02 Materials

(a) Container main body : Stainless steel or FRP

2.03 **Accessories** (per Unit)

(b) Lifting hook x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11610

Section 11620

Oil Removal Equipment: Manually Operated Slot Skimmer

Part 1 - General

1.01 General

This skimmer shall be installed in front of the grit chamber overflow weir. The oil generated on the water surface shall be removed out of the tank as the manual operation type pipe skimmer shall be turned in normal and reverse directions within a definite angle.
This pipe skimmer shall be constructed with manual operating handle, support stand, bearing, etc.

1.02 Design Conditions

(1) This skimmer shall be strong enough to endure water pressure, torsion during rolling motion, etc.

(2) The bearing portion shall be constructed to accommodate thermal elongation and contraction of steel pipes.

(3) For any portion which may corrode or wear, wall thickness shall be given consideration.

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) Operating equipment

An operating handle mounting metal shall be provided at the end of the pipe skimmer main body, and the pipe skimmer shall be able to be turned within a definite angle by means of the operating handle (lever).

(2) Pipe skimmer main body

The pipe skimmer shall be made of a steel pipe. It shall have an opening necessary to remove the oil. This skimmer shall be constructed to be strong enough to endure torsion and deflection caused by double-end supporting even it is mounted across the width of the tank. As necessary, an adjusting means shall be provided to make adjustment of the skimmer main body easy.

(3) Operating handle

The operating handle shall have adequate strength and skimmer main body adjustment by means of this handle shall be easy. The handle shall be dismountable.

(4) The main body of the bearing portion shall be made of good quality of cast iron and shall be constructed with a bush provided on its inside to prevent water leakage. The

bearing shall have optimum construction for the load and have an adequate bearing capacity. It shall have complete function of lubrication.

(5) It shall be easy to supply oil to the bearing portion from a place above the tank.

2.02 Materials

The materials shall be as follows.

(a) Skimmer main body	:	Steel pipe
(b) Bearing portion main body	:	Cast iron
(c) Frame	:	Rolled steel or cast iron

2.03 Protection Equipment

The mechanical protection equipment shall be as follows.
The skimmer shall be provided with stoppers to prevent turning beyond a definite angle.

2.04 Accessories (per Unit)

(a) Mounting bolts and nuts	x 1 set
(b) Oil supply equipment	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11620

Section 11621

Oil Removal Equipment: Oil Holding Tank

Part 1 - General

1.01 General

This tank shall be used to separate oil and water. It shall be a vertical tank.

1.02 Design Condition

The capacity shall comply with Particular Specification.

Part 2 - Products

2.01 Fabrication

(1) The tank shall be a welded structure of steel plate, as a rule, and the tank internal surface shall be painted with tar epoxy resin for corrosion resistance. However, FRP shall be acceptable.

(2) The drain pipe and overflow pipe for oil and water shall be provided at the lower parts of the tank.

2.02 Materials

(a) Main body : Rolled steel + internal surface tar epoxy painting or FRP

2.03 **Accessories** (per Unit)

(a) Foundation bolt and nut x 1set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11621

Section 11622

Oil Removal Equipment: Motor Driven Oil Skimmer

Part 1 - General

1,01 General

The Skimmer shall be installed at the end of the grit chamber oil and grease collection trench.
The oil generated on the water surface shall be pushed by the return flights of the sludge collector in the grease chamber towards the skimmer. The oil and supernatant shall be scraped by the rotating blades of the skimmer and taken into the concrete trench.
The scraped oil and supernatant shall flow by the gravity into the pump pit and pumped to the container.
The motor driven oil skimmer shall be constructed with geared motor, shaft and blades etc.

1.02 Design Condition

(1) The skimmer shall be designed so that oil and supernatant on the surface of water can be removed by the turning blades of the skimmer.

(2) The top of trench shall be furnished with curved plate to ensure smooth contact between blades and trench.

Part 2 - Products

2.01 Fabrication

(1) Main shaft shall be installed above the water level such that blades will touch the water surface and scrape out the oil and supernatant. The bearing blocks shall be installed at both end of main shaft so that main shaft and blades can rotate smoothly.

(2) The belt driven pulley shall be attached to the driving side of shaft end.

(3) Three (3) blades shall be attached on the shaft. Each blade shall be positioned at 120 degree apart. Blades shall be fixed on the shaft by clamp plates and fastened with bolts & nuts so that blades can be removed for maintenance. The end of blades shall be furnished with rubber plates.

(4) Geared motor shall be installed on the grease chamber slab. The belt driven pulley shall be attached with geared motor shaft end so that motor power can be transferred to the main shaft pulley.

(5) Stainless steel plate's motor cover shall be installed with on touch open inspection cover(s).

2.02 Materials

The materials shall be as follows.

(a) Main shaft : Steel pipe with hot dip galvanized.

(b) Blades and cramps : Stainless steel

(c) Blade end scraper : Synthetic Rubber

(d) V-belt pulley : Cast iron

(e) Geared Motor Cover : Stainless steel

2.03 Protection Equipment

Motor thermal protection shall be installed on the control panel.

2.04 Accessories (per unit)

(a) Mounting bolts and nuts x 1 set

(b) V belt x 2 sets

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11622

Section 11630

Filter: Up Flow Rapid Filtration

Part 1 - General

1.01 General

This filter shall be used to supply plant water, such as washing water, by filtering treated sewage, which is forwarded from a filter feed pump in the upswing flow.

This apparatus shall be composed of filter main body, filter media, changeover valves, filter media washing device, local control panel, etc.

1.02 Design Condition

(1) The filtration rate shall be 1,200 m^3/day or less.

(2) This filter shall be of a structure that can be washed at high efficiency by joint use of mechanical agitation and water-flow backwashing.

(3) The volume of water needed to wash this filter shall not be more than 3% of the filtered raw water volume.

Part 2 - Products

2.01 Fabrication

(1) Filter Main Body

(a) The filter body shall be of rolled steel or FRP structure, and shall be provided with various pipe-connecting parts.

(b) The raw water shall be equally distributed to the filter from the bottom side. The filtered water that passed through the filter media shall make outflow through the filtered-water outlet located on top of the filter.

(c) A filtered-water collecting device shall be provided on top of the main body.

(d) The main body shall be provided with a manhole to charge the filter media and for inspection.

(2) Filter Media Washing Device

(a) Valves shall open/close automatically with a timer or upon detection of pressure rise with filtration resistance to allow for washing.

(b) Washing shall be performed by mechanical agitation or water flow backwash, or by the combination of both.

(3) Automatic Valves

(a) The automatic valves shall be motor-operated or pneumatic flangeless butterfly valves.

(4) Filter Media

(a) The filter media shall be made of synthetic resin or equivalent.

(5) Local Control Panel

(a) The type shall be an outdoor type, and this local control panel shall be capable of controlling local-independent running and local-linked running of filtration processes (filtration, filter media washing, drain, and water discharge).

2.02 Materials

(a)	Filter main body	:	Rolled steel, FRP or equivalent
(b)	Collecting nozzles	:	PVC, stainless steel or equivalent
(c)	Bolts and nuts	:	Stainless steel
(d)	Agitator	:	Stainless steel
(e)	Filter media	:	Synthetic resin or equivalent

2.03 Accessories (per Unit)

(a)	Pressure switch	x	1 set
(b)	Inflow and outflow pressure gauge	x	1 set
(c)	Valves	x	1 set
(d)	Flow meter (local indicator)	x	1 unit
(e)	Piping around filter	x	1 lot
(f)	Local control panel	x	1 unit

Part 3 - Execution

Refer to various sub-sections in Section 11000.

END OF SECTION 11630

Section 11640

Auto. Feed Water Supply Unit: Pressure Tank Type

Part 1 - General

1.01 General

This unit shall be a pressure tank combined with horizontal centrifugal pumps. The tank shall be installed to store pressurized water in it to accommodate variations of the water usage.

1.02 Design Conditions

(1) This unit shall be constructed to produce less vibration and noise and to endure a long time of continuous operation.

(2) The tank shall be a product conforming to the applicable laws and regulations.

(3) The pressure tank shall have a sufficient capacity selected considering the frequency of motor start-up.

(4) Pump operation shall be automatic parallel and alternate operation in accordance with the tank internal pressure.

(5) The condition of suction of the horizontal centrifugal pump shall be forced suction.

(6) The quantity of pumps to be mounted in the feed water pump unit shall be 2 as standard.

Part 2 - Products

2.01 Fabrication

(1) The pump shall be sturdy and shall have a wall thickness having an adequate allowance for wear and corrosion.

(2) The tank shall be an air make-up type tank and shall have sufficient strength.

(3) The control panel shall be composed of a control circuit for automatic operation and a drive-power circuit.

2.02 Materials

Materials shall be as follows.

(1) Horizontal centrifugal pump

(a) Casing : Cast iron

(b) Impeller : Bronze casting or cast iron

(c) Shaft : Stainless steel

(d) Motor : Totally enclosed fan-cooled type and continuous rating

(2) Tank : Rolled steel or equivalent

2.03 Accessories (per Unit)

(a) Common base	x 1 set
(b) Foundation bolt and nut	x 1 set
(c) Coupling and cover	x 1 set
(d) Pressure gauge or compound pressure gauge	x 1 set
(e) Pressure switch	x 1 set
(f) Control panel	x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11640

Section 11650

Stop Log: Steel Plate Type

Part 1 - General

1.01 General

The stop log shall be installed in the water treatment facility for the purpose of stop of influent flow.

1.02 Design Conditions

(1) The stop log shall be made of carbon steel plate. Strength calculations shall be made under the assumption that a water pressure of the water level corresponding to the indicated lift head is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the stop log shall be calculated from the water pressure and the load of self-weight, etc.

Part 2 - Products

2.01 Fabrication

Fabrication shall be as follows.

(1) Regarding the specifications for the stop log, the following requirements shall be observed.

(a) The stop log shall be constructed to provide sufficient watertight.

(b) The stop log shall be made of carbon steel.

2.02 Materials

Materials shall be as follows.

(a) Stop log : Carbon steel

2.03 **Accessories** (per Unit)

(a) Stop Log x 1 set

(b) Rubber packing x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11650

Section 11660

Decanter: Variable Speed Surface Skimming Type

Part 1 - General

1.01 General

The decanter shall be composed of a drive unit, a collection unit and a discharging unit. It shall discharge the supernatant from the SBR tank after aeration, mixing and sedimentation process**.**

1.02 Design Condition

Each part of this equipment shall be designed with sufficient safety factor in strength. Mainly it shall be made of stainless steel, cast iron and FRP in order to resist the corrosion, wear, etc. The steady operation and stable discharging of supernatant without sludge or scum shall be required of this equipment. The collection part shall collect the supernatant equally and shall not obstruct the aeration and mixing.

Part 2 - Products

2.01 Fabrication

(1) Drive unit

(a) A power cylinder shall be used as the drive unit. The speed of ascent and descent shall be adjustable with inverter.

(b) The limit switches for the detection of the ascending/descending position shall be provided. The switches shall be operated easily and manually.

(c) The collection part shall ascend and descend through the arm.

(2) Discharging unit

(a) To discharge the supernatant from SBR tank, the discharging unit shall be lowered by drive unit.

(b) The discharging unit shall consist of the main pipe and down pipe, etc. The main pipe shall discharge the supernatant from the collection unit and the down pipe shall connect the main pipe and the collection unit.

(c) The main pipe shall be sustained by a bearing which can be rotated smoothly.

2.02 Materials

(a) Head weir : Stainless steel

(b) Down pipe : Stainless steel

(c) Main pipe : Stainless steel

(d) Submergible bearing : SUS304, FC oil-less

(e) Submergible support : Stainless steel

(f) Rod : Stainless steel

(g) Anchor bolt : Stainless steel

2.03 Protection Equipment

Mechanical protection

(a) Built-in crutch and thrust force torque limit switches shall be provided. (for ascending and descending)

(b) Position limit switches shall be provided.

2.04 Accessories (per Unit)

(a) Anchor bolts, etc. x 1 set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11660

Section 11670

Nitrification Unit: Nitrifying Pellets Dosing Type

Part 1 - General

1.01 General

This system shall be used to treat ammonium nitrogen contained in the inflow sewage to nitrate-nitrogen by nitrification-acceleration type carrier-adding method. This apparatus shall be composed of inlet trough, entrapped immobilization pellets, pellet separator, diffuser, etc.

1.02 Design Condition

(1) This apparatus shall provide the function to execute stable nitrifying treatment under the design flow rate and design water quality specified in the Particular Specification.

(2) This apparatus shall be of a structure that provides excellent corrosion resistance and that is capable of withstanding continuous running (24 hours a day) for a long time.

Part 2 - Products

2.01 Fabrication

(1) The inlet trough shall be used to transfer sewage from the anaerobic or anaerobic tank in the pre-stage to the aerobic tank. It shall be of a structure that leads downward in a vertical direction from the tail end of the water-level section, and that opens at the bottom of the aerobic tank, and it shall not allow reverse flow of pellets, which are charged to the aerobic tank by mixing of aeration air. It shall be of a rectangular-trough form made of steel sheets, or of pipe form made of steel pipe.

(2) Entrapped immobilization pellets shall be manufacturer's standard products that are produced by collectively immobilizing nitrifying bacteria in pellets so as to accelerate nitrification. Furthermore, they shall be able to maintain stable-treating performance even in continuous running for a long period of time.

(3) The pellet separator shall be installed in the outflow section of the aerobic tank. It shall provide the function to prevent outflow of pellets by separating pellets from treated water. This apparatus shall be composed of a screen main body using wedge wires, frame, etc.

(4) The diffuser shall be of a whole area aeration type, and shall be located at the bottom of the aerobic tank. It shall provide the capability to execute the nitrifying treatment of wastewater by efficiently dissolving the oxygen in the air by diffusing in the water the air fed from the blower. The material grade of the diffuser shall be synthetic resin, ceramics, or the like providing excellent corrosion resistance, with prevention of plugging taken into account.

(5) If it is necessary to circulate nitrifying liquid to the anaerobic or anaerobic tank located in a stage before the aerobic tank in the nitrifying and denitrification process, a circulation pump and a circulation line shall be provided. This apparatus shall provide the function that is capable of transferring the nitrifying liquid, which passed through the pellet separator, to the tank in the pre-stage through the circulation line by air-lift method.

2.02 Materials

(1) Inflow trough

(a) Trough : Rolled steel (steel pipe) or equivalent

(2) Pellets

(a) Pellets : Organic synthetic resin such as polyethylene glycol

(3) Pellet separator

(a) Screen : Stainless steel

(b) Frame : Rolled steel or equivalent

(4) Diffuser

(a) Diffuser : Synthetic resin, ceramics or equivalent

(b) Holder : Synthetic resin or stainless steel

(c) Riser and header pipes: Steel pipe or equivalent

(5) Circulation pump

(a) Circulation pump : Steel pipe or equivalent

(b) Circulation trough : Rolled steel or equivalent

2.03 Accessories (per Unit)

(a) Bolts and nuts x 1 lot

(b) Piping and valves x 1 lot

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11670

Section 11682

UV Disinfection Equipment : Low Pressure High Intensity Type

Part 1-General

1.01 General

1.1. The work under this section shall cover furnishing a complete and operational open channel, gravity flow, ultraviolet (UV) disinfection system. The system shall be complete with UV modules, power distribution, system control, UV detection system, and automatic wiping system as specified herein.

1.2. The UV system shall be a "low pressure, high intensity" with a new lamp rated output of 125 watts UV-C (254 nm) per lamp, measured with lamps having operated for 100 hours.

1.3. The system shall utilise active control based on the following dose parameters;

Lamp output intensity
Quartz sleeve transmittance
Water quality transmittance
Water flow

Based on these parameters, the system will automatically vary the UV lamp power proportionally to the dose requirement.

1.4. The dose delivered by the UV system shall be linearly variable within a range of 50% to 100% of maximum power.

1.5. The system shall be capable of continuous disinfection while automatically cleaning the UV lamp sleeves without reducing or shadowing the output of the lamps.

1.6. A single manufacturer qualified and experienced in the production of similar equipment shall provide the system. Manufacturer must have at least 5 years experience in manufacturing and delivering open channel, low-pressure high-intensity UV wastewater disinfection technology. The manufacturer must have a minimum of 50 installations operating worldwide using this technology.

1.02 Design Conditions

(1) Condition of raw water

Kind of raw water : secondary treated sewage or better

Fecal Coliform Bacteria Inlet (estimated) $< 1 \times 10^5$ cfu/100 ml
Fecal Coliform Bacteria Outlet < 1,000 cfu/100 ml
(monthly geometric mean of more than 5 samples per month)

UV Transmittance @ 254 nm > 60%

SS concentration : Less than 20 mg/L (value for reference)

Part 2-Products

2.01 System Manufacture and Construction

2.1. The lamp array configuration shall be a uniform array with all lamps parallel to each other and to the flow. The lamps shall have equal centreline spacing along the horizontal and vertical axes.

2.2. The system shall be designed for complete immersion in the effluent of the UV lamps within their protective quartz sleeve. Both electrodes and the full arc length of the lamp shall be below the water surface. Both lamp electrodes shall operate at the same temperature and be cooled by the effluent.

2.3. All metal components in contact with the effluent shall be at minimum type 304 stainless steel. Aluminium wetted materials shall not be used.

2.4. All materials exposed to UV light shall be 316 stainless steel, quartz glass, Teflon, Viton, or other suitable long-term UV resistant materials.

2.5. UV Lamps

2.5.1. Lamps shall be low-pressure mercury amalgam “dotated”, high intensity type.

2.5.2. UV output energy of the lamp shall be variable. The lamp will be capable of maintaining a UV-C output proportional to the variable power settings from the ballast.

2.5.3. Lamp life shall be guaranteed at 12,000 operating hours.

2.5.4. Lamps shall be removable with the quartz sleeve and wiper system remaining in place

2.6. UV Modules

2.6.1. Each UV module shall consist of a dual (side-by-side) row configuration of UV lamp assemblies

2.6.2. The UV modules shall be designed such that operating personnel at the plant can change the lamps and quartz sleeves without requiring special tools.

2.6.3. The UV modules shall be designed for complete submergence without causing failures or damage to the system or components. They shall not contain any components, such as electronic cards, that cannot withstand complete submergence.

2.7. Wiping System

2.7.1. Each UV module shall be equipped with an automatic mechanical wiping system with selectable wiping frequency and number of strokes.

Systems without automatic mechanical wiping or systems requiring chemicals or removal of the module from the channel as the only means of cleaning will not be

acceptable.

2.7.2. The automatic wiping system shall be pneumatically powered and shall use Teflon wipers to clean the quartz sleeves. Wiping frequency shall have an adjustable number of strokes and an adjustable timer interval.

2.8. UV Monitoring System

2.8.1. A submersible UV sensor shall continuously sense the UV intensity produced in each bank of UV lamp modules.

2.8.2. The sensor shall measure only the germicidal portion of the light emitted by the UV lamps as measured at 254 nm. it shall have sensitivity at 254 nm of greater than 95%.

2.8.3. The sensor shall be automatically cleaned at the same frequency as the lamp sleeves to prevent fouling of the sensor and hence spurious false alarms for low intensity.

3. Electrical

3.1. General

3.1.1. The electrical system shall be designed to provide:

- Maximum reliability of the UV disinfection system.
- Plug and socket quick disconnect facilities enabling non-technical personnel to carry out lamp replacement, wiper insert replacement etc. without the need for any tools or specialist isolation procedures.

3.1.2. The enclosures for the UV system shall be painted sheet steel where inside a building and stainless steel for the outdoor units.

3.1.3. The major components of the UV electrical system shall be:

- System Control Enclosure (SCE)
- Power Distribution Enclosure(s) (PDE)
- Electronic Ballast Enclosures (EBE)

3.1.4. The operator interface will provide access to all status and control functions for operations personnel. With password access to limit change options dependant on authority.

3.1.5. The UV system shall provide a group of volt free signals to allow for hardwired alarms to be taken directly from the UV system, independent of the main works PLC or alarm annunciation:

- "UV System Power Failure". Failure of a main power supply to the UV plant.
- "Critical Instrument Failure". Failure of an instrument or communications link resulting in a control signal being lost. This condition shall instigate a default routine in the PLC control to energise all available UV lamps and ensure that disinfection will be achieved. Personnel and plant safety must be maintained at all times.

- "Failure to Meet UV Dose". Failure to meet the minimum dose level, either due to effluent conditions or possible plant limitations, during servicing etc.
- "Low Priority Alarm". An alarm, which requires attention but is not currently putting the plant at risk of failure, i.e. requires attention at the next convenient time slot.
- "High Priority Alarm". An alarm, which requires urgent attention to stop or prevent plant from failing, i.e. requires immediate attendance.

The low and high priority alarms shall be fully configurable to allow the Engineer / Owner to determine the priority levels for individual alarms.

3.1.6. Low UV intensity alarms shall be provided to detect possible water quality problems or fouling of the system. Alarm set point shall be field adjustable.

3.1.7. Individual lamp status shall be monitored by the PLC and provide status information on the operator interface showing:

- Individual lamp On / Off status
- Bank running hours
- Bank On/ Off cycles

Single and multiple lamp failures shall initiate appropriate alarms.

3.1.8. The ballasts shall be electronic microprocessor controlled, designed as slot cards fitting into a rack system with a plug connector for ease of maintenance.

3.1.9. The ballast shall detect lamp failure and initiate a re-strike sequence, independently from any external influence. The ballast shall attempt three re-starts before shutting off.

3.1.10. The ballast shall be capable of varying the lamp power between 50-100% proportional to a 4-20 mA control signal.

3.1.11. A UV Disinfection Management System shall control the ON/Off cycling and lamp power of the UV banks based upon a Dose pacing philosophy.

The Management System shall utilize a UV sensor located within the UV bank(s) to accurately sense any change in lamp power, effluent transmittance and compensate for any reduction in the UV-C output due to lamp aging.

The UV Disinfection Management System shall receive inputs from the UV sensor and flow meter and shall automatically adjust the received UV dose to maintain the required levels under all operation conditions.

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11682

Section 11683

Mixer for Chlorine Solution Tank

Part 1 - General

1.01 General

This mixer is to be used when operator mix powder with water in chlorine solution tank.

1.02 Design Condition

(a)	Chemical	: Bleaching powder
(b)	Dosing rate	: Average 3 mg/L (Reference)
(c)	Solution tank	: Cylindrical PE Tank, Open top

Part 2 - Products

2.01 Mixer for Chlorine Solution Tank

(a)	Type	: Motorized vertical propeller mixer	
(b)	Material	: Propeller	Stainless or equivalent
		Shaft	Stainless or equivalent

2.03 **Accessories** (per Unit)

(a)	Foundation bolts and nuts	x 1 set
(b)	Air exhaust pipe	x 1 set
(c)	Air vent pipe	x 1 set
(d)	Support for mixer (SS)	x 1set

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11683

Section 11684

Chlorine Dosing Charger with storage tank

Part 1 - General

1.01 General

This system is composed of chlorine dosing charger and storage tank. This system shall be used for disinfection of treated water.

1.02 Design Condition

(a) Chemical : Bleaching powder

(b) Dosing rate : Average 3 mg/L (Reference)

Part 2 - Products

2.01 Chlorine Dosing Charger

(a) Type : Manual flow control and gravity flow type

(b) Accuracy : Within ±10% of full scale

(c) Material : Body PVC

(d) Accessory (per unit) : Pipe from storage tank to charger x 1set
Base for the charger (CS) x 1 set

2.01 Chlorine Storage Tank

(a) Type : Open top cylindrical tank

(b) Tank volume : 0.1 m^3 (Reference)

(c) Material : Polyethylene or equivalent

(d) Accessory (per unit) : Base Plate for tank x 1 set
Outlet ball valve (PVC/EPDM) 15A x 1 pc
Ball tap 1 set/ dosing charger and 1 set/ storage tank

Part 3 - Execution

Refer to various sub-sections in Section 11000 hereof.

END OF SECTION 11684

DIVISION 12.

FURNISHINGS

(Not Used)

Division 12: Furnishings

Section 12100 Laboratory Equipment and Fittings

Part 1 General

1.01 Description

The work included in this Section comprises design, supply, installation, inspection, testing at site and commissioning of the laboratory including all specified equipment, instruments, glassware, chemicals, books, furniture and fittings, services and spares, all to an approved programme, supply, installation, inspection, testing at site and commissioning of the laboratory including all equipment, instruments, glassware, chemicals, books, furniture and fittings, services and spares.

1.02 General Requirements

A A fully furnished laboratory is to be provided with the capacity to undertake the chemical, physical, bacteriological and biological examination and testing of water, the quality control of chemicals delivered for treatment purposes, the testing and treatment of sludge and the testing of filter media as detailed herein, in order that the performance and operation of the treatment works can be adequately monitored.

B The design shall be in accordance with best modern practice and shall facilitate inspection, cleaning, routine maintenance, and repair to ensure satisfactory operation under all service conditions. The laboratory or any part may be a standard design provided that this is generally in accordance with the Specification.

C Whenever provisional ratings and quantities are stated in the Contract Documents, the figures quoted are for guidance only. The Contractor shall be responsible for establishing the correct final ratings and quantities to meet the requirements of the Specification.

D The Contractor shall employ a specialist in laboratory design in the planning and design of layouts for the laboratory. The Contractor shall submit detailed drawings of the laboratory design and layout for the Employer's approval prior to placement of orders for furniture, fittings or equipment. The drawings shall coordinate all equipment and fittings and shall include details of benches, furniture, air handling (including extraction), electrical wiring and sockets, lighting, plumbing, drainage and all other laboratory services.

1.03 Safety Requirements

A The Contractor shall ensure that the laboratory is safe in use, and that the duties of those who design, manufacture, import, or supply any part of the equipment and fittings in connection therewith are fulfilled in respect of any safety regulations imposed by law or by any authorised body empowered to make such regulations.

B Safety instructions relevant to the operation of the Plant shall be included in the Instruction Manual, and on any permanent labels fixed to the Plant.

C Leakage and pressure tests shall be carried out on all pipe-work which is to be built in. These tests shall be carried out after erection. The Contractor shall ensure that the pipe-

work is suitably anchored and supported to sustain the test pressure. The Contractor shall advise the Engineer when these tests are to be carried out and all tests shall be witnessed and subject to the Engineer's approval.

1.04 Particular Requirements

The Laboratory shall be fully equipped to undertake chemical analysis and laboratory testing of water with particular reference to the tests listed below and the analytical methods given in 'Standard Methods for the Examination of Water and Wastewater' latest edition published by APHA, AWWA, WEF or the UK Standing Committee of Analysts, 'Methods for the Examination of Waters and Associated Materials', HMSO, London. The Contractor shall also allow for such other test as will be required for his proposed plant and processes etc.

Chemical/Physical Tests

taste and odour	
temperature	silica -reactive
pH value	phosphorus -total
colour	nitrogen -ammoniacal
turbidity	nitrogen -nitrite
conductivity	nitrogen -nitrate
dissolved solids	aluminium
suspended solids	iron
alkalinity	manganese
total hardness	biochemical oxygen demand
calcium	chemical oxygen demand
magnesium	chlorine residual
oxygen -dissolved	Sludge evaluation and treatability testing
fluoride	Sludge cake solids content
chloride	Sieve analysis and testing of filter media
sulphate	Specific gravity
cyanide	Laboratory treatment (jar) testing

Treatment process chemical consignment testing of:

Alum	Lime

Bacteriological tests

Total coliforms	
E. coli	Colony counts

Biological testing

Giardia cysts and cryptosporidium	Algal enumeration and identification

1.05 Quality Assurance

Workmanship and the general finish shall be of first-class commercial quality, in accordance with the best instrument technology practice. Labels in compliance with BS5378 and BS5499 shall be provided to warn of dangerous or potentially dangerous circumstances or substances. Inscriptions or graphic symbols on warning labels shall be black on a yellow background as detailed in BS5378. Instruction labels shall be provided where safety procedures are essential to protect operating and maintenance personnel from hazardous or potentially hazardous

conditions e.g. requiring the wearing of protective clothing. These obligation signs shall have inscriptions or graphic symbols in white on a blue background as detailed in BS5378.

1.06 Submittals

The following manufacturer's data shall be provided:

1. Published data, or manufacturer's letter, clearly indicating that each product to be furnished complies with these Specifications and is recommended for the application shown.
2. Complete instructions for handling, storage, installation and protection of each product.

1.07 Delivery, Storage and Handling

A Materials shall be delivered in manufacturers' unopened containers or bundles fully identified with brand, type, grade, class and all other qualifying information.

B Materials shall be stored in a dry location in such a manner as to prevent damage or intrusion of foreign matter. Materials, which have once been damaged, shall be conspicuously marked "Rejected" and removed from the work site.

Part 2 Products

2.01 General

A The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, may be acceptable subject to the Engineer's approval.

B Each area in the laboratory shall have sufficient enclosed storage space for all materials and glassware in frequent or regular use. Storage space shall be provided in the laboratory store for appropriate stocks of materials and spare parts. Secure storage shall be provided for inflammable or otherwise hazardous materials.

C Laboratory equipment listed shall generally consist of standard products. Catalogues or commercial pamphlets describing each major item shall be provided by the Contractor together with details of laboratory furnishings and services.

D Materials used in the construction of laboratory furnishings and fittings shall be the best of their respective kinds and shall be selected for their specific applications. Methods of construction shall be of proven design.

E The laboratory floor shall be able to withstand heavy traffic as well as stationary loads. The surface shall be non-slip, seamless, resistant to chemical attack and easy to clean.

F Air handling shall be provided throughout the laboratory area with allowance being made for fume extraction within the laboratory .The bacteriological laboratory shall be provided with independent air handling facilities.

G The main laboratory area shall have natural light with a minimum average intensity of 500 lumen/m^2 at working level for artificial light throughout the laboratory area. Direct sunlight shall be avoided for all benches.

H Sectional units shall be designed and constructed to develop maximum strength and rigidity. Each sectional unit shall be completely fabricated ready for placement in the laboratory assembly and shall be a complete integral rigid unit in itself to permit relocation at any subsequent time. Under-bench components located on the laboratory floor shall be equipped with levelling devices, easily adjustable from within the units, to compensate for any unevenness in the laboratory floor. Above-bench units shall include draining and equipment racking and shelving of various kinds. Shelving shall be of a width appropriate for its purpose and shall be restricted so that only single line capacity is available when used for carrying chemical reagent bottles, glassware or items needing careful handling, in the main laboratory rooms.

I Sectional units shall be constructed of timber with timber under-framing. Both sides of the sectional units shall be surface impregnated with epoxy or equivalent chemical resistant resin.

J Materials for the construction of bench tops shall be appropriate for their use. Bench tops for supporting sensitive instruments shall be rigid and have a surface that is hard and stable and easily cleaned. Bench tops for balances shall be made of marble and provided with anti-vibration supports.

K For main laboratory rooms, the bench tops shall be of epoxy resin (or material of equivalent durability and chemical resistance). Bench tops in bacteriological/biological rooms shall be made of epoxy resin or equivalent material, to enable easy maintenance of surface cleanliness.

L Bench tops intended for applications where protection from heat is necessary shall be of a suitable fire-resistant material of low thermal expansion.

M Units shall be supplied complete and ready for installation from an approved laboratory supplier.

N Fume cupboards shall be confined working bench spaces equipped with services and provided with an efficient means of removing objectionable fumes. Fume cupboards shall be provided with an efficient extraction system designed to give a face velocity of not less than 0.5m/s. The framing shall be a one-piece interior lining moulded from epoxy or polyester resin reinforced with fibreglass and epoxy-coated steel exterior. The vertical sash shall be tempered safety glass of about 6 mm thick, counter-balanced for fingertip control. Airfoil below the sash shall be epoxy-coated. Epoxy resin work surface with sink unit, remote control service fittings and flow indicator shall be provided. One fume cupboards of about 1800(W) x 800(D) x 1500(H) mm with chemical storage base cabinets for organic solvents, corrosive chemicals, acid and alkaline shall be provided.

O At least two canopy exhaust hoods of approximate dimensions 1200(W) x 750(D) x 450(H) mm shall be provided.

P Ducting for extraction systems shall be of suitable material chosen to give the best resistance to the chemical and physical conditions to which they will be subjected such as polypropylene, rigid PVC or moulded glass fibre laminate. The extraction system shall be designed to draw air through the cupboard at such a rate that with the window fully open the velocity of air entering the cupboard shall not be less than 0.5 m/s.

Q Service pipework shall be located as far as possible behind the sectional units and shall be readily identifiable for purposes of inspection and repair. Pipes shall be colour coded in accordance with BS 1710 or ISO/R 509.

R Sinks which shall be provided in each laboratory shall be of glazed fireclay or approved alternative inert material, fitted beneath the bench top, this being cut to overhang the sink and throated on the underside to provide a water break. Sampling sink shall be of stainless steel and drain boards constructed of 1.5 mm thick stainless steel as an integral assembly.

S Waste systems shall be supplied in "Vulcathene" or similar high density polyethylene. All sinks shall be fitted with suitable anti-syphon bottle traps, with removable bases.

T Balance tables shall be floor mounted, anti-vibration, marble topped to provide a firm mounting for the analytical balance. They shall consist of a worktop of at least 80 mm thickness mounted on 2 side members and a centre member through rubber anti- vibration pads. The side and centre members shall be at least 80 mm in thickness and a minimum of 450 mm apart to form a kneehole for the operator. The table top shall be at a height of approximately 750 mm above floor level. The working surface dimensions of the table shall be a minimum of 1500 mm x 600 mm.

2.02 Spare Parts

A All laboratory equipment shall be provided with spares which will be sufficient to cover the usual needs of equipment being used regularly and for a period of one year of operation.

B Spare parts shall be accurately manufactured from the same materials and to the same dimensions and tolerances as the originals. They shall be new, unused and inter-changeable with the parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions at the Site. Each spare part shall be clearly and permanently marked on the outside of its packing with its description and purpose. If more than one spare is packed in a single container, a general description of its contents shall be shown on the outside of the container and a detailed list enclosed. Containers shall be; marked and numbered in an approved manner for identification. Containers shall be designed to facilitate opening and repacking.

Part 3 Execution

3.01 Conditions of Surfaces

The Contractor shall examine substrata, adjoining construction, and conditions under which the Work is to be installed and the work shall not proceed until unsatisfactory conditions have been corrected.

3.02 Installation

A All carpentry shall be in accordance with Sections 06100 and 06400 as appropriate.

B All plumbing shall be in accordance with Section 15410.

C All mechanical and electrical installations shall be in accordance with the relevant sections of these Specifications.

3.03 Protection

All finished work shall be protected so that it will be without damage at the time of completion of the Works. Damaged or soiled items, surfaces, panels, etc. shall be removed and replaced to the satisfaction of the Engineer.

END OF SECTION 12100

DIVISION 13.

SPECIAL CONSTRUCTIONS

Section 13410

General Instrumentation and Control

Part 1 General

1.01 Description

A This Section covers the general requirements for furnishing and installation of all instrumentation, control and monitoring (ICM) systems complete in every detail for the purposes specified and shall form a part of all ICM Sections of Division 13 unless otherwise specified. Other ICM Sections shall supplement this Section as necessary.

B The Contractor shall carry out the work included in the ICM Section of Division 13 as specified herein and other parts of Division 13. The intent of the ICM Sections of Division 13 is to require that the complete Instrumentation, Control and Monitoring System, i.e., primary elements, panel mounted and miscellaneous field instruments, etc. shall be furnished by the electrical installation contractor to assure system uniformity, subsystem compatibility and coordination of all system interfaces. Deviations may be considered in special circumstances but must be approved by the Engineer.

C The Contractor shall furnish all tools, equipment, materials, and supplies and perform all labour required to complete the furnishing and installation of, including all instrumentation signal and power conduit and wiring not specifically shown on the electrical drawings, validation, start-up and operational testing of a complete and operable Instrumentation, Control and Monitoring System as indicated on the Drawings and as specified herein.

D The Contractor shall provide all the necessary equipment components and interconnections and the services of the manufacturers, engineering representatives for the engineering, implementation, start-up, operation, and instruction, to insure that the Employer receives a completely integrated and operational ICM system as herein specified.

1.02 System Responsibility

A The Contractor's attention is directed to the fact that the ICM system as specified in these ICM Sections of Division 13 is an integrated system and therefore shall be provided by a single competent, qualified instrumentation subcontractor (hereinafter referred to in these ICM Sections as the ICM Subcontractor) who shall have total responsibility for the ICM work of this Division. The entire system installation including calibration, validation, start-up, operational testing, and training shall be performed by qualified personnel, possessing all the necessary equipment and who have had experience performing similar installations. The System shall be integrated using the Subcontractor's latest most modern proven design and shall, as far as practical, be of one manufacturer. Overall system performance shall be guaranteed by the electrical installation contractor.

B The Contractor shall subcontract the work under these ICM Sections to a qualified electrical installation contractor who shall perform said work but it shall be understood that this shall not relieve the Contractor from any responsibility under the Contract. Although many references made herein are to work requirements and responsibilities of the electrical installation contractor, such provisions shall only mean that responsibility shall pass through the electrical installation contractor but in the final analysis shall rest with the Contractor, and as such any provisions herein shall not waive the Contractor’s

responsibility to complete these works in complying with the requirements set out herein and the Contract.

C The electrical installation contractor shall be responsible for the correct installation of all hardware and systems specified in these ICM Sections. Certain Primary Elements, Final Control Elements, etc., although provided as part of this Division, shall be installed in the process lines under other Divisions of these Specifications; however, this installation shall be under the direct supervision of the electrical installation contractor.

D The electrical installation contractor shall be responsible to see that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling, and alarming devices and all appurtenances, are completely compatible and shall function as outlined and he shall furnish and install such additional equipment, accessories, etc. as are necessary to meet these objectives at no cost to Employer.

1.03 Quality Assurance

A. The electrical installation contractor shall be a recognized DCS systems integrator, a panel fabricator, and installer of field instruments. The electrical installation contractor shall have a minimum of 10 years documented experience in providing ICM equipment on a single system responsibility basis for municipal water and wastewater treatment processes. Also, the personnel employed for system engineering, supervision, start-up, operational testing and training shall be regular employees of the electrical installation contractor. The electrical installation contractor shall be fully responsible for the technical supervision of the installation to ensure that it is proper in all respects.

B. At the time of quoting to prospective Contractors prior to tender opening, each prospective single electrical installation contractor shall execute and submit a written certification of intent to assume full responsibility for the complete requirements of all ICM Sections.

C Each prospective Contractor shall include with his tender a certification completed by the proposed single electrical installation contractor. The certification shall be signed by his authorized responsible representative, and it shall include the following statement.

(Corporate name of Subcontractor)

hereby certifies intent to assume and execute full responsibility to select, to furnish, to supervise installation and connection, to test, calibrate, validate, and place into operation, all meters, instruments, alarm equipment, control panels, and all other assemblies, components, and accessories needed to place into service complete operating process control systems, and in full compliance with the requirements of all ICM Sections.

In addition, it is certified that drawings and data will be prepared and submitted, specified field services will be performed by qualified personnel, operating personnel will be instructed, and technical manuals will be prepared and submitted, all as required by the ICM Sections.

Finally, it is certified that the quotation offered provides for full and complete compliance with the requirements of the ICM Sections of Division 13 without exception.

D Standard of Quality: Furnish equipment of the types and sizes specified which has been demonstrated to operate successfully. Wherever on the Drawings and in these

Specifications, materials or equipment have been specified by using the name of products or manufacturers, the term "or equal and approved" is always understood to follow immediately. Material or equipment, so specified, have been selected as being most suitable and are regarded as a standard and are not intended to eliminate others of equal quality and performance. Workmanship for the installation of instruments, wiring, piping, painting and labelling shall be equal to the best industrial standards for instrumentation and control work. All electrical equipment and materials, including their installation, shall conform to Division 16 unless specified otherwise in this Division.

E Factory Inspection: The Engineer or his representative, including the Employer's representative as the case maybe, may inspect fabricated equipment at the factory. Notify the Engineer in sufficient time so that factory inspection can be arranged. Factory inspection shall be made only after manufacturer has performed satisfactory checks, adjustments, tests and operations. Tests shall be made using simulated inputs and output loads. Approval of equipment at the factory only allows the manufacturer to ship the equipment to the site, and does not constitute final acceptance by the Engineer.

F The Engineer will indicate on return of the approved submittal each item requiring factory inspection. Lack of such indication by the Engineer shall constitute a waiver of factory inspection.

1.04 Submittals

A. Refer to Section 01300 hereof for required method of preparation and transmittal, and conform to requirements herein.

B. The electrical installation contractor shall provide all drawings, data and information required to supplement the Drawings. The following information relative to the work of the ICM sections shall be the responsibility of the electrical installation contractor to determine, furnish, coordinate with other Divisions, and submit for approval, based upon the systems specified.
   1. Location of all primary elements, control panels, and final control elements.
   2. Instrumentation signal and power conduit runs between control panels and field instruments and devices.
   3. Quantity and sizes of instrumentation conductors.
   4. Location of all equipment having alarm and equipment status contacts.
   5. Major instrument conduit runs.
   6. General control room and control panel layouts.
   7. Tubing for hydraulic and pneumatic signals and/or power between main headers and control panels, field mounted primary elements, field instruments and final control elements.
   8. Number of sizes of tubing required for all pneumatic and hydraulic signals.
   9. Point of connection to any hydraulic or pneumatic supply lines.
   10. Detailed control panel layouts.

C. Arrange a conference between the electrical installation contractor and the Engineer or his representative within sixty days after award of the Contract for the purpose of informally discussing in detail and verifying the correctness of the electrical installation contractor's system engineering methods and equipment and to generally provide a framework for communication and coordination. This conference shall be attended by electrical installation contractor's representative and duly authorized representatives of the Contractor and the Engineer. Prepare a draft of the submittal for review. The draft shall include the following, as a minimum:

D Identify items by tag number, description, function, manufacturer, model number, descriptive literature and statement as to whether item is "as specified or equivalent". Refer to the General Conditions regarding the submission of equals.

E Before proceeding with any manufacturing, submit Shop Drawings for approval in complete bound sets indexed by specification number. Describe the items being submitted. Manufacturer's specification or data sheets shall be clearly marked to delineate the options or styles to be furnished. Submit only complete systems, not pieces of equipment from various systems. Show dimensions, physical configurations, methods of connecting instruments together, mounting details, and wiring schematics. Schematics shall be complete with tag and terminal numbers. submit fabrication drawings, nameplate legends, and control panel internal wiring and piping schematic drawings clearly showing all equipment and tag numbers on all panels. Submit panel graphic drawings where applicable. Include material specifications lists where applicable. Include a draft of the theory of operation for all relay logic circuits whether implemented via programmable controllers or relays to be included in the instruction manual required below.

F Submit an "Equipment Specification Data" form for each item of equipment which shall summarize the specification features as called for in these Specifications and include such other necessary data as would provide a complete and adequate specification for reordering an exact duplicate of the original item from the manufacturer at some future date. The assigned tag numbers and manufacturer's part numbers shall be included but will not be considered as a substitute for any of the required statement of specifications. More than one tag numbered item may be included on a sheet.

G Prepare and submit instrumentation loop diagrams for all work included in the ICM Sections in accordance with ISO.

H Contractor shall submit reproducibles of complete schematics, wiring diagrams and installation drawings to include all installed field and panel conduit and piping/tubing runs and routing, tray systems, supports, mounting details, point to point diagrams with a cable, wire, tube and termination numbers. Drawings shall be a record of work as actually constructed and shall be labelled as "Record". One copy of applicable schematics and diagrams shall be placed in each control panel in a protective envelope or binder.

I Instruction Manuals. Furnish Instruction Manuals and Part Lists for instrumentation equipment provided under the ICM Sections. Obtain distribution method instructions from the Engineer or his representative.

1. Schedule. Deliver two copies of manuals not later than the equipment shipment date. After installation is complete, update the manuals to reflect any changes which occurred during installation and deliver balance of manuals to the Engineer.

Contents. include, in the manuals, not less than the following information, as applicable, for each instrument, equipment, subsystem and/or control loop:

a. General, introduction and overall description, purpose, functions, simplified theory of operations, etc.
b. Specifications (including equipment specification data sheet as described above under Shop Drawings).
c. Installation instructions, procedures, sequences, tolerances, and precautions.
d. Operational procedures.
e. Shut-down procedures.
f. Maintenance, calibration, and troubleshooting instructions.
g. Schematics and wiring diagrams.

h. Detailed circuit operational description including annotated programmable controller ladder diagrams.
i. Parts list and spare parts recommendations.
j. Material, test and calibration certificates.

2. Format. Use drawings and pictorials to illustrate the text to the extent necessary to insure a clear, concise presentation. if manuals have been written to cover a family of similar instruments or equipment, strike out inapplicable information in a neat fashion or emphasize applicable portion by heavily weighted arrows, circles or boxes; whichever provides the clearest and neatest presentation. Where identical instruments are used in more than one control loop or subsystem, include only one instruction manual, however, an index by tag number for all instruments shall identify its location in that manual.
   Control loop and/or subsystem operational descriptions shall identify the function of each instrument and its relation to the other instruments in the loop.
3. Binding. Bind each manual in a cover which indicates the system name, manufacturer's name, local address and telephone number, and year of purchase. Punch and bind manuals in standard three ring binders and include system name and ICM Subcontractor's name on binding.

J The ICM Subcontractor, or his authorized representative, shall submit a certified report for each control panel and associated field instruments certifying that the equipment (1) had been properly installed under his supervision, (2) is in accurate calibration, (3) was placed in operation in his presence, (4) has been checked, inspected, calibrated and adjusted as necessary, (5) has been operated under maximum power variation conditions and operated satisfactorily, and (6) is fully covered under the terms of the guarantee.

K Demonstration and Final Operating Test Plans and Results. Submit for approval not later than 30 days prior to the test demonstration, a written plan for demonstrating that each system of equipment provided under the ICM Sections meets the specified operational requirements. The plan shall include procedures to be used in final operation testing of entire systems including a description for each system of test methods and materials, testing instruments and recorders, a list of the equipment involved with the functional parameters to be recorded on each item, and shop drawings of required temporary by-passes and like facilities. Submit three copies of test results and records for all final operation tests.

1.05 Product Delivery, Storage and Handling

Box, crate, or otherwise enclose and protect instruments and equipment during shipment, handling, and storage. Keep all equipment dry and covered from exposure to weather, moisture corrosive liquids and gases or any element which could degrade the equipment. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Repair any damage as directed and approved.

1.06 Job Conditions

Drawings are diagrammatic and show the intended arrangement for system operation, piping, and appurtenances. Conform to Drawings as closely as possible and exercise care (1) to secure neat arrangement of piping, valves, conduit, and like items, and (2) to overcome structural interferences. Verify dimensions and conditions at the place of work, and install materials and equipment in the available spaces.

1.07 Warranty

A. Warranties and guarantees by the suppliers of various components in lieu of single-source responsibility by the equipment manufacturer will not be accepted. The equipment manufacturer shall be solely responsible for the warranty. In the event a component fails to perform as specified or is proven defective in service during the warranty period, excluding items normally expended during operation, the equipment manufacturer shall provide a replacement part without cost to the Employer.

B. The Contractor shall furnish the Employer with manufacturer's guarantee and warranty certificates for all equipment, duly registered with the manufacturer.

1.08 Accessory and Maintenance Manuals

A Furnish the following items as specified herein. Deliver to the Engineer, as directed, with itemized list in a letter of transmittal accompanying each shipment.

B Furnish special tools, instruments, and accessories for maintaining instruments and equipment requiring periodic repair and adjustment as specified elsewhere herein. Also, furnish special lifting and handling devices for equipment requiring such devices.

C Deliver in manufacturer's original containers labelled to completely describe contents and equipment for which it is furnished. Spare parts shall be sufficient for years of normal service and shall include, as a minimum, the following basic items:

1. Five percent but not less than one minimum of each type of plug-in unit, etched or printed circuit board assembly.
2. Ten percent but not less than one of each type relay and timer used.
3. Ten percent but not less than one of each type switch used.
4. Ten percent but not less than six of each type light bulb and fuse used.
5. Minimum of two years supply of expendable items, diskettes, toner cartridges etc.

Part 2 Products

2.01 Materials and Standard Specifications

Provide instruments, equipment and materials suitable for service conditions and meeting standard specifications such as IEC, ANSI, ASTM, ISO, BS, JIS and SARA. The intent of this Specification is to secure instruments and equipment of a uniform quality and manufacture throughout the plant; i.e., all instruments in the plant, supplied by the electrical installation contractor, of the same type shall be by the same manufacturer. This allows the stocking of the minimum number of spare parts.

2.02 Structural Steel Fabrications

Design all fabrications for dynamic and vibratory loadings. Use structural steel shapes conforming to ASTM A36, A500, A501, A570, A618, or equal and approved, as applicable. Conform welding to AWS D2.0 Code. Galvanize specific items in accordance with ASTM A123 or A386 as applicable; use galvanized bolts and fasteners with galvanized assemblies. Use minimum 6 mm thickness for steel entirely or partially submerged during equipment operation. Submit design calculations showing adequate structural integrity for the intended purpose.

2.03 Mountings

A Mount and install equipment as indicated. Where not shown, mount field instruments according to best standard practice on pipe mounts, pedestal mounts, or other similar means in accordance with supplier's recommendation. Where mounted in control panels, mount according to requirements of that Section.

B Equipment specified for field mounting shall be suitable for direct pipe mounting, pedestal mounting, or surface mounting and non in-line indicators and equipment with calibration adjustments or requiring periodic inspection shall be mounted not lower than 900 mm nor higher than 1500 mm above walkways, platforms, catwalks, etc. All such equipment shall be weather and splash proof, and electrical equipment shall be in NEMA 4 cases. External equipment shall be protected from direct sunlight by a well-ventilated cabinet, canopy or other type of sunshade. If mounted in a designated hazardous area, the equipment shall be explosion proof or rated intrinsically safe, whether so specified herein or not.

C The equipment shall be guaranteed suitable for operation under the environmental conditions specified in Section 2.06 and shall be designed:-

1) Such that routine and occasional maintenance throughout its life shall be a practical minimum compatible with the preservation of maximum reliability.
2) To withstand the electrical, mechanical, thermal and atmospheric stresses to which it may be subjected under operational conditions, without deterioration or failure.
3) Constructed to the highest available standards of manufacture, reliability, accuracy and repeatability.

D The degree of protection for equipment enclosures shall be in accordance with NEMA or BS EN 60529, IEC 529 or other approved equivalent standard.

2.04 Instrument Identification

All major instrumentation and equipment items or systems specified in the ICM Sections are identified by system and tag numbers. This same number appears in the tag number designations on the Drawings and on the schedules of these Specifications. All instrumentation and equipment shall be identified by nameplates and/or tags. Nameplates for panels and panel mounted equipment shall be as specified under Panels and Control Room Hardware. Field equipment shall be tagged with assigned instrumentation tag number and function. Tags shall be black lamacoid with engraved white characters of 5 mm minimum height. Tags shall be attached to equipment with a commercial tag holder using a stainless steel band with a worm screw clamping device or by a holder fabricated with standard hose clamps and meeting the same description. In some cases where this would be impractical, use 20 gage stainless steel wire. For field panels or large equipment cases use stainless steel screws, however, such permanent attachment shall not be on an ordinarily replaceable part. In all cases the tag shall be plainly visible to a standing observer. In addition to tags, field mounted control stations, recorders or indicators shall have a nameplate indicating their function and the variable controlled or displayed. Nameplate shall be attached by one of the above methods.

2.05 Electronic Equipment

If the equipment is electronic in nature, provide solid state equipment to the extent practicable. Select components of construction for their suitability and reliability. Employ adequate component derating to preclude failures because of transients and momentary overloads reasonably expected in normal operation. Design units for operation without forced cooling, unless such cooling is an integral part of the device. Provide protection on all relevant circuits and equipment against the effects of lightning and other induced voltages.

2.06 Equipment Operating Conditions

All equipment shall be rated for normal operating performance with varying operating conditions over the minimum specified ranges.

2.07 Power Supplies

Provide electrical instruments, transmitter power supplies and control devices for operation on 230 Vac, 50 Hz current. Transmitter power supplies shall be provided for individual transmitters. Process critical instruments shall receive power from a UPS, as specified in Section 16.

2.08 Signal Isolators, Converters and Conditioners

Insure that input-output signals of all instruments and control devices (whether furnished by the electrical installation contractor or not) are compatible. Unless otherwise specified signals between field and panels shall be 4 to 20 mAdc unless specifically approved otherwise. Granting such approval does not relieve the electrical installation contractor from the compatibility requirement above. Provide signal isolators and converters as necessary to obtain the required system performance. Mount the devices behind control panels or in the- field at point of application.

2.09 Auxiliary Contacts by Others

Provide instruments and equipment to connect to auxiliary contacts provided by others for alarms, status of equipment, interlocking, and other functions as indicated and as specified herein.

2.10 Air Supply Valves

Provide 316 stainless steel valves for instrument air supply shutoff, regulating, switching, metering, valve manifolds, etc.

2.11 Instrument Piping

Provide instrument air and instrument pneumatic piping, as specified in other Divisions and as necessary and/or as specified herein. Instrument air header shall be furnished and installed under other Divisions. Connect to main instrument air header at a point not more than 3 m distant from air consuming device(s). Use 10 mm minimum 316 stainless steel tubing. All connections to equipment shall be made with separable or union type fittings and shall include shut-off valves. All hydraulic and/or pneumatic piping shall be tested for leaks prior to placing the system in operation. Provide instrument pneumatic air fittings, with double ferrules.

2.12 Filter Regulator

Furnish a filter-regulator and discharge pressure gage furnished with a dripwell assembly for each point of use where regulated instrument air is required. Separate regulators shall be used for each control loop.

2.13 Manifolds

Furnish an integral three-valve manifold for each differential pressure transmitter on a flow application.

2.14 Painting

Provide factory paint for all instruments and equipment except where in pipelines. Provide paint as required in Division 9 for structural supports, brackets, etc.

2.15 Electrical

A. The construction work shall include all the power supply wiring, instrumentation wiring, interconnecting wiring and equipment grounding as indicated, specified and required and not specifically included under Division 16.

B. Wiring installations shall include cables, conductors, terminals connectors, wire markers, conduits, conduit fittings, supports, hardware and all other required materials not specifically included in the work of other Divisions.

C. Provide the materials and complete all the required installations for equipment grounding as specified in Division 16 of these Specifications indicated on the Electrical Drawings or necessary to complete the Work.

D. Incidental items, not specifically included in the Contract Documents, that can legitimately and reasonably be inferred to belong in the instrumentation work shall be provided by the ICM Subcontractor.

E. Field Wiring. Ring out signal wiring prior to termination. Provide wire number tags marked in indelible waterproof form of slip-on type or equal for each termination. Provide preinsulated crimp-on connectors for wire terminations and splices. Use ratchet type crimping tool which does not release until proper crimp pressure has been applied.

2.16 Process Connections

Piping, tubing, and capillary tubing shall be 316 stainless steel. If this material is unsuitable for ambient or process conditions, piping and tubing shall be of a material approved by the Engineer. Slope lines according to service to promote self-draining or venting back to the process. Terminate connection to process lines or vessels in a service rated block valve, that will permit closing off the sense line or removal of the element without requiring shut down of the process. Include drip legs and blow-down valves for terminations of sense lines at the instruments when mounted such that condensation can accumulate. Process vessels, line penetrations, connecting fittings, and block valves shall be furnished and installed under other Divisions of these Specifications but coordinated by the ICM Sections. Instrument process taps shall be a minimum 18 mm NPT except flow meter taps which shall be 12 mm NPT.

Part 3 Execution

3.01 Inspection

Inspect each instrument and piece of equipment for damage, defects, completeness, and correct operation before installing. Inspect previously installed related work and verify that it is ready for installation of instruments and equipment.

3.02 Preparation

Ensure that installation areas are clean and that concrete or masonry operations are completed prior to installing instruments and equipment. Maintain the areas in a broom clean condition during installation operations.

3.03 Factory testing of Control Panels

Verify, at the factory, wiring continuity and verify panel operation by simulated inputs and outputs. Provide report certifying the control panels are operable and meet the Specifications.

3.04 Manufacturer's Installation and Supervision

When specified elsewhere in Sections 13415, 20, 30, 40 and 50 furnish the services of authorized factory personnel especially trained and experienced in the installation of the equipment to: (1) supervise the installation in accordance with the approved Instruction Manual; (2) be present when the instruments and equipment are first put into operation; (3) inspect, check, adjust as necessary, and approve the installation; (4) calibrate the instruments, in accordance with the Specifications herein, until all trouble or defects are corrected and the installation and operation are acceptable; and (5) prepare and submit the specified Manufacturer's Certified Report. Include all costs for representative's services in the Contract Price.

3.05 Instrument Calibration

Provide the services of trained and experienced instrumentation technicians, tools and equipment to field calibrate each instrument to its specified accuracy in accordance with the manufacturer's specifications and instructions for Calibration. Each instrument shall be calibrated at 10 percent, 50 percent and 90 percent of span using test instruments to simulate inputs and read outputs that are rated to an accuracy of at least 5 times greater than the specified accuracy of the instrument being calibrated. Such test instruments shall have accuracies traceable to the National Bureau of Standards, as applicable. Provide a list and basic specifications for instruments used. Provide a written report to the Engineer on each instrument certifying that it has been calibrated to its published specified accuracy. This report shall include all applicable data as listed below plus any defects noted, correction action required, and correction made. Data shall be recorded on prepared forms and shall include not less than the following items:

1. Facility identification (Name, location, etc.)
2. Loop identification (Name or function)
3. Equipment tag and serial numbers.
4. Scale Ranges and units.
5. Test mode or type of test.
6. Input values or settings.
7. Expected outputs and tolerances.
8. Actual readings.
9. Explanations or special notes as applicable.
10. Tester's certification with name and signature.

3.06 System Validation

A Provide the services of trained and field experienced instrumentation engineer(s) to validate each system to verify that each system is operational and performing its intended function within system tolerance. System tolerance is defined as the root-mean-square sum of the system component published specified accuracies from input to output. Validate each system by simulating inputs at the first element in loop (i.e. sensor) of 10 percent, 50 percent and 90 percent of span, or on/off and verifying loop output devices (i.e. recorder, indicator, alarm, etc. except controllers). During system validation, make provisional settings on levels, alarms, etc. Verify controllers by observing that the final control element

moves in the proper direction to correct the process variable as compared to the set point. Verify that all logic sequences operate in accordance with the specifications.

B Cause malfunctions to sound alarms or switch to standby to check system operation. Check all systems thoroughly for correct operation. Test equipment for this function shall be as specified under "Instrument Calibration".

C Immediately correct all defects and malfunctions' disclosed by tests. Use new parts and materials as required and approved and retest. Provide a report certifying completion of validation of each instrument system. This report shall indicate calculated system tolerances, data verifying that the system meets these tolerances, and any provisional settings made to devices. Data sheets shall be similar to those used for Calibration.

3.07 Final Operational Testing and Acceptance

A Upon completion of instrument calibration and system validation, test all systems under process conditions. The intent of this test is to demonstrate and verify the operational interrelationship of the instrumentation systems. This testing shall include, but not be limited to, all specified operational modes, taking process variables to their limits (simulated or process) to verify all alarms, failure interlocks, and operational interlocks between systems and/or mechanical equipment.

B Immediately correct defects and malfunctions with approved methods and materials in each case and repeat the testing. Upon completion of final operational testing, submit certified report, with substantiating data sheets, indicating that total ICM System meets all the functional requirements specified herein. The Engineer will countersign this report and it shall constitute final acceptance of the ICM System.

C Testing shall be observed by the Engineer. Notify the Engineer in writing a minimum of 48 hours prior to the proposed data for commencing the test. Upon completion of this test the Contractor shall begin or have begun system start-up. The Employer reserves the right to set the schedule.

3.08 Start-up Assistance

When specified elsewhere in Sections 13415, 20, 30, 40 and 50 provide the services of a factory trained and field experienced instrumentation engineer to assist the Employer personnel during start-up of the system. Purpose of this assistance is to support in making final adjustments of settings on the instrument systems.

3.09 Instruction of the Employer's Personnel

Provide the services of a trained and field experienced instrumentation engineer to conduct group training of the Employer designated personnel in the operation of each instrument system. This training shall be for a minimum time period of 3 days, one day of which may be performed during the operational testing period. Obtain the Engineer's written consent that the training has been adequate. Include instruction covering basic system theory, operating principles and adjustments, routine maintenance and repair, and "hands on" operation. The text for this training shall be the single line loop system drawings (P&ID's/I-Drawings) and operation and maintenance manuals furnished under these Specifications.

3.10 Quality Control and Training Program

A. The Employer has designated certain pieces of equipment, electrical systems and instrumentation systems as key elements of this Project. Where such key items are identified in the individual specification sections, the Contractor and the vendor/manufacturer shall provide a quality control and training program for the Employer personnel to be held at locations overseas. The program shall be submitted to the Employer for approval and shall be designed to: obtain information regarding equipment or components proposed for the Project; witness the manufacture, assembly and testing of equipment and components for the Project; receive training in the proper operations and maintenance of the equipment and components; or for any other purposes as may be directed by the Employer. The program may be used for any of the following purposes or in any other manner required by the Employer.

1. Prior to the approval of key equipment or components for the treatment plant, the Employer may wish to visit the point of manufacture and assembly of the equipment. The Employer may also wish to inspect facilities where the equipment is in use and interview the owners and operators of the equipment to learn their experience and level of satisfaction with the equipment.
2. Following approval of shop drawings for the mechanical equipment, electrical equipment, and instrumentation systems for the Project, the Employer may wish to witness the manufacture, assembly and testing of the items. The Employer may also wish to receive additional operations and maintenance training in the use of the items.

B. The Contractor shall provide whatever assistance is requested by the Employer to develop meaningful itineraries for the program. The Contractor shall provide a bar chart. schedule showing the dates of manufacture, assembly, and testing of each major item or component of the treatment plant. The Contractor shall also provide airline and hotel information as necessary to develop program itineraries. Whenever requested in writing by an authorized representative of the Employer, the Contractor shall provide prepaid air travel, hotel accommodation, surface travel, and other advanced arrangements for the Employer designated personnel. Airline transportation shall be, as a minimum, full fare economy class. Hotels shall be minimum 4-star following recognized grading criteria. Surface transportation shall be by rental car or similar private means. The Contractor shall also provide subsistence. The full cost of the program shall be borne by the Contractor and shall be included in the unit price of the equipment or system indicated in the individual Specification section.

C. The program shall be limited to a maximum of five designated members of the Employer's staff and for a maximum duration of six months, with an average of two weeks allocated for each key element of the program. A goal of the program shall be to achieve a continuous itinerary in a logical progression of destinations, rather than as a series of individual trips.

END OF SECTION 13410

Section 13415

Sequence of Operation

Part 1 General

1.01 General Reference

A This Section describes specifically the Instrumentation, Control and Monitoring System (ICM). It is the intent of this Section to supplement, where applicable, other parts of Division 13 and to describe briefly each main system in order that the electrical installation contractor, as well as suppliers of packaged systems and subsystems, shall be aware of the magnitude of the total ICM System. Interfacing with all systems is a part of the work of this Section.

B Instrumentation and Control Philosophy. The instrumentation and control equipment for the treatment works as described herein, is based on providing sufficient indication and/or automatic control to enable process operation within the design criteria. Automatic control loops are specified only where necessary and include manual bypass control options. Adequate monitoring equipment is specified to permit complete process operational management and evaluation and for operator protection.

C The overall ICM system shall provide instrumentation hardware and software as necessary to perform control functions specified herein and shown on the Drawings. Ensure coordination of instrumentation manufacturer with other work so that necessary wiring, conduits, contacts, relays, converters and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, control panels and receiving stations.

D The Specifications include functional descriptions of the process instrumentation and control systems which specify the responsibility of the ICM Systems Suppliers. These descriptions are to supplement the P&ID - Drawings and neither is complete without the other. If devices other than shown on the Drawings and/or specified herein are required to achieve the result required by the system description, these devices shall be provided to obtain the required result. The system descriptions herein cover all processes in general even though no specific ICM work may be required in a given system. These descriptions are provided for completeness and to indicate the relationships of the ICM work to other divisions. The control loop descriptions are not intended to be an inclusive listing of all elements and appurtenances required to execute loop functions and shall not be considered equal to a bill of materials.

E The Drawings and system descriptions are divided by system designations as shown on the Drawings. All equipment numbers using these designations and systems are described in the indicated order.

1.02 Description of Work

A Except when specifically described otherwise, all motors specified for automatic operation shall be provided with HAND -AUTO (HA) selector switches on local control panels to be installed in local control rooms and with remote position on local panels to be installed adjacent to motors. In the HAND position, the motor shall operate continuously when its START switch is actuated and automatic interlock, if any, shall be by-passed. In the

AUTO position, the motor shall be dependent on the status of the output contact of the control circuit to be described for the individual equipment, which may originate from the PLC local control logic commands will be initiated by manually software control routine generated requests.

B When an item of equipment is selected as Remote, using the LOCAL REMOTE (L/R) switch located on the local panel, commands will be generated from the PLC. Commands will be initiated either by manually entered or software control routine generated requests.

C When specified for automatic standby, motors in multiple unit systems shall also be provided with either a DUTY-STANDBY (D/S) selector for automatic motors with HA switches or START/STOP (S/S) switches for manually operated motors without HA switches. Automatic motors with selectors on AUTO and DUTY shall be controlled by the automatic control circuit, those selected for AUTO and STANDBY shall operate only if a DUTY motor fails to respond. The standby function shall be inoperative when the HA selector is in HAND. For manually operated motors with start-stop (S/S) switches, motors selected for STANDBY shall operate if a motor selected for HAND fails to operate.

D Any lockout stop switch (LOS) associated with operating equipment shall be utilized to stop the equipment on an emergency basis only and shall not permit operation in any mode until the switch is physically reset. Whenever a LOS switch is actuated an alarm signal shall be transmitted to the auxiliary relay panel where the stopped equipment shall be identified. In the case of any conveyor or other operating equipment with exposed moving parts the LOS switch shall be replaced with a lanyard type safety switch (HSS) which extends around the perimeter of the equipment. This device shall allow actuation of the switch from any position around the equipment. Whenever a HSS switch is actuated an alarm signal shall be transmitted to the auxiliary relay panel where the stopped equipment shall be identified.

E LCP displays designated as “OA” shall indicate a failed alarm when an overload trip has occurred at a motor starter. An overload trip shall require reset at the LCP.

F HAND -AUTOMATIC switches which are located at various pieces of equipment or at the MCC shall be provided with additional contacts connected to the DCS for indication to the operator that the equipment has been placed in either the AUTO or REMOTE mode. Equipment running status shall be indicated at all local control panels (LCP) and equipment manufacturer furnished unit control panels (UCP) as well as at the central supervisory PC monitor. Motor running status of all open-close gates or valves shall be indicated at the central supervisory PC monitor as “in transition” by utilizing the position limit switches to deduce that the valve is neither opened or closed. All excess torque switches (WSH) shall be connected to the central supervisory PC monitor where a high torque alarm (WAH) or failed alarm shall be displayed.

1.03 Applicable Standards

ISO3511 Process Measurement Control Functions - Instrumentation Symbolic Representation

1.04 Quality Assurance

Refer to Section 13410 hereof

1.05 Submittals

Secure from the ICM manufacturer and include with submittals, control loop descriptions for each loop in the system. Ensure that tag numbers cross reference with loop diagrams and tag numbers shown on instrument specification forms. Describe each element and include appropriate tag number in parenthesis. When additional elements are necessary, use and assign tag number not in conflict with others and in accordance with ISO procedures.

Part 2 Products - Not applicable to this section

Part 3 Execution

The execution of the system is described in the Particular Specifications

END OF SECTION 13415

Section 13420

Monitoring Devices

Part 1 General

1.01 Description

This Section specifies primary elements of process instrumentation, auxiliary equipment and supplies directly related to the installation an operation of these primary elements, to perform the required functions in conjunction with information and equipment specified in other ICM Sections. Schedules indicating required information are given in the Particular Specifications but shall not be construed as Bills of Material or as a complete listing of all required devices.

1.02 Quality Assurance

A. In addition to requirements of Section 13410, instrumentation and controls equipment furnished shall be manufactured by a firm regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.

B. All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

1.03 Submittals

A. Manufacturer's literature, illustrations, specifications and engineering data including: dimensions, actual weight, performance data and curves showing overall pump efficiencies, flow rate, head, brake horsepower, motor horsepower, speed and shut-off head. Shop drawings showing: fabrication, assembly, installation and wiring diagrams.

Part 2 Products

2.01 Electromagnetic Flowmeters

A. General:

1. Magnetic flowmeters shall use electromagnetic induction to produce a dc voltage proportional to the liquid flow velocity and shall feature absolute zero stability and noise elimination. The meters shall have automatic zero correction.

2. The flowmeters shall comply with standards and recommended practices of ISO 6817. Local indicators shall be supplied with all panel and surface mounted local indicators. Integral converters shall have wall or pedestal mounted local indicators.
3. Flowmeters shall be certified intrinsically safe and suitable for hazardous area class 1, division 1, Group D, where specified in the schedule.
4. Manufacturer shall calibrate and test the flowmeters and provide certificates.
5. Overall accuracy better than ± 0.25 percent throughout the operating range when the velocity is within 0.3 m/s to 10 m/s.

B. Sensor:
1. Flanged NP 16 process connection
2. Stainless steel 304 metering tube and flanges
3. Stainless steel 316 electrodes
4. Stainless steel 316 earthling ring or electrode
5. Lining material suitable for withstanding abrasion of the fluid
6. Enclosure fully submersible, protected to IP 68 and IP 65 for a sensor and a transmitter respectively
7. Sensor/transmitter cable to be fitted and potted by manufacturer. Screened and armoured cable shall be used.

C. Transmitter
1. Remotely installed from sensor
2. 240 Vac 50 Hz power supply unless otherwise specified.
3. Inbuilt flow rate and total flow display
4. Isolated 4-20 mA dc and pulse outputs
5. Inbuilt empty pipe detection including any fault in the system shall be indicated immediately via a transistor and alarm
6. Programmable range and engineering units
7. Two inbuilt relays for alarm

2.02 Rotameters

1. Borosilicate glass metering tube
2. Stainless steel 316 float
3. Stainless steel 316 wetted parts and housing
4. Scale with black markings on white background, nominal length 250 mm, graduations in units specified in the schedule.
5. Flanged connection with rear inlet and outlet
6. Easy access shall be available to the glass tube for cleaning
7. ± 2% accuracy
8. Range ability of 10:1

2.03 Thermal Dispersion Mass Flowmeters and Flow Switches

1. Flow sensor shall be suitable for the measurement of air flow with a single point insertion to the process line.
2. Stainless steel 316 wetted parts
3. Inbuilt Temperature compensation
4. 240 Vac 50 Hz power supply
5. IP65 enclosure
6. 4-20 mA dc output isolated from sensor and power supply or SPDT relay where used as a flow switch
7. Local flow rate indicator to be calibrated in Engineering Units.

8. Overall accuracy of ± 1% of the flow rate.
9. Enclosure shall be certified intrinsically safe when used for gas flow measurement in hazardous area as indicated in schedule.

2.04 Vortex Gas Flow Transmitters and Flow Switches

1. Ultrasonic detection of turbulence (vortices) created by an obstruction shall be used to measure the flow velocity
2. Measurement shall be independent of process pressure and temperature variations.
3. 240 Vac 50 Hz power supply
4. Enclosure protected to IP65 and certified intrinsically safe when used for gas flow measurement in hazardous areas.
5. 4 to 20 mA dc output isolated from sensor and power supply or SPDT relay when used as a flow switch.
6. Stainless steel 316 wetted parts
7. Inbuilt flow rate and total displays
8. Overall accuracy of ± 1% of flow rate.

2.05 Vane Type Flow Switches

1. Stainless steel 316 wetted parts
2. Enclosure protected to IP66 and explosion proof when specified in schedule.
3. NPT threaded process connection
4. SPDT contact magnetically actuated by the vane.

2.06 Ultrasonic Level Transmitter

A. The system shall comprise of a transducer and a transmitter as per the following specifications:
   1. The transmitter shall be certified intrinsically safe and suitable for hazardous area class 1, divisions 1, group D where specified in schedule.
   2. Overall accuracy shall be better than ± 1% with a repeatability of ± 0.5%

B. Transducer:
   1. Stainless steel 316 construction.
   2. Enclosure protected to IP68
   3. Inbuilt temperature compensation
   4. Supplied complete with mounting accessories.

C. Transmitter:
   1. Wall mounted and protected to IP55
   2. 240 Vac 50 Hz power supply
   3. 4-20 mA dc output proportional to measured level.
   4. Inbuilt level indications
   5. When used for open channel flow measurement as specified in schedule, the transmitter shall have inbuilt flow rate and total indications.
   6. Programmable range
   7. Relays for sensor failure, level and flow alarms.

2.07 Cut Throat Flumes

1. Fiberglass reinforced flumes shall be used for open channels flow measurement.
2. One piece moulded with 5mm thick walls, reinforcing ribs.

3. Internal removable blocking shall be provided to prevent distortion during shipment and installation.
4. Self-supporting and cast in reinforced concrete channel.

2.08 Float Level Switches

1. Stainless steel 316 float and linking rod
2. Stainless steel 316 enclosure protected to IP66 and certified explosion proof where specified in schedule.
3. Flanged process connection.
3. Contact shall be isolated from process and magnetically actuated SPDT rated 240 Vac 5A, 30 VDC IA.

2.09 Tilting Level Switches

1. Tilting level switches shall be used for solids level detection
2. NEMA 4 enclosure unless explosion proof is specified in schedule
3. Tilting ball enclosure shall be stainless steel or suitable plastic material
4. Contracts shall be rated 240 Vac, 5A.

2.10 Submersible Hydrostatic Level Transmitter

Submersible pressure detection type level transmitters shall be used for wet well level measurement as per the following specifications.

1. Capacitance sensor - flush diaphragm type to avoid sensor clogging.
2. Stainless steel 316 sensor protected to IP68 and certified intrinsically safe.
3. Loop powered transmitter with 4-20 mA dc output
4. Accuracy of $\pm$ 0.5% of full scale.

2.11 Pressure Gauges

1. 150 mm diameter dial with black markings on white background
2. Stainless steel bourdon, case and process connections.
3. $\pm$ 1% accuracy
4. 1/2" NPT connections
5. Complete with micrometre pointer adjustment
6. Stainless steel 316 diaphragm shall be provided when specified in schedule.

2.12 Pressure Switches

1. Diaphragm type sensor
2. Stainless steel enclosure certified explosion proof where specified in schedule.
3. Adjustable switching differential
4. Stainless steel 316 wetted parts
5. SPDT contact rated 240Vac 5A, 30 vdc 2A
6. Accuracy $\pm$ 1% of span

2.13 Pressure Transmitters

1. Pressure transmitters shall be gauge or differential pressure as specified in schedule.
2. Transmitters shall be 2-wire loop powered with 4-20 mA dc output
3. Accuracy $\pm$ 0.1%

4. In built zero and span adjustments
5. Over pressure limits shall be at least 50% above the specified process pressure in the schedule.
6. Enclosure shall be weather-proof or certified explosion proof where specified in schedule.

2.14 Differential Pressure Switches

1. Diaphragm type sensor
2. Stainless steel 316 wetted parts
3. Adjustable switching differential and dead band
4. Stainless steel IP65 enclosure to be certified explosion proof where specified in schedule.
5. ± 3% accuracy

2.15 Indicating Pressure Switches

1. Diaphragm or bellows operated for pressure or differential pressure
2. 150 mm indicating with adjustable preset pointer setting
3. DPDT contact rated 240 Vac 5A
4. 1/2" NPT process connection

2.16 Empty Pipe Switches

1. Empty pipe detection switches shall be used for pump protection
2. Attenuation of a low frequency signal shall detect the presence of liquid.
3. SPDT contact 230 Vac 5A.

2.17 Limit Switches

1. Limit switches shall sense position of equipment such as valves, penstocks, gates etc. as specified in schedule.
2. Contacts shall be SPDT or DPDT as specified in schedule and rated 240 Vac 5A.
3. Enclosure shall be IP65 unless explosion proof is specified in schedule
4. Actuating mechanism and mounting shall be appropriate for the mechanical equipment being monitored.

2.18 Temperature Sensors

1. Temperature sensors shall be either a Resistance Temperature Device (RTD) or Thermocouple (TC)
2. Thermocouple sensors shall be as per ANSI Standard C96.1.1964 corrected for IPTS 68
3. RTD sensors shall be of Pt 100 element per SAMA Standard RC 21-41966 corrected for IPTS 68.
4. Compensating cables shall be reused for remote temperature indications.

2.19 Bi-metal Thermometers

1. 125mm diameter adjustable angle dial
2. Stainless steel 316 thermowells
3. 1/3 pipe diameter insertion lengths
4. Ranges as indicated in schedule

5. Flanged or threaded connection generally as indicated in the plan
6. Location subject to the Engineers approval.

2.20 Gas Detection System

A. The system shall consist of a sensor, control module, calibration kit including sensor separation accessories and calibration gas cylinders.

B. Control Module:
   1. Rack mounted
   2. Provide audio and visual alarms when preset limits are exceeded
   3. Provide high, low and malfunction alarms.
   4. 2 or 3 digit display
   5. Output contact SPDT rated 240 Vac 2A
   6. Analogue output 4-20 mA dc
   7. Alarms to be displayed on local alarm panels and DCS

C. Oxygen Sensor:
   1. Electrochemical fuel type sensor
   2. Explosion proof enclosure
   3. O-25 percent range full scale

D. Combustible Gas Detector:
   1. Catalytic bead type sensor resistant to degradation by silicones and reduced sulphur gases.
   2. Explosion proof enclosure
   3. 0-100 LEL range full scale

E. Hydrogen Sulphide Gas Detector
   1. Solid state MOS type sensor on ceramic substrate
   2. Explosion proof enclosure
   3. 0-50 ppm range full scale

F. Chlorine Gas Detector
   1. Sensor to detect minimum concentration of 0.5 ppm
   2. 30 secs. Maximum response time for 80 percent of range to 10 ppm
   3. 3 minutes recovery time for 90 percent of range to 10 ppm

2.21 Water Quality Monitors

A. This section covers individual elements to measure and transmit pH, turbidity and residual chlorine. Each system shall consist of a transmitter and sensor assembly.

B. Transmitter:
   1. 240 Vac, 50 Hz power supply
   2. IP65 enclosure unless explosion proof is specified in schedule.
   3. Inbuilt digital display
   4. Isolated 4-20 mA dc output
   5. Overall accuracy of $\pm$ 1%

C. pH Sensor:
   1. Sensor shall measure hydrogen ion activity or oxidation reduction potential.
   2. Glass measuring electrode, reference electrode, solution ground and temperature sensor
   3. Electrolyte refill shall not be more than once a year

4. Integral preamplifier
5. Flow through type electrode assembly
6. Wetted parts shall be stainless steel or plastic unless otherwise specified.
7. Sensor shall have glass electrode and temperature compensation. .
8. Wash-water cleaner or ultrasonic type cleaner to be provided.

D. Residual Chlorine Sensor:
1. Platinum cathode and anode.
2. PH and temperature compensated
3. 0-20 ppm range
4. Flow through installation.

E DO (Dissolved Oxygen) Sensor/Probe:
1. Luminescent DO (Dissolved Oxygen) type
2. 0.01-20.00 mg/L range
3. Resolution: 0.01 mg/L
4. Accuracy:
   Less than 1 ppm: ±0.1 ppm
   Greater than 1 ppm: ±0.2 ppm
. 5. Accessories:
   Plug in extension cable to extend the distance between the sensor and a transmitter
   Extension cables
   Pole mount kit
   Ball float mount kit
   Air blast cleaning assembly

Part 3 Execution

3.01 Installation

Installation, testing and start-up shall be in accordance with Section 13410 of these Specifications.

3.02 Spare Parts

Spare parts for all instruments listed in the schedules shall be provided for two years of normal service.

END OF SECTION 13420

Section 13430

Panel Mounted and Miscellaneous Instruments

Part 1 General

1.01 Description

A This Part specifies the panel mounted and miscellaneous instruments and equipment to perform the required functions in conjunction with information and equipment specified in other Parts of the Specifications.

B It shall be the responsibility of the Contractor to ensure that the panel instruments and equipment supplied under this Part are compatible with the primary elements and equipment specified under other Sections of these specifications, and that the signal transmission methods are compatible.

C Enclosures of front of panel mounted instruments shall be of uniform design and colour scheme wherever possible. Front of enclosure colours shall be compatible with panel colours and subject to final approval by the Employer. Normally, compatible standard colours of the manufacturer shall be acceptable.

1.02 Reference Standards

Applicable standards referred to in this section:

1 BS 5863, Analogue d.c. signals for telemetry and control.
2 BS EN 60529, Ingress Protection
3 EN 50014 to 50020, Enclosure Protection
4 IEC 61000-4, RF Protection
5 IEC 61131-3, Programming Languages for Programmable Controllers

Part 2 Products

2.01 General

A Instrumentation and control equipment furnished shall be manufactured by a Company regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of the most recent design.

B All equipment shall be designed for ease of maintenance and repair, and access to critical Parts shall not require major dismantling. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer.

D Manufacturers shall test and calibrate each input/output to operate within specified limits Calibration and compliance certificates provided by the manufacturer, shall be authenticated by the Contractor and submitted to the Employer.

2.02 Digital Indicators and Totalizers

Digital indicators shall be panel mounted type, 96 mm (w) by 48 mm (H) dimensions. 110 V a.c. 50 Hz power supply. 4 1/2 digit LED or backlit LCD display for process variable. Range shall be programmable in Engineering units. Input shall be 4-20 mA d.c. or volt free contact as specified in the Project Specification. Loop power for 2-wire transmitter shall be provided as required. At least two programmable alarm contacts for high or low alarms. Totalizers shall have 8 digit display with manual reset facility.

2.03 Trip Amplifiers

Trip Amplifiers shall be surface or rack mounted with 110 V a.c. 50 Hz power supply. Input shall be 4-20 mA d.c. 1 or 2 independent adjustable set points shall be provided as specified in the Project Specification. Outputs shall be SPDT relay contacts rated 110 V a.c. 5A.

2.04 Relays-Electromagnetic Type

A Relays shall be provided as necessary to perform switching functions required of control panels and other control circuits.

B Control relays shall be provided for the control and alarm circuits as indicated. The relays shall be electrically held, 50 Hz, continuous duty, multiple connected to 110 V a.c. control circuits and mounted inside control panels or separate metal enclosures as indicated. Enclosures shall be IP66. The relay base assembly shall accept from 1 through 8 convertible poles. Relays shall be attached to pre-shaped mounting channels with captive screws.

2.05 Timers

A Timers shall be provided as specified herein or indicated in the Project Specifications. Timers shall have four types of operation: (1) On Delay (2) Off-Delay (3) Single Shot, and (4) Duty Cycle timers. Time ranges shall be as shown in the Project Specification.

B Panel mounted timers shall be of the motor driven adjustable type with dials and presentable pointers. The timers shall operate from 110 V, single-phase, 50 Hz power and shall be of the square bezel type for flush panel mounting. Output contacts shall be double throw and rated for 10 A at 110 V a.c.. The number of contact sets shall be sufficient to perform the required control functions. Where more contacts are required than supplied as commercial standards, control relays of equal rating shall be used to supplement the timer contacts. When specified, relay contacts shall be supplied as Part of the timer and shall be operated by the timer control power independently of the timed contacts. Repeatability of the preset time delays shall be within ± 2%. Timers shall be of the plug-in type and enclosed in dust-proof cases. Connection shall be by numbered screw terminals in the rear of the timer connector.

C On delay timers. When a start signal is applied, the timing cycle begins. Output contacts change state after the time delay is completed. Contacts shall return to original state when a reset signal is applied or power is removed.

D Off delay timers. When a start signal is applied, the output contacts change state immediately. When the start signal is removed, the timing cycle begins and the output contacts return to the original state when the cycle is completed. Timer shall be reset by a

reset signal or by removal of power.

E One shot timers. When a start signal is applied, the output contacts change state immediately and the timing cycle begins. The output contacts return to the original state when the cycle is completed. Timer shall be reset by a reset signal or by removal of power.

F Duty Cycle timers. Two timer cycles shall be incorporated. When a start signal is applied, the first timing cycle beings. The output Contacts change state at the end of the cycle and the next timing cycle begins. When this delay is completed the output contacts return to the original state. This sequence is repeated until a reset signal is applied or power is removed.

2.06 Running Time Meters

Running time meters shall be of the synchronous motor driven type having a minimum of six decimal digits where the least significant digit shall represent tenths (1/10's) of hours. Unless specified otherwise in the Project Specification, they shall not be equipped with a reset button. They shall be for panel mounting with a square bezel approximately 60 mm on a side. Motor voltage shall be 110 V a.c.

2.07 Programmable Logic Controllers (PLCs)

A Each PLC System shall comprise a Central Processing Unit (CPU), Input/Output modules, serial interface module and programming units. PLCs shall be installed inside Local Control Panels or in separate cubicles, as specified in the Project Specification. PLC shall be suitable for ambient temperature of up to 50°C and 95% relative humidity. Power supply shall be 230 V a.c. 50 Hz. The system shall include at least 25 % spare capacity for future expansion. Panel mounted display units shall be provided for man machine interface where specified in Project Specification. PLC shall be of modular construction with plug in I/O cards and facility to install expansion modules when necessary. The PLC shall have a real time clock with battery backup.

B PLC diagnostic indications shall include the following:
1 power OK
2 low battery
3 forced I/O
4 CPU fault
5 I/O status indicators

C The CPU shall perform the following function:
1 scan all inputs, execute relay ladder logic programs and generate outputs for the final control elements
2 monitor status of in the system hardware and provide diagnostic information
3 process scan time shall be 8 ms/k maximum.

D Random Access Memory (RAM) for real-time program execution with lithium battery backup for data retention and flash PROM backup for permanent storage of program shall be provided. The PLC memory shall be as required for the programs and future requirements subject to a minimum of 16 kb.

E Analogue input modules shall be for current, voltage, RTD Pt 100 or thermocouple input type with a 16 bit resolution. Power supply for 2 wire transmitters shall be provided where specified. Analogue outputs shall be isolated 4-20 mA d.c with 14 bit resolution, unless

otherwise specified. Digital I/Os shall be optically isolated. Contacts shall be rated 1A at 24 Vd.c. The systems shall support on-line replacement of I/O modules, in case of failure.

F Programming shall be through a lap-top programming unit. Programming shall be user friendly, self-documenting type with facility for identification and comments. PLC programming shall be compliant with IEC 61131-3 standard on programming languages for PLCs.

G PLC shall be provided with serial interface ports for peer to peer communication, HMI for operator interface or Telemetry, as specified in the Project Specification. Communication protocol shall conform to the seven layer ISO Open Systems Interconnect (OSI) model, subject to approval by the Engineer.

H Where specified, a panel mounted VDU or a PC based control station shall be provided for Human-Machine Interface (HMI).

I A panel mounted VDU shall be provided for the PLC when specified, as follows:
1 a panel mounted TFT graphic colour display unit for graphic, numeric and message display
2 membrane keypad with one million cycle's minimum operation
3 240 V a.c. 50Hz power supply
4 enclosure protected to IP65
5 1.6 MB flash and expansion memory card for application program storage
6 provide restricted access to the PLC database for simulating or forcing inputs/outputs.

J A PC based control station for programming and real-time process control shall be provided when specified:
1 PC system hardware shall utilize current technology in terms of architecture, system clock speed, processor bus, random access memory, disk drives and input/output sub-systems. Programming and operations shall be accomplished using an alphanumeric keyboard and mouse or trackball. As a minimum the PC shall be provided with two 90 mm floppy disk drives, 530 mm colour monitor with 1600 x 1200 pixels resolution and tilt and swivel base. Communication ports shall be provided for serial mouse, PLC interface including a port for a future PLC network, an additional spare port and other requirements as specified. The monitor shall comply with EC60950 for product safety. The entire system shall be ruggedized. A colour printer, with facility to print directly in black without combining colours, shall be provided for alarms, reports and graphics printing. Print speed shall be minimum 4 ppm in monochrome and 2 minutes per full page in colour. Uninterruptible Power Supply (UPS) with 30 minutes autonomy shall be provided to facilitate orderly shut-down. Power supply shall be 240 Va.c. 50 Hz.
2 The following software functions shall be provided for the control stations:
a windows7 operating system or latest version.
b pixel based graphics.
c real-time and historical trends.
d data logging functions
e alarms reporting & handling.
f floating point calculations and totalization functions.
g generation of reports based on hourly, daily and monthly averages.
h systems diagnostics. Monitoring the status of the PLC and
i communication link.
j facility to download/upload data to the PLC.
k password protection for programming functions.
l a minimum of 50 pages of VDU mimic and report screens shall be provided.

Sufficient screen pages shall be configured to represent the process the remainder shall be available for future use.

3 detailed display requirements shall be as specified.

K Data base development and system configuration shall be the Contractor's and the ICM Subcontractor's responsibility. The data base developed by using the P&IDs and I/O point list shall be submitted to the Engineer for approval prior to installation in the operating system.

2.08 Chart Recorders

A Recorders shall be single or multi-point, strip chart type or as specified in the Project Specification. Recorders shall be microprocessor based, universal input type with programmable input type, range and engineering units. In-built digital display for all inputs and totalizers for flow measurement shall be provided. Display accuracy shall be better than 0.25 percent. Programmable alarm contacts for high and low level alarm of each input shall be provided. Recorder power supply shall be 110 V a.c. 50 Hz. Enclosure shall be protected to IP66. Recorders shall be supplied with mounting accessories required for panel or wall mounting as specified. Date and time shall be stamped on the chart at frequent intervals and at least every 24 hours.

B Strip Chart Recorders. Recorders shall have 1 through 6 traces of multicolour and digital data recording on 25 mm fan fold chart or roll chart as specified in the Project Specification. Chart speed shall be configurable between 1 mm and 1500 mm/hour. Recorders shall be panel mounted with 144 mm by 144 mm dimensions. Recorder shall have a glass filled polycarbonate door with polycarbonate window.

END OF SECTION 13430

Section 13440

Control Panels and Control Room Hardware

Part 1 General

1.01 Description

This Part specifies the control panels and control room hardware to perform the required functions in conjunction with information and equipment specified in other Parts of the Specifications.

1.02 Reference Standards

Applicable standards referred to in this section:

BS 88	Fuses
BS 546	Electrical outlets
BS 3871	Design of MCBs
BS 7430	Code of practice for earthling
BS EN 60529	Ingress protection
BS 5486	Low voltage switchgear and control gear assemblies

1.03 Submittals

The ICA Subcontractor shall submit shop drawings for all control panels, including details for the following items, as applicable:

1 electric power wiring circuits and schematics
2 air supply piping schematics
3 electric signal wiring circuits and schematics
4 pneumatic signal tubing schematics
5 fabrication drawings
6 details of all panels accessories
7 listing of all panel mounted (both front and rear) instruments
8 control panel layouts and nameplate inscriptions

1.04 Delivery, Storage and Handling

A Control panels shall be assembled and shipped in sections, properly packed to prevent damage during shipment. Panel sections shall facilitate easy handling and Site installation. Panels and associated instrumentation shall be handled carefully to avoid damage. Proper lifting and handling equipment and accessories such as grounding straps for handling electronic cards shall be used.

B ICA equipment shall only be delivered to Site just prior to their installation to minimise the possibility of damage. Delivered instrumentation shall be protected and not scattered or left unprotected on the Site.

C Materials and equipment not required for immediate installation shall be stored in a separate store protecting them from shock, weather, dust and damage from chemical and construction material.

D ICA equipment shall not be stacked unless crated

Part 2 Products

2.01 Panels General

A Control panels shall be free standing and floor mounted cabinets of console or desk pattern. Console layouts shall permit the operator to readily observe all instruments.

B The panels shall be manufactured to a high standard of quality in terms of visual appearance, colour and finish. The panels located in the main control room shall have an appearance and quality suitable for a pumping installation environment. The panel design including colour, style and appearance and detailed specifications of panel instruments shall be submitted to the Engineer for approval prior to manufacture.

C Control voltage. Panel instruments and controls shall operate from 110 V a.c. power supply, unless otherwise specified in Project Specification. A separate 24 V d.c. circuit shall be provided for the indicating lamps and panel instruments, as necessary.

D Where specified in the Project Specification, panel space shall be provided for instruments supplied by others. Installation and wiring of such instruments shall be carried out by the panel manufacturer. Co-ordination of instrument delivery shall be the Contractor's responsibility.

E Unit Control Panels for mechanical and electrical equipment can be the manufacturers standard panels. Details of such panels shall be submitted to the Engineer for approval, prior to manufacture. The Contractor shall be responsible for interfacing the unit control panels with the main control panel or central control system, as necessary.

2.02 Panel Construction

A All consoles and auxiliary cabinets shall be fabricated of cold rolled sheet-steel and be of rigid and stable construction without bows and ripples. The front surface shall be flat and the corners and edges shall be rounded to give a smooth appearance.

B Panels shall be of sufficient size to enclose all the panel instruments with ample interior clearance to allow for installation and maintenance of instruments. Annunciator displays shall be located in the top portion of the console assembly. Control panels shall be of sectional design with provision for easy extension. Pushbuttons shall be provided to enable acknowledgement and resetting of alarm annunciators and lamps on the console.

C Panels shall be formed of IP55 panel sections and each enclosure shall be a maximum of 2100 mm high, 800 mm wide and 600 mm deep unless otherwise specified in the Project Specification. Each section shall be fully enclosed including the top and bottom with no visible seams on the front. Externally visible screws and bolts shall not be acceptable.

D Each panel section shall be provided with two door rear access. Door hinges shall be knuckle type. Handles and other hardware shall be chromium plated. Where necessary, removable access covers secured by quick release fasteners shall be provided to facilitate easy maintenance.

E Undrilled gland plates shall be fitted at a sufficient height above the floor level to provide easy access under the gland plate. Suitable side covers shall provide access to the gland plates and also provide the specified ingress protection.

F Electrical general purpose outlets for test and repair purpose shall be provided in all consoles and cabinets. The outlets shall be in accordance with BS 546.

G All consoles and auxiliary cabinets shall be ventilated by natural circulation to maintain the equipment working temperature below to 50 °C.

H Panel lighting shall be provided to ensure adequate illumination for carrying out delicate adjustments or repairs on small items of equipment.

I After fabrication, all external welds must be ground smooth. The entire unit shall be thoroughly degreased, then filled and sanded. At least one coat of synthetic primer shall be applied, baked on, and sanded. This first coat shall be followed by two coats of baked-on synthetic enamel. The first coat shall be sanded after baking. The final two coats shall provide a glossy or semi-matt finish to a colour and finish approved by the Engineer. The average overall finish shall be at least 1.25 micrometres in thickness. Any minor damage to the finish during installation shall be touched up at Site, provided such remedial works are to the approval of the Engineer.

J A copper earth bar shall be provided within the panel for earthing of the panel, all the panel instruments and the cables to BS 7430, code of practice for earthing.

K Isolating switches shall be provided for all incoming power supplies. These switches shall be clearly identified, labelled and suitably protected from inadvertent operation.

L MCBs to BS 3871, shall be provided for the distribution of electrical power within the panel. The MCBs shall be arranged to minimise disruption to the equipment operation and also to prevent unsafe operating conditions. Power supplies from control panels shall conform to BS 5486.

2.03 Panel Wiring and Termination

A Panel wiring shall be carried out in PVC insulated multi-strand cable of adequate grade and rating. Wiring within each panel shall be done in a structured manner, grouped and supported to give a neat appearance.

B 110 V a.c. wiring shall be colour coded with black-unswitched live phase, red-switched live phase, white-neutral and green-ground. Signal and d.c. wiring shall also be neatly segregated under an approved colour coding scheme. Wiring shall be bundled and laced or tied with plastic ties and supported to prevent ragging or damage.

C All control and auxiliary cabinets shall be manufactured and assembled with all internal wiring connected to terminals blocks, requiring only connection to external wiring at Site.

D Separate terminal blocks shall be provided for incoming and outgoing analogue and digital signals and power supply connections. Each terminal block shall be clearly identified and labelled. Layout shall permit convenient access to terminals and wires and enable ferrule numbers to be easily read. Terminals shall be at sufficient height from the cable gland to facilitate easy routing of wires. Terminals shall slump the wire between two plates using a captive screw. Where wires are terminated on screw terminals, insulated crimp spade lugs shall be used.

2.04 Instrument Labelling

A All panel instruments shall have engraved nameplates showing their tag number and service in the English language. Materials for nameplates shall be selected in accordance with the relevant environmental conditions and shall be of non-metallic material, with black inscription on a white background.

B Name plates on control panels shall be mounted on or near the relevant instruments to ensure clear identification

C An additional nameplate engraved with the instrument tag number only, mounted at the rear of the panel, shall be provided for each panel mounted instrument. These plates shall be attached to the instrument, the panel or instrument support near the instrument.

D For panels where opening the circuit breaker does not shut off all of the power, the following sign shall be provided and letters shall be 6 mm high, red colour on a white background: "THIS CABINET CONTAINS CIRCUITS SUPPLIES FROM EXTERNAL SOURCES." "OPENING THE CIRCUIT BREAKER DOES NOT TURN OFF ALL POWER".

2.05 Control Desk

A The control room desk shall be a pedestal type, of modular construction and located as indicated. The exact designs including colour finish and location to be approved by the Engineer. Control desks shall be provided for each operator workstation (OW) as detailed.

B Sufficient rack space shall be provided in the base to adequately enclose all control desk equipment and permit access for installation and maintenance purposes. Cable entry shall be via floor mounted cable gland plates with facility to route cables through desk sections as required.

C Desk construction and material shall be generally as specified for control panels. Work surfaces shall be of smooth finish, durable, stain resistant and easy to wipe clean. Sufficient surface area shall be provided for all necessary monitors, keyboards, telephones and workspace for a minimum of two operators.

D All control desk cabling shall be arranged in a structured way such as to permit relocation of any terminal. Power supply sockets shall be provided for future expansion and maintenance purposes.

Part 3 Execution

3.01 General

Each instrumentation item shall be checked by the Contractor upon receipt for compliance with purchase specifications, damage, shortage and shortage of components. Items shall be repaired, replaced or the vendor notified of non-conformance as instructed by the Engineer.

3.02 Testing and Commissioning

A All control panels and instruments shall be tested and commissioned by the Contractor prior to final inspection and acceptance by the Engineer.

B Calibration of all panel instruments shall be tested and corrected as necessary.

C Panel wiring shall be tested to ensure that wiring is done as per the submitted wiring schedules. Correct identification on ferrules and tag plates shall also be verified.

D Panel power supply voltages shall be checked to ensure that they are within the operational limits of each instrument.

E Damaged or defective instruments and equipment shall be identified and replaced.

END OF SECTION 13440

Section 13450

Supervisory Control and Data Acquisition System

Part 1 - General

1.01 General Reference

This specification is provided for consideration against standard products and systems and where advantages or cost savings might be realized by alteration of the specification the contractor shall propose such changes as part of a complete alternative offer in addition to that specified.

1.02 Description Of Works

The works Supervisory Control and Data Acquisition System (SCADA) shall follow the international Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall be non-proprietary and meet the requirements of the ISO.

The system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions, monitoring all important system parameters and providing facilities for plant optimization. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OS) and Engineers Terminal (ET), after successful log on by security password.

For each abnormal condition, plant failure, plant unavailable or failure to respond to a command within a given period, the SCADA shall provide the appropriate alarm. Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers at the CCR (Central Control Room). Each LCR (Local Control Room) shall be provided with a common alarm, logging and report printer, alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.

PLC (Programmable Logic Controller) shall provide plant interface facilities and shall control, monitor and store plant input/output data and linked to the main system servers over the plant Ethernet data LAN.

Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Drawings.

1.03 Applicable Standards Referred In This Section

ISO 9075 (BS 6964)	-	Structured Query Language (SQL)
BS 5515	-	Documentation of Computer Based Systems

1.04 Quality Assurance

1. All equipment shall be suitable for installation and continuous services in the ambient conditions at the job site.

2. All equipment of a similar type shall be supplied from a single manufacturer to ensure common spares, operations and maintenance procedures.

3. All hardware and software proposed shall have been successfully proven in a similar water application for a period of at least two years, and be from established and reputable suppliers.

1.05 Submittals

A. Functional Design Specification (FDS)

The Functional Design Specification (FDS) shall be submitted to the Engineer and approved before manufacture and purchasing commences. The system vendor and/or contractor shall include the following material as a minimum :

1. Description of the design and design criteria
2. Details of associated equipment.
3. Functional Design Specification
4. Quality Plan
5. Outline of acceptance test procedures
6 Implementation program for manufacture, installation and commissioning with particular reference to interface with existing equipment.
7. Manufacturers literature for each item of equipment supplied.

B. Contractor's Drawings

The Contractor shall submit general and detailed dimensioned arrangement drawings, schematics and wiring diagrams of all major items of Plant for the Engineer's approval. Manufacture of an item of Plant shall not commence unit the associated drawings have been approved in writing by the Engineer.

C. Instruction Manuals

These manuals shall include but not limited to the configuration of data base, reports, logs and screen displays.

Part 2 - Products

2.01 Master Station/Central System - Hardware

A. Computer

The system shall support hardware and software interconnectivity to other networks in accordance with the ISO Open System Interconnect reference model.

Engineers' terminals and plant Operator Workstations (OW) shall be RISC based and shall be similar throughout.

B. Redundancy

The DCS shall be supplied with dual redundant servers and suitable proven software to ensure high system availability and to prevent loss of service or data.

C. Visual Display Unit (VDU)

All visual display units shall be 525 mm colour monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. Monitors shall simultaneously display a minimum of 256 colours from a palette of 16

million colours and be non - interlaced, low radiation, flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less than 1280 x 1024 pixels and a refresh rate of not less than 50 Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image.

D. Keyboard
The master station keyboards shall be of the standard QWERTY pattern, separate from the VDU, low profile and have non-reflecting surfaces and keys of low intensity to reduce unwanted reflections.

E. Logging / Alarm / Report Printers - Continuous Feed
These printers shall be used for logging of system wide events and alarms shall comply with the following:-

Print speed	:	160 characters per second.
Paper feed	:	Adjustable width tractor feed mechanism.
Paper width	:	18 to 38 cm fan fold.
Print pitch	:	10 or 12 cpi.
Print width	:	132 characters at 10 cpi.
Character set	:	Full ASCII.
Noise level	:	< 50 dBA

F. Colour Printers (Laser)
These printer shall be used for the production of colour screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the colour printer is operational and comply with the following:-

Print speed	:	80 characters per second (text).
Print speed	:	2 minutes per page full colour graphics.
Colours	:	Compatible with VDU graphics.
Paper feed	:	A3 and A4 with auto sheet feeder mechanism and minimum 50 sheets per tray.
Paper width	:	A4/A3.
Resolution	:	600 DPI.
RAM	:	8 MB

G. Monochrome Printers (Laser)

Print Speed	:	8 pages per minute
Paper feed	:	A4 with auto sheet feeder mechanism and minimum 250 sheet paper tray.
Resolution	:	600 DPI
Character set	:	Full ASCII.
RAM	:	4 MB

H. Audible Alarm
An audible alarm shall be provided which is initiated by any fault condition arising and silenced on operator acceptance of all fault conditions. An alarm mute function shall be provided to silence the audible alarm without accepting any fault conditions. It shall be possible in the engineer's mode to enable/disable this audible alarm.

I. Data Storage
A hard disk historical data system with removable optical or disk media for archive and backup shall be provided.

The historical data system shall store all alarms with the time of occurrence for one month and the daily average, total, maximum and minimum with time of occurrences for all analogues connected to the system, in addition to their value at the set logging intervals. All events shall be archived in a first in first out buffer for a period of one month.

A high speed back up device with removable media, such as streaming tape cartridge or optical disk, shall be provided for each server, suitable for backing up the whole system on a weekly basis. Archiving shall be fully automatic with non-archived data being overwritten.

Data selected for archive shall be written to removable media which shall be sized to support at least one month's worth of archive data.

J. Un-interruptible Power Supply (UPS) System

The Contractor shall supply a UPS system with sufficient capacity to maintain power to the supplied equipment, its peripherals and process critical instrumentation on a mains power failure for a minimum period of 1 hour.

In the event of power failure, the master central system shall be supported by the un-interruptible power supplies specified.

The central system equipment shall be programmed to degrade gracefully once UPS power is exhausted or execute a shutdown routine after a preset time from the original mains failure.

The UPS systems shall be monitored by an and a fault in the UPS system shall be accorded the highest priority status.

The Functional Design Specification shall detail modes of failure and process shutdowns and itemize signals to be supported by UPS.

Power distribution from the UPS in the control room area shall be via floor plate mounted sockets, the design of which will be such as to prevent inadvertent connections of non-system hardware, for example cleaning equipment.

2.02 Central System Software Functions.

A. General

The Contractor shall be responsible for supplying complete software packages to enable the Plant to operate as stated in this specification. Provision must be made for the adding of further software tasks as and when required. All software functions shall be user friendly with instruction and messages to aid the operator. The contractor shall make available all standard software functions even if not specifically detailed in the specification.

The computers shall utilize a real time multi-tasking and networked operating system with a proven track record in real time distributed process control applications.

It is a requirement that the system be supported by on line configuration and editing of all mimic displays and database.

The system shall be capable of supporting the allocation of plant to zones and these zones may be allocated for the attention of particular OWs

Each Operator Workstation and Engineers Terminal shall be a high performance RISC system with disk storage for all local area and frequently used graphics displays. High resolution, multi-screen graphics, (minimum 1280 x 1084 pixels 256 colour) is required. Operational mimics and other graphics shall be presented in an industry standard GUI format. A minimum of four active windows should be displayable concurrently. Both text and graphics shall re-size automatically to accommodate changes made to the size of a window. Operator interface shall be via low profile minimum 102 key keyboard with associated mouse or track ball pointing device. The system shall be designed to minimize the operators use of the keyboard. All major functions shall be accessible on-screen through use of the mouse or track ball.

An Operator Workstation shall be provided for each process area control centre and be connected to the plant data highway. Functionality shall be identical to that of the Main Control Room OWs allowing full access to all system functions at the authorized access level. Operator system entry for each area will be Password coded with different levels of entry depending on the level of authority of the operator. Development and Systems level entry passwords will be provided for the MCR and Engineer workstations. Each action taken by any operator at any level of entry, or, at any operator terminal shall be log file recorded, and time and date stamped. Log in and out time and dates will be printed on the control room event logging printer.

VDU mimics will display dynamic colour details of flow rates and pressures, pump status, well levels, alarms, treatment dosing rates, electrical power supplies and other general treatment and plant status conditions. Commands via the operator terminals, will operate in a GUI working environment using a mouse or track ball pointing device, all requests and commands shall be via icons, whether menu linked or linked to plant control actions. A permanent dynamic alarm banner shall be displayed at the bottom or top of each operator screen. Each control action will be routed through a series of confirmation routines.

The complete system database shall be available to each operator terminal offering pre-configured reports per process area. These reports shall be available for printing in graph or tabular format, dynamic trend displays shall also be available for all analogue flow, level and pressure values. Custom, as well as pre-configured reports and trends shall be available to a higher level of entry. A colour A4 size screen dump printer shall be provided for graph and trend prints.

An operator Help utility shall be provided offering help linked to the particular action being carried out by the operator at that time. At least one help screen per screen page shall be available. This facility shall be pre-configured with an option for updating by operators via a password entry. Typical information available shall consist of guides of actions to take under particular plant conditions, general process information and help in operating the telemetry system itself.

B. Display Facilities

The displays shall be user configurable, with the user being able to construct any desired symbol for display. Any display shall appear (excluding historical recall) within 3 seconds of selection and the displayed data shall be updated from the database as information is recovered from the IOPs. Alarms shall typically appear within 3 seconds of being received into the central system database.

The Contractor shall configure all display pages as fully as possible. However, facility must be incorporated to permit easy construction and modification of the display pages by using a standard library of shapes and symbols. The library shall be added to and modified by the user as required.

The initial application software shall provide for the display pages listed below and any pages necessary for the system to function as a complete entity.

1. Mimic Displays.
2. Alphanumeric configuration pages for the complete I/O and IOP's.
3. Graphic Displays.
4. Trend Displays.
5. Alarm Summary tables with date and time.
6. Alert Summary with date and time.
7. Event logs of past 72 hours with date and time.
8. Tabular display of data.
9. Inset windows showing an analogue trends may be mixed with mimic displays. In such a display the main mimic and inset trend shall all be live with automatic display updates.
10. Pan and zoom facility with automatic de-cluttering on zoom out.

Indexing of information and menus shall be presented in the form of active windows on the screen while the mimics etc. are still available for view.

No display or function shall effect the logging / monitoring of data. It shall be possible for the master station terminal and auxiliary terminals to perform different tasks within the displays simultaneously.

The system shall support full Pan and Zoom graphic display facilities.

C. Plant Monitoring and Plant Alarms.

The operator shall be able to monitor all of the information at all workstations. He shall be able to view active plant information on a series of VDU based graphical and tabular displays.

On occurrence of a plant alarm, the following shall occur at the master station:

1. Alarm message displayed in the alarm message area of the screen.
2. The audible alarm shall sound
3. The appropriate section of the display page shall change colour and flash.
4. A full message shall be written on the alarm page.
5. The full alarm message shall be printed on the alarm printer
6. The full alarm message shall be recorded, stored on disk and automatically archived on a daily basis

The operator shall acknowledge the alarm by pressing an Accept Alarm key or Icon. This action shall stop all associated alarm messages and displays flashing, however the display shall remain in the alarm state fixed colour to indicate an accepted alarm. When all outstanding alarms have been acknowledged the audible alarm shall be silenced.

Once the alarm has cleared the messages/displays will return to normal the alarm message shall stay recorded on the event/alarm log and an alarm cleared message shall also be recorded.

If the alarm clears before being acknowledged the sequence of events shall continue as above except the message shall change to indicate a cleared alarm.

An audible alarm silence function shall be provided to enable an operator to silence the audible alarm without acknowledging all alarms. On occurrence of any subsequent alarm the audible alarm shall sound.

For multiple bit points (where 2 or more inputs are combined to function as one point) the assignment of status/alarm levels shall be on the combined signals.

Each signal within the configured system shall be capable of being assigned an alarm based on the following:
- 4 levels per analogue (Lo Lo, Hi Hi, Lo and Hi)
- rate of change
- deviation from setpoint or other control parameter

A minimum of four alarm priorities shall be provided so that those requiring immediate attention may be separated from alarms of lower priority. An audible alarm shall sound for alarms requiring operator action. It shall be possible to acknowledge alarms from any operator station provided the operator is logged on to an approved access level.

Typical alarm assignments are as follows:

Critical Alarm	-	An alarm that requires immediate operator action.
Non Critical alarm	-	An alarm that requires operation action but not necessarily immediate action.
Operator Guide Alarm	-	An alarm that provides information to the operator.
Event	-	A low priority condition which is recorded.

The alarm software shall produce an alarm summary which will show all currently active alarms in priority and chronological order.

D. Plant Control
The system shall support a high security plant control facility. This should be password based and work on a select, check-back and execute philosophy of operation.

E. Data Archiving
Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable read/write optical disk system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes, for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 90% full.

Analogues will be stored at a rate selected by the operator in the range 1 minute to 1 hour. The operator shall have the facility to select the way in which an analogue is stored, the system will provide any combination of the following:
1. Instantaneous value.
2. Average value.
3. Maximum value.
4. Minimum value.
5. Not stored.

Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.

The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

F. Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable read/write disk system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes, for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 90 percent full.

G. Mimic Displays

The Contractor shall configure all the mimics to provide total detailed coverage of the monitoring and control of plant as detailed in this specification. It is expected that display modifications will be required in the future and therefore the ability to change the displays without programming skills is essential.

Instrumentation shall be displayed using ISO standard symbols. For mimic configuration it shall be possible to call up a library of standard symbols representing items (e.g. pumps, valves) and add new symbols to the library. Building mimics shall be simple and be achieved by using a mouse or tracker ball pointing device. The mimic displays shall consist of the following pages:

1. A general diagram covering the whole of the system on a single screen with key data.
2. A general block diagram for each site or area of site showing the plant displayed on a series of single screens with key data.
3. Mimic of the plant and instrumentation connected to each IOP displayed on as many screens as necessary.

H. Tabular Representation of Data.

It shall be possible to put any data into a tabular format, with the data entered in row or columns. The user shall be able to add headings to any of the rows or columns and store the table as a blank for later use.

I. Trend Displays

It shall be possible to plot dynamically updated real time data and archived data on a line graph to represent analogue or digital information. Each graph shall be capable of displaying 4 plots overlaid on a graph of different colours and line texture. By the graph there shall be a key relating each colour to its function. The horizontal axis shall be time based and user selectable in minutes, hours, days, weeks, etc. together with a start time.

The vertical axis shall be scaled in units to suit the individual readings and be displayed in the colour of the selected reading. To avoid cluttering the vertical axis scale shall be changed by selecting the individual display. The vertical axis shall be automatically scaled for each selected point between limits entered by the user.

The display of the data shall also be available in tabular form.

J. Manually Entered Data

Some data will need to be entered into the system manually via the keyboard. This data will fall into three types.

1. Constants which will be changed infrequently. This data may have time and date associated with it e.g., unit cost of power.
2. Variables which will mainly be the results of laboratory testing. This data will need to have a time and date entered manually with the data.
3. Maintenance related comments.

K. Manually Corrected Data

The system shall allow an operator to manually correct false data via the keyboard. This data shall include a marker to enable modifications to be highlighted.

L. Reports

There shall be a real time spreadsheet facility supplied and installed by the contractor in the master station. The users shall be able to transfer data from either the archive system or live data to the spreadsheet. The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). Typical reports would be:
Power consumption and costs.
Effluent Quality
Total Flows
Failures of Plant
Maintenance Schedules
It shall be possible to configure and store blank templates for later use, facilities for editing stored templates shall be provided.

M. Input Tables

Each Input shall have a table covering every characteristic of the input. This data shall be automatically sent to the appropriate locations when the user has completed entering or modifying data into the table. The contractor shall compile all input tables as indicated in the input/output schedules, plus any other I/O to enable the complete and optimum monitoring and control of the plant. The user shall be able to modify, amend or create new tables. The Contractor shall ensure all possible characteristics are included in the table including the following.
Point Identity
Point Description
Point Type
Point State
Point Range
Point Units
Status/alarm and priority levels
Alarm set points - high, low, out of range high/low
Log interval - time between logs
Log type - average, total, etc.
Log in IOP - for communications failures

N. Output Tables

Each output shall have a table covering every characteristic of the output. This data shall be automatically sent to the appropriate locations when the user has completed entering or modifying data into the table. The contractor shall compile all output tables as indicated in the Input / Output schedules, plus any other I/O to enable the complete and optimum monitoring and control of the plant. The user shall be able to modify, amend or create new tables. The Contractor shall ensure all possible characteristics are included in the table including the following.
Point Identity
Point Description
Point Type
Point State
Point Range
Point Units

O. Profiling

From an average, typical or manually entered plot it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. The user may select for the system to alarm if the reading is outside the profile and / or highlight such exceptions as part of a report and so reduce the need to examine all data to ensure acceptability. The number of exceptions shall be logged.

P. Data Manipulation

It shall be possible to perform simple mathematical functions on any data, including the following functions:

1. Addition.
2. Subtraction
3. Multiplication
4. Division
5. Square Root

It shall be possible to log, display or use in a control loop the resultant data.

Q. Database Query Facilities

The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible to easily configure queries and save them for future use.

R. Downloading IOP Configuration

It shall be possible to download configuration to the IOP's from the Engineers Terminal. This facility shall be in addition to any local programming of the IOP.

S. Diagnostics

The system shall have on-line diagnostic facilities to report system faults as they occur. A set of off-line diagnostic routines shall be supplied for more extensive fault diagnosis.

T. Access Levels

The functions available on the system shall be fully flexible so as to allow users access levels to be customized by the System Operator to suit individual user requirements.

Access to management and engineering levels shall be restricted by user selectable passwords or keyswitch. The security systems shall be based on a set of privileges which may be granted or denied to individual uses by the System Operator.

U. Control Loop and Sequence Programming

The method of programming will depend upon the Contractor's systems requirements. However, the following standards shall be followed:

1. All programs shall be written such that they lend themselves easily to alterations and additions.
2. Good programming practice shall be followed using structured programming techniques. All programs shall be tidy in format and logical to follow, and shall be accompanied by flow diagrams. Programs should be extensively annotated with comments and be self-documenting.

The system shall be supplied with programs that use a high level language for the master station.

V. Program - Documentation

As part of the requirements of this specification full documentation is required as below :

1. Software User Manuals
2. Database Point Allocation Table.
3. Complete program listing, flow charts for all sequences and control routines.

4. Application Software Source Code.
5. End User License Agreements.

W. Relational Database

X. Maintenance Management
Y. Management Information System and Administrative LAN

2.03 Future Expansion

The system hardware, application software and database shall be sized to accommodate a total of 50 percent increase in signal capacity and up to 100percent increase in an individual zone.

Sufficient plug in modules shall be provided and wired to terminals ready to accept future signals of up to 10 percent for each IOP.

Each IOP shall be able to accept at least two more I/O cards without requiring replacement of the original equipment.

2.04 IOP - Hardware

Each IOP shall be mounted in an IP52 enclosure and constructed to allow easy replacement and maintenance of cards. Plant. Mounting shall be of the 475 mm rack type. Particular attention shall be given to the ability of the IOP and its enclosure to withstand the harsh gases prevalent in certain areas of a Sewage Treatment

Input/output cards shall be mounted in a card rack where any slot can be used for any type of card.

Each IOP shall form a network node and shall be linked to the data highway through dual redundant communications interface adapters.

The IOP shall be an intelligent device that can collect data, generate alarms, perform process and control functions and communicate with other IOPs on a peer to peer basis.

The program and data held within memory shall remain intact and error free if all external power is removed from the IOP for a minimum period of two weeks.

The Contractor shall supply batteries for each IOP with sufficient capacity to maintain full power to the IOP for 8 hours after a power failure. The UPS system shall be integral to the IOP. The batteries shall be of a sealed maintenance free type.

All field connections shall be made in terminal strips located for easy access. These terminals shall be clearly marked and identified. Terminals carrying voltages in excess of 24 volts shall be fully shrouded. All terminals shall be of the 'flip up' isolator type with test points.

A hand held programmer, shall be provided for local display of signals, programming and fault diagnosis.

IOP's shall be equipped with RS232/485 links for interconnection to standalone control systems and standard plant packages.

Connection to other devices will use Modbus ASCII or RTU protocol as standard. Details of other protocols available should be included within the tender. Each controller shall support peer to peer

communications.

LED's indicating status of input and output digital signals shall be provided on the input/output cards.

IOPs shall be configured such that a single IOP or IOP module failure will not interrupt or degrade plant monitoring and control functions. IOP failure shall be alerted to the operator at the highest alarm priority.

2.05 IOP - Software

The IOP shall be capable of processing locally input plant information before broadcasting it on the data highway to reduce transmission overheads.

Total internal scan time interval for all inputs and outputs in an IOP shall not exceed 100 ms.

There shall be two pairs of alarm settings for each analogue input, one an alarm warning of a possible fault, the other warning that the input is outside a valid range of readings.

The IOPs shall have sophisticated in built control facilities to permit control loop configuration using simple building blocks. These blocks shall sequence control, three term control and other control routine components as required by the Specification. The IOP shall be capable of routine signal processing including integration, summation, subtraction and totalisation of one or more inputs. Control loops shall incorporate deviation and rate of change alarms, bump-less transfer facility, set point and output high and low limits.

The IOP shall be capable of executing sequential control logic. Programming of sequential control shall be by means of vendor supplied high level function block language or ladder diagram format as a part of an integrated package.

The IOP's shall have standalone capability, able to continue monitoring plant and executing control loops if the communication link to the master station fails. In the event of such a failure the IOP shall log all alarms and required analogues until all the total memory is filled. When the communication link is restored the IOP will automatically upload the logged data to the data archiving system.

The IOP's shall have a watchdog function and full self-diagnostics capable of detecting and reporting faults to the master station and displayed locally.

The Contractor shall program the IOP's fully under this Contract. It shall be possible to modify the programs remotely by downloading from the Engineers Terminal. It shall also be possible to change the program locally, using the portable programmer unit if necessary.

2.06 Data Communications Links

A. Communication Standards

Transmission of data shall conform to a recognized CCITT standard. The data transfer system shall be self-monitoring such that any equipment or line failure shall be displayed at both ends.

B. Site Data Highway

All IOPs, Operator Workstations and Control Room hardware shall be linked by a redundant data highway to transfer data between the master station and IOP. Both links shall transmit all

communications at all times. Neither link shall be dormant. The system shall continuously monitor the performance of both links and output an alarm on detection of an abnormal condition.

C. Leased or Private Cable

The system shall have the ability to use leased or private cables to transfer data between the DCS and the offsite IOP. The modems used shall be of a type approved by the telecommunications authority.

2.07 Inputs/Outputs

A. All process I/O and plant interface boards shall comply with the following:
   1. Plant wiring termination's shall accommodate up to 0.9 mm diameter conductors, terminals shall be of the test disconnect type to permit ease of signal isolation and loop monitoring for commissioning and maintenance purposes.
   2. Hot (powered) replacement of I/O boards shall be possible without special tools.
   3. Provision to power two wire loop powered transmitters.
      a. Digital Inputs
         All digital inputs shall be optically isolated.

All alarm and state indications shall be from dry contacts or 60 Vdc wet contacts. An isolated +24V dc supply shall be provided to source the opto-isolated inputs when connected to dry contacts, adequate filter circuits and software de- bounce techniques will be necessary. Contact operation shall be as follows :

Alarms In the healthy condition the contacts shall be closed with the relay coil energized; in the alarm condition the contacts shall be opened with the relay de-energized.

States Contacts shall be open with relay coil de-energized in the off (logic '0') condition, and closed in the on (logic '1')condition.

Two bit Digital One contact shall close when the plant is in one state and a second contact shall close when the plant is in the opposite state.

B. Analogue Inputs
Independently configured channels in the range 4 - 20 mA, 1-5 V dc, 0-1 V dc, 0-5 V dc, 0-10 V dc or +/-10 V dc. All analogues shall be screened and segregated from other cables. The signal ground shall be separate from the system ground. Input impedance shall be greater than 1 Mohm. ADC conversion at ten times per second shall be 12 bit, system accuracy $\pm$ 0.2 percent of span.

C. Digital Outputs
All digital outputs shall be optically isolated.

All control circuits shall operate from a 24V dc supply. The contact will be normally open and energized to close when an action is initiated. Outputs shall be either open-collector or volt-free contacts as follows:

- Open collector : 100 mA at 35 V dc.
- Contact : 2A at 60V dc or 120 VA (resistive)
  0.5A at 60V dc or 120 VA
  (inductive).

D. Analogue Outputs

In general all analogue outputs shall be 4-20 mA or 1-5 V dc, selectable, and drive a maximum loop impedance of 600 ohms. The signal ground shall be separate from the system ground. DAC conversion shall be 10 bit, system accuracy $\pm$ 0.2 percent of span.

E. RTD Input

Capable of receiving 10-ohm Copper or 100-ohm Platinum Resistance Temperature devices directly without external transmitter. Conditioned signal must be capable of being directly accessed by the on board IOP controller without external intervention.

F. Thermocouple Input

Capable of receiving type E, J, K, input directly without an external transmitter. Linearization shall be performed at the IOP without external intervention.

G. Pulse Input

Capable of receiving a zero based pulse or rectangular wave or sinusoidal wave form with amplitude of 4-6 or 21.6-27 volts and rate of 0 to 5000 pulses per second for totalizing, frequency counting and period determination.

2.08 Power Supply Requirements

A. Operating and Protection Power Supplies
All power supplies provided by the Contractor shall conform to the followings:
1. Be comprised of standard available units.
2. Be fitted with adequate input/output fuse protection.
3. Power supplies to be fitted if applicable with short circuit protection and current limiting facilities.
4. All power supplies to be selected such that they are de-rated to allow for future expansion to improve the reliability, and help increase the MTBF of the units. With all the expansion described in this specification the loading on the power supplies shall not exceed 75 percent of their total capacity.

2.09 Environment Conditions

A. Temperature and Humidity Range
The equipment shall be installed in an environment having a temperature range of 10°C to 50°C and a relative humidity of 10 to 90 percent (non- condensing).

The Contractor will use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment.

All parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

B. EMI / RFI Noise Immunity
The Plant to be provided shall be adequately protected against interference from the use of the radio transmitters, at any point external to the equipment housings, and no malfunction of the Plant shall result from this cause.

Responsibility for the correct and reliable operation of the Plant shall rest with the Contractor, who must ensure that the Plant is adequately protected against the ingress of radiated, mains-borne signal-borne interference.

C. Generated Interference
The Contractor shall ensure that the DCS, instrumentation and communications equipment conforms to relevant standards for noise emissions.

Part 3 - Execution

3.01 Tools

The Contractor shall include for the supply of all spanners, key, special tools, gauges and all other electronic and calibration tools required for the efficient installation, commissioning and operation of the plant.

3.02 Training

A. The system supplier shall conduct training courses at four levels for personnel selected by the Employer. Training shall be provided at maintenance, plant operator, programmer, and management (administrative) levels and shall be conducted by personnel employed by the system supplier familiar with the system supplied that have experience and training in developing and implementing instructional courses.

B. The entire cost of the complete training program, except per diem expenses for the Employer personnel to attend the maintenance training program, shall be the responsibility of the system supplier and shall be included in the contract price.

C. The system supplier shall submit information on the training program for approval prior to shipment of the equipment. This submittal shall include a course outline, time required, course schedule, sample workbook and instructor qualification information for each level.

D. The supplier shall make a workbook on each course available to every person taking any of the four courses listed herein. The workbook shall be of sufficient detail so at a later date a trainee could review in detail the major topics of the course.

E. The training times shall be scheduled by the Employer in advance with the Supplier so as to minimise disruption to the Employer's work schedules.

F. Maintenance Training:
1. Training shall be provided for six of the Employer's personnel at the system supplier's facility on routine preventive and emergency maintenance of all system components. The training program shall be divided into two segments and shall consist of at least five (5), eight (8) hour working days in length each.
2. The maintenance training program shall be developed for personnel that have electronics maintenance and repair experience and a general knowledge of computer systems, but shall not assume any familiarity with the specific hardware furnished. As a minimum, the following subjects shall be covered:
System Architecture and Layout
Hardware Components.
Module Switch Settings (Configuration Switches)
I/O Modules
Power Supplies.

Data Highway:
Programmer connection
IOP programming and diagnostic techniques
Battery replacement and recording.
PC and workstation Familiarization and maintenance:
Troubleshooting
Disassembly
Cleaning
Component Replacement
Reassembling

3. Provide the following interactive Audio/visual programs with ten (10) workbooks (each program) for self-paced instruction from Reliance Electric/AVID Communications:
VMBA 001 Fundamentals of A-C Motors
VMBA 001 Concepts of Digital Controls
DTMV 50 How to use a Multimeter

G. Operator Training:
1. Training shall be provided for at least ten of the Employer's personnel on the operation of system hardware and software and shall consist of a least twenty (20) eight (8) hour days in length. The training program shall include an additional session to be held six months after start-up. The second session shall consist of a least five (5) eight (8) hour working days in length. At a minimum, the following topics shall be covered:
Power-up, bootstrapping and shutdown of all hardware devices.
Interpretation of all standard displays.
Appropriate actions for software and hardware error occurrences.
Use of operator interface displays and keyboards
Use of printer including replenishment of supplies
Manual data entries
Creation and editing of graphic operator display screens.

H. Programmer Training:
1. Training shall be provided for at least four of the Employer's personnel at the Employer's facility on the high level applications software. The training program shall consist of at least five (5) eight (8) hour working days in length and shall include at the following topics in addition to the operator training:
Loading of any required software into the system
Data base creation and editing.
Configuration of printed report formats
Creation and editing of tabular and graphic operator interface display screens.
Diagnostic routines.
SCADA and System interface requirements.
2. The programmer training shall be conducted using equipment and software furnished hereunder and shall be developed for personnel with a general familiarity of computer operation and high level application programs, but shall not assume any familiarity with the specific hardware or software furnished.

I. Management Training:
1. Training shall be provided for at least four of the Employer's personnel at the Employer's facility covering topics on hardware and software. A special emphasis shall be placed on the functional characteristics of the major components of the system. The training shall consist of two (2) eight (8) hours working days in length and shall cover at a minimum the following topics:
System architecture

Hardware components
Software capabilities
Operator interface description
Operator interface displays.
Report generation including printer operation
SCADA information available for configuration.

2. The management training shall be conducted for the Employer's designated personnel who need a basic understanding of system functions and operations.

3.03 Works Test (Master Station And IOPs)

Before dispatch from a manufacturer's works each item of plant hardware, software and its components shall be tested in accordance with the relevant specification or code issued by the British Standards Institution. In the absence of such a specification or code these tests shall be performed in a manner subject to the approval of the Engineer, and witnessed and approved by the Engineer or his representative.

3.04 Works System Tests

The equipment will be generally inspected to ascertain compliance with the Specification (FDS), satisfactory finish, workmanship etc. and relevant functional tests shall be carried out with simulated inputs/outputs as necessary.

If simulated inputs/outputs are necessary then the simulation equipment shall be provided by the Contractor as part of the Works unless otherwise agreed.

The works system tests shall take place according to the program detailed by the Contractor.

In the event of testing and/or inspection being carried out at a Sub-Contractor's works, the Contractor's representative shall accompany the Engineer or his representative if the Engineer attends such tests.

Any surface coating applied prior to the initial inspection of Plant or equipment shall be considered sufficient reason for its rejection. Where any attempt to conceal defects is discovered the works may be rejected.

A Test Plan shall be produced by the Contractor. The plan shall indicate a logical step by step schedule comprising step, action and reaction, e.g.:

Step 1 Action : Simulate high level
Reaction : Tank Symbol Change Colour

1. Hardware Tests
   All hardware including spares shall be required to pass an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.
2. Functional Testing
   Functional testing using the system software shall be comprehensive. Simulation of the inputs and responses from Plant operation shall be as realistic a reproduction as possible of Site conditions.
3. System Diagnostics
   The means of fault detection and diagnostics provided by the system software shall be validated. This will involve making provision for including a sufficient variety of faults and out-of-range conditions in the system to ensure the detection processes are adequately tested.

3.05 Demonstration Works Tests

The Engineer shall have the option not to attend these original factory tests but to witness a repeat of these tests as a demonstration of the final correct operation of the system.

Alternatively the Engineer can instruct the Contractor to carry out the witness tests on a Self Certification basis.

3.06 Work Test Results

Three copies of all tests certificates, log sheets, performance curves, etc. relating to the tests at manufacturer's works shall be dispatched to site before the Engineer has approved such certificates etc. in writing.

3.07 Factory Acceptance Test

The Factory Acceptance Tests shall include items 3.01 to 3.02 inclusive.

3.08 Commissioning

The Contractor and any appropriate conversant customer Engineers shall be present when his equipment or installation is commissioned.

Tests to be carried out during commissioning shall include operating the equipment in a variety of modes and sequences to prove its satisfactory operation to the contractors Project Manager prior to initializing the formal Site Acceptance Tests.

3.09 Site Acceptance Tests

The Engineer shall have the option to attend the Site Acceptance Tests before setting to work.

1. Master Station Tests
   These tests shall be carried out after commissioning to an agreed specification. This shall include operating the equipment in a variety of modes and sequences as determined by the agreed specification (SAT document).
2. IOP Tests
   These tests shall be carried out either during commissioning or at another time as determined by the Engineer.

   The tests shall include operating the equipment in a variety of modes and sequences as determined by the agreed specification (SAT document).

3.10 Setting To Work

After commissioning and Site Acceptance Tests (when the latter is included) the equipment shall be set to work by the Contractor in agreement with the Engineer. Setting to work means connecting to the master station but not repeating Site Acceptance Tests.

END OF SECTION 13450

DIVISION 14.

CONVEYING SYSTEMS

(Not Used)

DIVISION 15.

MECHANICAL WORKS FOR BUILDING SERVICES

SECTION 15100

Pipework for Building Services

Part 1 – General

1.01 Work Included

A. Pipe(s) and Pipe Fitting(s).
B. Valves.
C. Hose Reel System Piping.
D. Deluge System Piping.
E. Clean Agent System Piping.

1.02 Quality Assurance

A. Valves and similar control gear shall have the manufacturer's name or logo, size, pressure rating and direction of flow cast-on, on the body.

B. Uniformity shall be maintained in respect of connection standards (threads or flanges), throughout. Where this is not practical due to justifiable reasons; compatibility shall be ensured by using appropriate adaptors, conversion spools, mating flanges and the like; with the written approval of the Engineer.

C. Pipes incorporated in the works shall have the standard of manufacturer, type, class or rating etc. continuously printed or marked otherwise in compliance with the standard of manufacture. Materials without such identification shall be rejected.

1.03 Submittals

A. Product data; samples; data on pipe materials, pipe fittings, valve and accessories and recommended coating materials and manufacturer's installation instructions or recommendations shall be submitted under provisions of Section 01300.

B. Copies of valve ordering schedules shall be submitted for approval prior to placing orders.

1.04 Delivery, Storage And Handling

A. Products shall be delivered to site, stored and protected under provisions of the General Conditions of Contract.

B. Two coats of approved primer shall be applied to all untreated ferrous pipes, prior to storage.

C. Pipes shall be stored on elevated racks and the ends kept closed with factory manufactured plugs to prevent the entry of foreign matter.

D. Plastic and rubber products shall be stored out of direct sunlight.

E. Valves shall be delivered and stored in shipping containers with labelling in place. Plug and ball valves shall be stored in open position and gate / globe valves in closed position to prevent damage to valve seats. Flange protectors shall be retained on the valves, until installation, to prevent damage to the flange faces.

Part 2 Products

2.01 Piping Materials

The types and quality of all pipework used shall comply with the following schedule unless otherwise stated on the drawings or elsewhere in the Specification.

(i) First aid hose reel, wet riser and hydrant installation pipework heavy gauge galvanised steel tubes to B.S. 1387.

(ii) Wet riser return pipe - medium gauge galvanised steel tubes to B.S. 1387.

(iii) All sprinkler pipes shall be medium gauge black steel pipe for above ground and heavy grade for below ground.

2.02 Steel Pipe Jointing

A. Screwed connections

All joints up to and including 150 mm dia. on steel pipeworks shall be made by means of screwed connections.

All screwed joints shall be made with teflon thread sealing tape or approved equivalent.

B. Flanged and welded connections.

All joints above 150 mm dia. on steel pipework shall be made by means of welded flanged connections.

All welding joints shall comply with relevant welding codes. Only qualified welders shall be allowed to work. All welded joints (except end to end pipework) shall be forged one piece welding flanges, reduces elbow etc. of approved make to B.S. 1965: 1963.

All scale and oxide shall be removed with chisel and hammer or file.

Appropriate mating flanges shall be used on all flanged connections. Flanges shall comply strictly in all respects with BS. 10 Table E or F, as necessary.

All flanged joints shall be flushed and aligned and shall be made with corrugated jointing ring, coated on both sides with the recommended jointing compound.

All bolts and nuts shall be of hexagonal type made from bright steel or approval manufacture to BS. 28.

Notwithstanding above, flanged connections or screwed connections shall be provided on all pipework at suitable locations for ease for dismantling or maintenance.

Reduction in the diameter for through-flow pipes shall be made by means of reducing sockets. Eccentric reducing socket shall be used on horizontal pipes and concentric reducing sockets for vertical pipes only.

2.03 Valves

A. General.

Valves from same manufacturer shall be provided throughout where possible.

B. Gate Valves

1. Up to 50 mm nom. size: Bronze body, rising stem and union bonnet, solid wedge or disc, threaded ends.
2. Over 50 mm nom. size: Iron body, bronze mounted (IBBM), outside screw and Yoke (OS&Y), solid wedge, renewable seats, flanged ends.

C. Directly Buried Valves.

1. Valves shall be of the inside screw type with socketed or flanged ends, protected internally and externally by epoxy coating of minimum 150 microns thickness, complying with the requirements of BS 5163 or equivalent. The extension spindles shall be provided with cast iron caps for operation by a removable key.
2. Materials of construction shall be as follows:
   a. Body Ductile or mechanite cast iron.
   b. Stem High Tensile brass or aluminium bronze.
   c. Wedge Ductile or mechanite cast iron.
   d. Facing rings Gun metal to BS 1400 LG4 or equivalent.
   e. Stem Nut Gun metal.
   f. Extension spindle Forged steel.
   g. Extension sleeve Cast iron.
   h. Surface Box Cast Iron.
   i. Fasteners Stainless Steel.

D. Globe Valves

1. Up to 50 mm nom. size: Bronze body, rising stem, union bonnet, renewable composition disc, threaded ends.
2. Over 50 mm nom. size: Iron body, bronze mounted (IBBM), rising stem , OS&Y, renewable seat, flanged ends.

E. Ball Valves

1. Up to 50 mm nom. size: Bronze body; stainless steel ball; Teflon seat and stuffing box ring; lever operation; threaded ends.
2. Over 50 mm nom. size: Cast steel body; stainless steel, full bore, floating ball, Teflon seat and stuffing box seals; lever / key operation; flanged ends.

F. Check Valves

1. Up to 50 mm nom. size: Bronze, in-line, resilient seat and disc, spring loaded, screwed ends.
2. Over 50 mm nom. size: Iron body, bronze trim, spring loaded, renewable composite disc and seat, flanged ends.
3. Over 50 mm nom. size: Iron body, bronze trim, swing type with external lever and weight, renewable seat and disc, flanged ends.

G. Drain Valves

Bronze angle globe pattern, key operated, threaded inlet and hose connection outlet with cap and chain.

H. Pressure Ratings

1. Valves shall be rated for 1700 kPa working water pressure at 120°C, unless otherwise indicated.
2. Contractor shall allow for selecting higher pressure rated valves to meet the valve construction features.

I. Valve Operators

1. Hand wheels / operating levers shall be provided for valves as appropriate. Hand wheels for gate and globe valves 50 mm nom. dia. and smaller, shall be non-ferrous metal (die cast zinc / aluminium alloy etc.).
2. One key/wrench of appropriate size shall be provided for each lever operated valve installed.
3. Chain operated sheaves shall be provided for valves located more than 2 meters above floor. Chains shall be extended to about 1500 mm above floor and hooked to clips in order to clear walkways and equipment.
4. Geared operators shall be provided for valves 200 mm and larger in size.

J. Thrust Blocks And Pedestals

1. Buried piping shall be supported by concrete pedestals resting on undisturbed soil, especially at abrupt changes of elevation.

2. Thrust blocks shall be provided at every bend, tee or reducer located to counter the thrust forces. They shall extend to the side of the trench and will rest on undisturbed, compacted soil.

3. It shall be the responsibility of the Contractor to calculate the thrust and design the thrust blocks and thereby ensure the integrity of the line. Submit design calculations for approval to the Engineer, prior to fabrication of the thrust blocks.

2.04 Steel Pipe Fittings

In all cases all pipe fittings shall be used on all pipework unless written confirmation is supplied by the Consulting Engineer.

On all changes of direction, long radius bends and sweep or 'pitcher' tees shall be used.

Reduction in the diameter for through-flow pipes shall be made by means of reducing sockets. Eccentric reducing sockets shall be used on horizontal pipes and concentric reducing sockets for vertical pipes only.

Part 3 – Execution

3.01 General

This section covers the supply, installation and testing of pipework as generally shown on drawings. All work shall be executed to the satisfaction of the Consulting Engineer and as far as possible avoiding any interference with the works of the other trades. All pipes shall be of approved manufacture and all pipes samples to be used shall be submitted for the Engineer's approval. Before being installed, all pipes shall be thoroughly cleaned, free from scales, rusts and obstruction and if necessary, the pipes shall be coated with one coat of primer to prevent rusting.

In all exposed pipework installed, there shall be a clearance of approximately 50 mm left between the outside of the pipe and the nearest wall, ceiling or equipment surface. Pipe joints or fittings will not be permitted within the thickness of walls floors or any other partitions.

All straight vertical run of pipe more than 30 m in length shall have dirt pockets formed from equal tees and plugs at the low points. Before horizontal runouts are taken off from such vertical risers, air bottles shall be fitted using equal or reducing tees at the high point of the risers.

Any open-ended pipe or pipe connection left overnight or for any considerable period shall be protected from the entry of duct, sand, etc. by the fixing of plastic or soft-wood plugs.

All pipes shall be anchored as required to control the movement of pipes due to thermal changes. General anchors shall also be fitted at the lower end of the vertical pipes. The location of these pipes anchors shall be carefully planned to make suitable allowance for temperature variations in the pipelines without causing undue stress in the pipework and fittings.

The anchors shall securely hold the pipe in a fixed position to resist the attempted movement due to expansion and the weight of the pipe and contents.

All pipework shall be installed in accordance with the F.O.C. Rules and to the approval of the Local Fire Brigade Authority.

3.02 Pipe Hangers And Supports

All piping shall be individually supported.

All necessary hangers and supports for all pipework installed shall be supplied and installed by the Contractor. Samples of hangers, brackets and supports to be used shall be submitted for the Engineer's approval.

Hangers and supports shall be of steel adequate dimensions and designed to allow for expansion and contractions. All hangers and supports shall be primed and finish coated with black bituminous paint to approval.

Hangers or support spacing shall not exceed the following:

Nominal Pipe Diameter	Hanger Diameter	Maximum Spacing	
		Horizontal Spacing	Vertical
Up to and including 40 mm bore	3/8"	6 ft.	6 ft.
50 mm	3/8"	10 ft.	12 ft.
65 mm bore up to and including 80 mm bore	1/2"	10 ft.	12 ft.
100 mm bore to 125 mm	5/8"	10 ft.	12 ft.
150 mm	7/8"	10 ft.	12 ft.
200 mm to 250 mm	7/8"	15 ft.	15 ft.

Piping 150 mm diameter and larger shall be supported from the floors below on stands or by bracketing off columns using column clamps.

Piping below 150 mm diameter may be hung on hangers from the floor above.

Pipe hangers or brackets shall be properly isolated, where necessary to prevent vibration and noise transmission and special care shall be taken in making piping connections to pumps and all other vibrating equipment.

Pipe hangers shall be placed not more than 0.6 m from each change of direction of pipes, preferably on the side with the longest run.

Vertical runs of pipes shall be supported by clamps or collars suitably supported from angles or channels in turn testing on special spring supports fixed to the floor slab. These supports shall be at least provided at each alternate floor slab and the top and bottom of each risers. Where vertical runs of pipes are turned at floor level to run horizontally, purpose-made collars and supports shall be provided to approval.
Hangers for horizontal pipe runs shall allow for expansion of pipelines and shall have provision made for adjusting grade and alignment. They shall be split ring and adjustable type or other approved design hung on around steel rods or approval equivalent.

Brackets or clamps may be used where pipelines run along walls, columns or ceiling.

All fixing of pipe hangers or brackets to the building structure shall be by means of approved nylon or metal expansion plugs. Suitable receiving holes shall be cut by approved rotary percussion electric drills to give true and accurate drillings.

3.03 Pipe Sleeves

Pipe sleeves shall be fitted for pipes passing through floors, walls or any other partitions. Sleeves for galvanised pipes shall be of galvanised pipe off-cuts, and sleeves for copper pipes shall be similar but of brass or copper.

Pipe sleeves fitted in floors shall generally be 20 mm above the finished floor level except in plant rooms and other areas where "Wet Floor" are expected in these cases, the sleeves shall end 50 mm above the finished floor level, and tightly caulked with suitable diameter asbestos rope.

Pipe sleeves fitted in walls or partitions shall end flushed with the finished plaster or other surface finish.

Generally pipe sleeves shall be one (1) nominal diameter larger than the service pipe concerned, except for sizes 100 mm bore and above where they may be specially constructed from not less than 1/8" galvanised sheet steel.

Where pipes pass through floor trench covers, special flanged sleeves shall be fitted to from a watertight seal.

Where pipes pass through fire-brick walls or other partitions, clearance between pipe and sleeve shall be tightly packed with suitable diameter asbestos rope to form a sound and fire barrier.

Where necessary for poured concrete fabrications, the Contractor shall supply the pipe-sleeves to the Contractor together with the necessary information for these sleeves to be correctly positioned in the shuttering before pouring the concrete.

3.04 Wall Plates

Heavily chromium plated split rolled steel or brass hinged wall plates shall be provided and fixed after the painting and interior decorations are completed where pipes pass through walls, floors, ceilings or any other internal partitions in occupied areas such as offices, toilets, workshops etc.

3.05 Slope of Pipes for Drainage

Sprinkler pipes shall be so installed that system can be thoroughly drained. As far as practicable all pipes shall be arranged to drain to the installation drain valve which should be not less than 50 mm dia. for Ordinary and Extra High Hazard Systems and not less than 40 mm for Extra Light Hazard Systems.

With dry pipe or alternate wet and dry pipe system range pipework should have a slope of at least 4 mm in 1 m and distribution pipework not less than 2 mm in 1 m.

In the case of basement and the areas where sprinkler pipework is below the installation drain valve and in other trapped points in the system auxiliary valves of the following minimum sizes should be provided:-

20 mm valves for pipes up to 50 mm dia.

25 mm valves for 65 mm dia. pipes

32 mm valves for pipes larger than 65 mm dia.

END OF SECTION 15100

SECTION 15110

Valves, Gauges etc. for Building Services

Part 1 – General

1.01 General

All valves shall be supplied, installed, connected up and tested in position as generally shown on the drawing and as required for the satisfactory operation of the system.

All valves shall be constructed, and applied in accordance with the relevant British Standards and the current edition of the F.O.C. rules and shall be fitted in accessible positions for operation and repair.

All stop valves shall be right-handed and shall have indication whether the valve is open or shut. The controlling wheel must be marked with the direction the wheel is to be turned to close the valve.

The connection between each valve and the adjacent equipment shall be made with union or a flange, for ease of dismantling.

Before installation, all valves shall be blown out to remove any foreign matter that might lodge in them.

Valves spindles shall be adequately lubricated with graphite and all glands shall be freshly packed before installation.

The size of the valves shall be of the same diameter as the pipe for which they are to be fitted.

All valves shall be suitable to the working and test pressure of the system in which they are installed and shall be of approved manufacture and shall be of the same manufacture.

Part 2 – Products

2.01 Check Valves

All check valve 50 mm and below shall be of the screwed bronze body type.

All check valves 65 mm and above shall be of flanged cast iron body of non-slam type.

2.02 Ball Valves

Ball valves shall be supplied and fitted completed with back nuts, ball float and arm. Ball floats may be of soldered copper, brass or polythene P.V.C. Ball-valves be of the low pressure type and shall comply with B.S. 1212/1957.

2.03 Strainers

In-line Y-type strainers shall be provided and installed where shown on drawings. All strainers shall be of steel of bronze body type screwed for sizes up to and including 50 mm dia. and for sizes 65 mm and above shall be of the cast iron flanged type. A removable bronze screen shall be provided and the degree of mesh size shall depend on the equipment to be protected.

2.04 Drain Cocks

Gun metal drain cocks shall be provided as necessary to ensure that all sections of the pipework and plan can be effectively drained. Sizes of drain cocks shall be as stated below:-

(a) Pipes up to and including 50 mm dia, - 20 mm dia.

(b) Pipes for 65 mm dia. - 25 mm dia.

(c) Pipes above 65 mm dia. - 32 mm dia.

Drain cocks of 20 mm dia. shall be complete with hose unions for draining down.

2.05 Air Vents And Drains

Air bottles and cock shall be provided for air-venting where required. For pipes up to and including 32 mm, the bottles shall be of the same dia. as the pipes to which they are fitted. For pipes above 40 mm dia. bottles 0.5 m long shall be used. At the top of the bottle a taper reducing fitting shall be installed with 20 mm vent pipe and air-cock fitted at low level.

Automatic air vents shall be provided as necessary and shall be complete with isolating cock. The discharge from these vents shall be pipes via copper pipe of appropriate size to the nearest floor drain or drain pipe. Drains shall be connected to equipment with unions to facilitate cleaning and removal.

2.06 Isolating Valves

Valves up to and including 50 mm dia. shall be of gun-metal with female screwed connections where fitted to steel pipes. Valves for copper pipe shall have compression type connection for sizes up to and including 40 mm. These valves shall be of the fullyway, split wedge disc pattern with non-rising spindles of high tensile steel, fitted with detachable cast iron hand-wheels.

Valves 50 mm dia. and above where fitted to copper pipe shall be flanged and similar to those for steel pipework.

2.07 Globe Valves

Valves shall be of the globe pattern, screwed gunmetal for sizes up to and including 50 dia. Valves 65 mm dia. and above shall be of the flanged cast iron type.

For copper pipework the relevant details specified earlier for isolating valves apply.

2.08 Non-Return Valves

Valves shall be of the swinging disc non-return type. These shall be of gunmetal with female screwed connection for sizes up to and including 50 mm dia. For sizes 65 mm and above they shall be of the flanged cast iron type with bronze discs.

The Contractor is required to select these valves in relation to the velocity of the water in the pipe. In all cases the valve is required to operate silently on reversal or water flow and if necessary valves of the double or articulated clack type or the spring assisted type shall be fitted.

2.09 Vibration Coupling

Piping connections to all pumps and all equipment shall be by means of wire or fabric reinforced moulded high-pressure convoluted rubber connectors. The fittings shall have integral rubber flanges, and be bolted onto the pipe lines using flanges for 50 mm dia. and larger, for smaller than 50 mm dia. connections shall be by means of high pressure hose clips and sealed with rubber plastic.

2.10 Orifice Plates

Orifice plates shall be fitted where necessary in order to assist in hydraulically balancing a system or to meet the pump characteristic curves. The dia. of the orifice shall be not less than 50 percent of the dia. of the pipe into which the plate is to be fitted. The orifice plates shall be of approved type and shall be installed in accordance with the FOC. Rules.

2.11 Pressure Gauges

Pressure gauges shall conform to BS. 1780 and shall be of minimum 6" dial type of Budenberg or equal approved type. The scale value of the gauges shall be of the order of 150 per cent of the maximum known pressure. All pressure gauges shall be fitted with gauge cocks.

2.12 Pressure Switches

Pressure switches shall be of the electrical operated type and shall be of Honeywell or equal approved type. They should be selected to suit the system installed.

END OF SECTION 15110

SECTION 15120

Painting and Labelling

Part 1 General

1.01 Description

A All paints shall be suitable for use in humid tropical environmental, and shall be to the approval of the Engineer. The Contractor shall furnish all necessary information to the paint manufacturer to enable him to supply the most suitable paint complying with the requirements of these Specifications.

B The Contractor shall, when required, provide sample panels 600mm x 300mm showing a 150mm wide band of each coat forming the paint schemes being used at the site for identification and control.

C The paints and workmanship shall comply strictly with the requirements of BS 6150, 1982 unless otherwise specified.

D All paints shall be obtained locally from a reputable local manufacturer whose products are equivalent or superior to those specified. A sufficient supply of all paints is to be maintained at site.

1.02 Storage of Paints

A Paints shall be stored in sealed containers in a lock-up store where they shall not be exposed to extreme temperatures. Any special storage conditions recommended by the manufacturer shall be observed.

B Paints which have not been used within 'shelf life' period specified on the containers or within 6 months of the date of manufacturer, whichever is the lesser, shall be replaced.

C Paints from painters kettles shall be returned to the store at the end of working period, where they shall be kept in sealed containers. Before they are re-issued for use, they shall be thoroughly mixed and no fresh paint or thinners shall be added.

1.03 References / Standards

A Applicable Standards referred to in this Section include but are not limited to the following:

1	BS 6150 (1982)	Code of Practice for painting for buildings
2	BS 7079 (1990)	Preparation of steel substrates before application of paints and related products

Part 2 Product

2.01 Paints

A The paints shall be suitable for use in humid tropical environment.

B The paints shall be obtained locally from a reputable local manufacturer.

Part 3 Execution

3.01 Painting scheme

For purpose of identification of painting schemes, reference has been made to paints manufactured by a certain leading paint manufacturer. Other manufacturers whose products are equal or better than those specified herein will be acceptable subject to the approval of Engineer and provided that the total dry film thickness is not less than that for the respective schemes specified below:

1 Outdoor Exposed Galvanised Steel

1st Coat	:	Copon EA-9 Red Oxide Primer, 50 Microns
2nd Coat	:	Copon 8048, 100 Microns
3rd Coat	:	Nippon Polyurethane Recoatable Finish, 50 Microns

2 Outdoor Galvanised Steel, Buried or Water Immersed

1st Coat	:	Copon EA-9 Red Oxide Primer, 50 Microns
2nd Coat	:	Copon Arocoat Brown, 200 Microns
3rd Coat	:	Copon Arocoat Black, 200 Microns

3 Indoor Galvanised Steel

1st Coat	:	Copon EA-9 Red Oxide Primer, 50 Microns
2nd Coat	:	Copon 8048, 100 Microns
3rd Coat	:	Copon EA-4 Finish, 50 Microns

4 Outdoor Exposed Mild Steel

1st Coat	:	Nippezinc E-2 Primer, 75 Microns
2nd Coat	:	Copon 8048, 150 Microns
3rd Coat	:	Nippon Polyurethane Recoatable Finish, 50 Microns

5 Outdoor Mild Steel, Buried or Water Immersed

1st Coat	:	Nippezinc E-2 Primer, 75 Microns
2nd Coat	:	Copon Arocoat Brown, 200 Microns
3rd Coat	:	Copon Arocoat Black, 200 Microns

6 Indoor Mild Steel

1st Coat	:	Nippezinc E-2 Primer, 75 Microns
2nd Coat	:	Copon 8048, 150 Microns
3rd Coat	:	Copon EA-4 Finish, 50 Microns

3.02 Labels

A Letterings on pipings shall be painted in contrasting colours and shall be in centre of bands. The lettering shall be in block letters with minimum dimensions of 20mm high for pipes 50mm diameter and under and 25mm high for pipes over 50mm diameter.

B Directional arrows shall be in black on all visible sides of ducting and pipings at 2.5m centres and on two visible sides of all pipings at each valve, fitting. The size of arrows

shall be 80mm long on pipes up to and including 50mm diameter and 150mm long on pipes over 50mm diameter.

C The position of all dampers, that is open, normal and shut shall be clearly labelled.

D Every valve in the installations, except those in the plain sight of the equipment they control, shall be provided with a 50mm diameter brass tag secured to it with a chain and stamped with the service and area the valve controls.

E Ventilation and exhaust fans, pumps and all duplicated equipment shall be numbered and labelled in 30mm high stencilled letters.

3.03 Application

A All paints shall be supplied from the store to the painters ready for application, and the addition of thinners or of any other material shall thereafter be prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

B All printing shall be carried out by skilled painters.

C The surfaces to be painted shall be perfectly dry, clean and free of all grease and salts before painting commences.

D Each coat of paint shall be applied by the method specified to produce a continuous film of paint of uniform and even thickness. Successive coats shall have different shades for identification and each coat shall be thoroughly dry before the application of a further coat.

E No paint shall be used after the expiration of the 'pot-life' stipulated by the manufacturer, and paints of limited 'pot-life' shall not be mixed with fresh paint or have thinners added to them.

3.04 Dropsheets & Protection Programme

A The Contractor shall provide and use sufficient numbers of drop cloth, covers, tarpaulins and other screens to protect adjacent surfaces and shall remove all spatter and stains from such surfaces. The Contractor shall also protect its own works. Any damage to adjacent works or to any part of the premise due to painting careless ness or accidental spillage shall be repaired or made good at the Contractor's expense. The Contractor shall arrange his programme in such a manner as to minimise the likelihood of paint work being damaged by other works in progress. The programme shall be to the approval of Engineer.

B All rags, waste, empty tins and other rubbish are to be removed from the site. Care is to be taken that such materials do not accumulate with the risk of spontaneous combustion or damage to wall or floor surfaces.

3.05 Surface Treatment

A All surfaces of non-galvanised steelwork shall be blast cleaned. Blast cleaning shall be carried out in accordance with B.S. 7079 : 1990 to a second quality finish as specified therein. For touching up, wire brushing may be acceptable, subject to the approval of the Engineer. Excessive burnishing of the metal through prolonged application of wire brushes shall be avoided.

B After the surface is cleaned down, the specified priming coat shall be applied the same day. The priming coat shall not be applied until the preparation of the surface has been inspected and approved by the Engineer.

C Galvanised surfaces shall be examined for rust marks at exposed edges and all damage to the zinc shall be cleaned and spot primed with zinc-rich primer. All steel surfaces to be painted shall be free of grease. Degreasing shall be done with degreasing agents approved by the Engineer.

D Primed steel shall be cleaned of dirt and grease and examined for damage. Damages areas shall be cleaned and spot primed.

END OF SECTION 15120

SECTION 15200

Ventilation and Air Conditioning Equipment

Part 1 General

1.01 This section covers the requirement for ventilation and air conditioning systems in buildings

1.02 Description

A Fans shall be capable of giving the specified performance when tested in accordance with B.S.848. Although estimated values of the resistance to air-flow of items of equipment may be indicated this does not relieve the Contractor of the responsibility for providing fans capable of delivering the required air volume through the system.

B Each fan shall be capable of continuous operation, having the capacity as indicated in the Equipment Schedules and/or in the drawings when operated at the specified speed against the friction in the system.

1.03 References / Standards

Applicable Standards referred to in this Section include but are not limited to the following:

1 BS 848 Fans for General Purposes.

Part 2 Product

2.01 Propeller Fans

A Propeller fans shall have blades manufactured from PVC-coated galvanised steel.

B The fans shall be wall mounted to suit the particular installations. Wall mounted fans shall be supplied with wall boxes and wall plates suitable for removal for cleaning or built in the wall where shown on the Drawings. The fan shall be completed with weather-proof, flush fitting grilles, draught preventing iris or similar shutters, wire guards, etc. as specified.

C Fan motors shall have IP 55 enclosures.

2.02 Axial Fans

A The fans shall be the tube axial, direct driven with aerofoil blades and manufactured from heavy gauge metal or other approved materials. Fan motors shall be non-overloading over the characteristic curve at the required rpm to deliver the specified airflows. Fans shall be the bifurcated type where so specified.

B The impellers shall be of steel or other equally approved materials and shall be accurately balanced after assembly. The blades shall be fastened to the hub or the blades and hubs shall each be formed in one piece.

C The casings shall be longer than the length of the fan and motor. The casings shall be of steel, shall have flanged ends and shall incorporate an inspection door. The fans shall be complete with resilient mountings, mounting feet or plates, connection spigots, wire guards and dampers. Silencers shall be included if required to comply with restrictions on noise levels.

D Fans shall be suitable for their particular service, position of fitting and chosen with respect to corrosion, inflamability or other hazardous applications and shall not exceed any specified noise levels. Extended lubricators shall be provided with a suitable size access panel for fans fitted in a run of ductwork.

E Fan speeds shall not exceed 1450 rpm unless specified otherwise. The fans shall be directly coupled to totally enclosed squirrel-cage induction motors suitable for either single-phase or three-phase, 50-Hz supply.

2.03 Roof Exhaust Fans

A Roof ventilator shall have aerofoil blades with weather-proof housing of aluminium, steel or other approved materials. Fans shall be directly coupled to their respective motors which shall be self-cooled and completely separated from the exhaust air streams. Bird screens shall be provided to prevent birds from entering inside the housings. Accessories shall include installation frames, automatic shutters, bolts and washers and sound attenuating curbs to comply with noise restriction requirements.

2.04 Centrifugal Fans

A The fans shall be backward curved or airfoil multi-blade centrifugal type, statically and dynamically balanced and complete with matching housings. Fan shafts shall not pass through their first critical speed as units come up to the rated speed. Bearings shall be the self-aligning ball type amply sized for the loads with factory sealed lubrication and with provision for lubrication. The maximum outlet velocity of each fan shall not exceed 1800 rpm. The housings shall be fabricated from black mild steel sheets.

Part 3 Execution

A Where shown on the drawing, spring hanger or other approved type of vibration isolator shall be used for vibration isolation.

B Canvas flexible connector shall be used for connecting a rigid ductwork to the ventilation fan.

C Where shown on the drawing, acoustic silencer shall be provided for attenuation of noise generated by the ventilation fan to acceptable level.

END OF SECTION 15200

SECTION 15210

Vibration Isolators for Ventilation and Air-Conditioning System

Part 1 General

1.01 Selection of Vibration Isolators

A Vibration isolators shall be selected based on the recommendations of Chapter 46 of ASHRAE Handbook 1999 HVAC Applications.

B The specification of vibration isolators referred to on the drawings and Schedule of Equipment are detailed in the following sections.

1.02 References / Standards

Applicable Standards referred to in this Section include but are not limited to the following:

1 ASHRAE Handbook 1999 HVAC Applications

Part 2 Product

2.01 Type "1" – Isolating Pads

A This type of vibration isolators shall be generally used where the vibrating force is transmitted directly to ground or the vibrating force is very small compared to the absorption capacity of the structural slab at higher levels.

1. Type "1 A" – Neoprene Rubber Pads: These shall be cross ribbed in multiple layers or of sandwich type to achieve the required deflection. The adhesive used in fabricating the pads shall be as recommended by the manufacturer.
2. Type "1 B" – Glass Fibber Pads: These shall be of pre-compressed fiberglass construction and suitable to take up to 34 kg/sq.cm load. The pads shall be coated with elastometric neoprene rubber spray to protect the glass fibre and increase the damping effect.
3. Type "1 C" – Cork Pads: These shall be constructed from natural cork granules compressed and steam baked to form slabs and shall have a density of 96 to 106 kg/cu.m (6 to 6.6 lbs/cu.ft). The cork pads shall be treated with hot Bitumen Asphalt coating for protection of cork.

2.02 Type "2" – Moulded Neoprene Rubber Mounts

These shall be used where a greater deflection is required than that for pads. The maximum deflection allowable on these rubber mounts shall be 12 mm (0.5 inch). The normal shape of mount shall be conical with a captive insert for attaching to equipment base.

2.03 Type "3" – Free Standing Spring Isolators

These shall be constructed with open type stable spring and load plates at top and bottom with an adjustable bolt for levelling. Neoprene rubber acoustical treatment shall be provided to prevent transmission of very high frequency vibration and noise. The spring shall be so designed that the horizontal stiffness is more than 75% of the vertical stiffness. The rated loads and deflection for these springs shall allow an additional 50 % travel to that of the rated

deflection before the springs are compressed solid, to accommodate any errors in actual load distribution.

2.04 Type "4" – Restrained Spring Isolators

These are similar to type "3", but with additional restraint in vertical direction. These isolators shall have hold down bolts to limit vertical movement. The restraints should have adequate clearance so that they are activated only when a temporary restraint is needed.

2.05 Type "5" – Housed Spring Isolators

These isolators are similar to type "4" except that they consist of two telescoping houses. The contact surfaces of houses shall be separated by resilient inserts such as Neoprene Sponge or equivalent material.

2.06 Type "6" – Rubber Hangers

These are similar to type "2" except that the conical rubber mould is housed in a steel casing and have a through hole for the hanger rod. The assembly shall allow for 20 to 35 degrees angular movement for the hanging rod without metal to metal contact.

2.07 Type "7" – Spring Hangers

These are similar to type "3" except that the spring is mounted in a steel casing and used for suspension only. The assembly shall allow for 20 to 25 degrees angular movement for the hanging rod without metal to metal contact.

2.08 Type "8" – Combination Rubber & Spring Hangers

This shall be a combination of type "6" and "7" having all the specified characteristics therein.

2.09 Type "9" – Thrust Restraints

These shall be similar to type "7", but installed in pairs to counteract the thrust caused by air pressure.

2.10 Type "10" – Air Springs

These shall consist of constant dry air supplying equipment and air bellows. These shall be used where 150 mm or greater deflection is required and natural frequencies do not exceed 80 Hz.

END OF SECTION 15210

SECTION 15220

Split System Air Conditioning Units

Part 1 General

1.01 Description

A Split system air-conditioning unit shall be of the air-cooled type, factory assembled and furnished complete with wall-mounted/ceiling exposed/ceiling concealed indoor unit, remote air-cooled condensing unit, refrigerant piping and all other related controls and accessories.

B The selection of the split system air-conditioning units shall be required to meet both sensible and total cooling load as specified on the drawings and Equipment Schedule. The capacity shall have to be suitably derated to take into account any differences in level between the indoor unit and remote air-cooled condensing unit and also the length of refrigerant piping involved.

1.02 References / Standards

Applicable Standards referred to in this Section include but are not limited to the following:

1 BS 2871 (Part 2:1972) Specifications for copper and copper alloys.

Part 2 Products

2.01 Compressors

Compressors shall be of the hermetic rotary type with overload protection. It shall be internally spring mounted for quiet operation. The compressor motor shall be interlocked with the condenser fan motor of each unit such that it may only be run when the condenser fan is operating.

2.02 Evaporators and Condenser Fans

Evaporator and condenser fans shall be direct driven. The evaporator fan shall be the centrifugal type and the condenser fan shall be the propeller type with provisions to eliminate condensate dripping.

2.03 Evaporator and Condenser Coil

Evaporator and condenser coils shall have copper tubing as the primary surface and aluminium fins for the secondary surface. They shall be factory tested for leaks. A suitable metering device shall be provided for the refrigeration system.

2.04 Filters

Air filters shall be of the reusable type and be efficient for its purpose. They shall be located so that they can be checked, cleaned and replaced easily.

2.05 Material For Refrigerant Pipeworks

A The refrigerant pipes shall be copper tubes complying with BS 2871 Part 2 1972.

B The pressure rating of copper tubes shall be

Suction Line	1200 kPa
Liquid and Hot Gas Line	2000 kPa

2.06 Pipe Material and Workmanship Condensate Drain Pipes

A The material of condensate drain pipes shall be PVC.

B Where possible, the condensate drain pipes shall be embedded in the brickwall or apron floor slab.

C Thermal insulation is not required for embedded pipes. All exposed condensate drain pipes shall be insulated with 12mm thick flexible, close cell light weight elastometric material.

D The spacing of supports for condensate drain pipes shall not be more than 2.0m.

Part 3 Execution

3.01 Refrigerant Pipeworks

The refrigerant pipes shall be routed in an orderly manner along the partition wall, brickwall or soffit of floor slab without obstructing other services. The refrigerant pipes shall be housed in white colour metal trunking of adequate thickness.

3.02 Condensate Drain Pipes

A The condensate drain pipes shall be routed in an orderly manner along partition wall, brickwalls and soffit of beam without obstruction to other services.

B The configuration and sizes of the pipeworks shall be as shown on the drawings.

C The horizontal run of the pipework shall be installed with a gradient of not less than 1/100.

3.03 Jointing of Copper Pipes

Jointing of copper pipes for air conditioning units of 5.5 Hp and below shall not be permitted.

3.04 Insulation of Refrigerant Pipes

The refrigerant pipes shall be insulated with 12mm thick flexible, close cell light weight elastometric material. Liquid and hot gas refrigerant pipe shall not be insulated together.

3.05 Pipe Supports

Adequate supports shall be provided for refrigerant pipes not housed in metal trunking. The spacing of supports shall be not be more than 2.0m.

END OF SECTION 15220

SECTION 15230

Ductwork and Accessories

Part 1 General

1.01 Description

A This section sets out the requirements of materials and standards of construction with respect to ductings, diffusers, grilles, registers, insulations, attenuators and accessories to be used on this project. All ductworks shall not be fabricated with less than the clear internal dimensions indicated on the Drawings and shall be installed generally as shown.

B It is the responsibility of the Contractor to check the actual spaces available on site for ductwork installation, prior to fabrication of the ducts. If any departures from the Drawings are deemed necessary, the Contractor shall submit details of such departures and reasons for approval.

C All ductworks shown on the Drawings shall be properly supported and anchored to the building structure in an approved manner using steel hangers, anchors, brackets and supports which shall be fixed by means of inserts on expansion shields of adequate size and number to support the loads imposed thereon.

1.02 References / Standards

A Applicable Standards referred to in this Section include but are not limited to the following :

1	SMACNA	Sheet Metal and Air Conditioning Contractors National Association of United States of America
2	BS 476 (Part 1, Section 3)	Fire Test on building materials and structures
3	ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
4	Jabatan Bomba Dan Penyelamat	Malaysia requirements

Part 2 Products

2.01 Ductworks

A All ductworks shall be fabricated from first class quality galvanized sheet metal and all ductworks and fittings shall be constructed in accordance with the practice as recommended by ASHRAE, SMACNA or other equivalent authority.

B The gauges of sheet metal, type of joints and brackings shall be constructed in accordance with the Sheet Metal and Air Conditioning Contractors National Association (SMACNA), of United States of America, "HVAC Duct Construction Standards Metal and Flexible, 2nd Edition (1995)".

2.02 Flexible Connections

A Flexible joints shall consist of, or be protected by, material having a fire penetration time of at least fifteen minutes when tested in accordance with BS 476 Part 1, Section 3. The material shall be of the glass fibre cloth type or 455 gm canvas. The width of the joints from metal edge to metal edge shall be not less than 80 mm and not more than 200 mm.

B All flexible joints other than fan inlet connections shall be between flanged ends. Each flexible material flange shall be backed by an angle or flat iron flange and the flexible joint shall be securely held between the metal flanges. Flat iron bands used with fan inlets shall be not less than 4.5mm thick.

2.03 Dampers

A Dampers shall be provided and installed in the sizes, types and locations as indicated on the Drawings and as may be necessary for proper operation of the air conditioning system. Samples of types of dampers to be installed shall be submitted for approval.

B Volume dampers shall be of the opposed blade type and the frames shall be steel, enamelled after fabrication and reinforced where necessary to prevent vibration. The blades shall be streamlined and fabricated of galvanised steel weighing not less than 8 kg/m^2. Each damper blades shall be tipped with 6mm thick hard felt to ensure silent operation. The shafts shall be of steel and the bearings shall be graphite impregnated bronze bushes or similar bearings.

C Manual dampers shall be provided with adjustable locking quadrants of approved manufacture. Automatic dampers shall have suitable connecting rod and base plate for mounting the electric motor as may be necessary. The permanent open and close position shall be marked and labelled, and after installation and complete satisfactory balancing, the normal working position of each damper lever shall be clearly labelled.

D Splitter dampers shall have approved quadrant operated locking device fitted with an external indicator to show the damper blade positions. Splitters shall be two gauges heavier than the duct in which they are installed.

2.04 Fusible Link Fire Dampers and Motorized Fire Dampers

A Fire dampers shall be supplied and fitted in all points where ducts enter through floors, fire walls and party wall and in all locations as may be required by the Jabatan Bomba dan Penyelamat Malaysia. Provisions shall be made to automatically stop the air conditioning systems upon the actuation of a fire alarm point and the automatic closing of dampers in specified zones.

B All fire dampers installed in supply air ducts shall be of combination fire smoke damper equipped with electric motor actuator and spring return mechanism and shall lock shut and be manually reopened and shall have external indicator of damper position. All return air fire dampers shall be fusible link type except for dampers installed in return air ducts passing through AHU Room and Lift Lobby fire wall where motorized dampers are required. All fire dampers shall be constructed of not less than 3 mm mild steel plate mounted on 13mm diameter mild steel shaft. The shaft shall rotate in sintered bronze bearings. The damper and blade shall be finished with two coats of zinc chromate paint.

2.05 Diffusers, Grilles and Registers

A Ceiling diffusers shall be either the perforated face type with air pattern controllers, or linear type or diffusion cone type as shown in the drawings or specified in the Equipment Schedules. The diffusers shall be designed to eliminate or minimise smudging and streaking of the ceiling. Maximum neck velocities shall not exceed 800 fpm.

B Diffusers in variable air volume (VAV) systems shall be capable of the "coanda" effect and not dump air downwards when the airflow volume is low. All supply diffusers in constant air volume (CAV) systems shall be provided with opposed blade volume control dampers with accessible key operator for adjusting the supply air quantities.

C The diffusion ranges shall be approximately 3/4 of the distance from the respective diffuser to the nearest wall or partition. Where exterior, exposed glass is present on the wall, the diffusion range shall be the full distance to the glass surface. The diffusion range between

two neighbouring diffusers shall be approximately 3/8 of the distance between them. Maximum noise levels within 1.8m of the outlets shall not exceed the noise criterion for the application as set out by ASHRAE or other equivalent authority. Diffusers shall be finished in baked enamel to approved colours.

D Perforated face supply diffusers shall each be formed from a single piece of perforated metal panel with 3/16" diameter holes on 1/4" staggered centres. The perforated surface plate shall completely conceal the pattern controllers and swing down for easy access to pattern and volume (if any) controllers. The pattern controllers shall permit the air distribution pattern to be easily adjusted to 1, 2, 3 or 4 way air discharge patterns on site. Airflow volume and sound levels shall remain constant regardless of the air pattern selected to eliminate rebalancing the air system when the air pattern is changed. Matching, perforated face, return diffuser models shall be available.

E Linear, ceiling supply diffusers shall be constructed of extruded aluminium and complete with internally insulated, inlet plenums. The number of slots and slot widths shall be as specified on the Drawings or Equipment Schedules. The vane design of the diffuser shall permit full 180^{o} adjustment of the air pattern and complete airflow rate control including blank off. Alignment strips shall be used in installations where the diffusers are to be installed in continuous runs. Diffuser frames and end configurations shall suit the type of ceiling and installation position. Matching, linear, return diffusers models shall be available. Diffusers shall be finished in baked enamel of any approved colour.

F Diffusion cone, supply diffusers shall be either the square or round type with no less than three concentric diffusion cones. All cones shall be of aluminium die-formed, one piece construction with no corner joints. The frame shall suit the type of ceiling.

G Side discharge wall registers shall be of the rectangular universal type with adjustable vertical and horizontal louvres for adjustment of air throw and with directional volume controllers designed to give even flow across the face of the registers.

H Grilles are to have the free area of not less than 80% or as specified in the Drawings and shall be of the louvred type. The static pressure drop across each grille shall not exceed 2.5 mm WG.

2.06 Insect Screens and Louvres

A Insect screens of the corrosion resistant type shall be provided and fixed behind all intakes and discharge louvres, grilles and openings where these occur on the outside of the building. The screens shall be fixed for easy removal for periodic cleaning and shall be of minimum gauge 22.

B All external supply and discharge air louvres shall be of the sizes indicated on the Drawings and shall be supplied and fixed by the Contractor. They shall be suitable for removal and be complete with suitable corrosion resistant insect screens and shall be constructed of stainless steel or aluminium.

2.07 Kitchen Hoods

A The hoods shall be manufactured from 0.9 mm thickness satin finish stainless steel. The construction details of the hoods shall conform to the details as indicated on the drawing.

B Hood sizes as given on the Drawings shall be considered approximate only and the actual hood sizes shall be determined on site prior to manufacture.

C Light fittings shall be of the single tube fluorescent batten type of 1220 mm nominal length unless otherwise indicated. The make and type of light fittings shall be subject to approval. The fittings shall be wired integrally with the hood construction using cables and conduits.

The circuits shall include an approved metal clad switch and a junction box for connection of supply. The positions of the switches and junction boxes shall be subject to approval.

D The grease filters shall be the panel type with an initial filter resistance of 25 Pa at the rated air flow and easily removable through the face of the hood without the use of tools.

2.08 Duct Mounted Attenuators - Material

A All sound attenuators shall be manufactured and supplied as complete packaged units by a recognised manufacturer of noise control equipment approved by the Engineer.

B The sound attenuators shall be installed where shown on the Drawings, and in accordance with the ductwork specification.

C The outer casing shall consist of galvanised sheet steel of minimum thickness 1.2mm for rectangular sound attenuators, and 1mm for circular sound attenuators. All seams shall be continuously welded or grooved.

D The casing and cells shall have a smooth finish with all edges neatly butted. Raw edges, fixing straps or screws shall not protrude into the air stream.

E The case shall be suitably braced so as to be completely airtight and free from drumming or distortion at all pressures up to 1.125kPa.

F Rectangular sound attenuators shall be provided with rolled steel angle end flanges and have adequate intermediate stiffening flanges.

G Sound absorbent side panels, splitters and pods shall have acoustic infill of mineral rockwool or fiberglass. The acoustic infill shall be covered by perforated galvanised sheet steel not less than 1.0mm thick, and between 10% and 40% open area. All splitters shall have a sheet metal nose cone.

H All splitters shall be capable of operating at air velocities up to 15m/s without erosion of infill material. Splitters shall be adequately braced so they do not sag or bulge and reduce airway width to less than 90% of the designed dimensions.

Part 3 Execution

3.01 Ductwork Construction

A All ductworks shall be machine bent and be free from buckles and waves. Transitions shall be made with sides pitched not exceeding 20^{o} (or 40^{o} included angle) for diverging air flow, or as indicated in the Drawings. Ducts may be constructed around obstructions at beams, etc., provided duct construction practice conforms to ASHRAE recommendations and overall air flow performance is not affected.

B Curved elbows shall have a center line radius of not less than 1.5 times the width or diameter of the duct. Where right-angled bends are used, double thickness turning vanes shall be incorporated.

C Pitot tubes access holes shall be provided at the suction and discharge sides of all fans or in such other locations which permit measurement of fan performance. The holes shall be 30 mm diameter, circular, flanged and with gasketed covers.

3.02 Joints

A Joints shall be made substantially air tight, and no marks from air leaks shall show at duct joints or connections to grilles and diffusers. Longitudinal joints of ductwork shall be made

at corners only with Pittsburgh or equally approved seams. Transverse joints either shop-made or field-made shall be flanged on ducts of 625mm and above with matching angles bolted together. Angles shall be of size not less than 25x25x3mm and shall be riveted to ducts. Angles shall be coated with approved non-setting compound before bolting up. No ductwork joints, bends or fittings shall be permitted within the thickness of the walls, floor or ceiling structures. Laps at joints shall be made in the direction of air flow. Button punch or bolt connections in standing seams shall be spaced at fixed centers not greater than 150 mm.

3.03 Ductwork Supports and Openings

A All ductworks shall be supported at intervals not greater than 2.4m and shall be supported rigidly from the building structure in an approved manner using steel hangers, anchors, brackets and by means of inserts on expansion shields of adequate size and number to support the loads imposed thereon. Wooden plugs shall not be acceptable. Steel angle iron hangers shall be of similar size to the bracings of that duct section. Ducts shall be so constructed and installed as to be completely free from vibration under all conditions of operation.

B Where ducts pass through floors, walls or partitions, the free space shall be adequately caulked with rockwool and a neat sheet metal angle flange arranged to cover the free space. Where ducts penetrate the roof construction, flashings shall be provided.

C Where ducts with fire dampers pass through fire barriers, 10 SWG mild steel sleeves shall be provided. The gap between each sleeve and fire damper shall be packed with rockwool for an air tight seal.

D Suitably sized air-tight access with rubber linings shall be provided at all changes of direction and connections with the cooling coils, suction side of fans, filter and fire dampers in the ductwork for maintenance, cleaning and inspection purposes.

3.04 Flexible Connections

A Flexible joints shall be provided on fan inlet and outlet connections and elsewhere on the ductwork where indicated. They shall be of the full cross-sectional area of the mating fan inlet or outlet or duct section. The ends of the ducts or the duct and the fan connection shall be in line.

3.05 Flexible Ducts

A Flexible ducts shall be constructed of a single aluminium plywall and helically corrugated with triple locking seam.

B Galvanised ducts/hose clamps shall be used for connection of the flexible duct to diffusers, VAV terminals and other ductwork.

3.06 Dampers

A Access doors or panels shall be provided for all concealed damper operators and locking set screws. Locking type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases or adapters to provide clearance between duct surface and operator of not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer.

3.07 Fusible Link Fire Dampers and Motorized Fire Dampers

A All fire dampers to be installed must be approved by Jabatan Bomba dan Penyelamat Malaysia.

3.08 Duct Mounted Attenuators - Installation

A Sound attenuators shall ideally be installed two duct diameters from any obstacles such as bends, dampers etc. Where this is not possible, splitters of rectangular sound attenuators shall be orientated in the same plane as the bend.

B Transformations between ducts and sound attenuators shall have a maximum included angle of 25^{o}.

3.09 Duct Mounted Attenuators - Performance and Testing

A Sound attenuators shall be sized by Contractor to ensure that the noise level in the rooms and boundary line comply with the specified values as detailed on the drawings.

B At the specified volume flow rate, sound attenuators shall not exceed the maximum pressure loss stated on the Drawings.

C Performance details of all attenuators shall be submitted for approval by the Engineer. These shall include:

1 The actual length, width (dimension across splitters), height (dimension parallel to splitters), splitter width and airway width of all attenuators. If the actual dimensions differ from the nominal dimensions, Contractor shall verify that there is sufficient space available for the attenuator, and that any necessary duct transitions are allowed for.

2 The splitter shape for all attenuators, e.g. shape of nose cone and taper of tail (if any).

3 All acoustical and aerodynamic performance data showing testing laboratory and relevant testing standards used.

END OF SECTION 15230

SECTION 15250

Testing, Adjusting and Balancing (Tab) and Functional Performance Testing

Part 1 General

1.01 Description

A The process of testing, adjusting and balancing shall include

1 Balancing air distribution system
2 Adjusting the total system to provide design quantities
3 Electrical measurement
4 Establishing quantitative performance of all equipment
5 Verifying automatic controls
6 Sound and vibration measurement

B Effective and efficient testing, adjusting, and balancing shall require a systematic, thoroughly planned procedure implemented by experienced, competent and qualified staff.

C All activities, including organization, calibration of instruments, and execution of actual work shall be scheduled and coordinated.

1.02 Schedule of Tests

A The Schedule of Tests shall consist of the following tests on individual equipment items and system tests.

1 Measuring, adjusting and balancing air flow in the ductworks.
2 Measuring, adjusting and balancing out door air.
3 Equipment and system check for ventilation fans, air handling unit, fan coil units and dampers.
4 Verification of control systems.
5 Measurement of electrical operating parameters.
6 Measurement of sound level outside equipment rooms and inside occupied areas.
7 24 hour system reliability test.

Part 2 Product

2.01 Instruments for Testing and Balancing

A The following calibrated instruments shall be made available for the testing and balancing of the air conditioning and mechanical ventilation system.

1 Electronic manometer
2 Digital, light sensing type tachometer
3 Clamp-on ammeter with voltage scales (rms type)
4 Rotating vane anemometer
5 Flow hood
6 Glass stem thermometer
7 Sound level meter with octave band filter set, calibrator and microphone
8 Vibration analyzer capable of measurement displacement velocity and acceleration
9 Test gauges
10 Sling pychometer

11 Digital thermometers, relative humidity and dew-points instrument
12 Recorder for temperature and humidity with charts

Part 3 Test Procedures

3.01 Test Procedures

A TAB procedures comprising method statements, sequence of work operation and test data sheets for each test and test on each equipment shall be submitted to the Engineer for approval not less than 60 days before commencement of tests.

The test data sheet shall contain the following

1 Contractor's name, address
2 Design parameter
3 Particulars of equipment installed
4 Checklist for functional test
5 Column for entering performance data
6 Remarks column
7 Criteria for acceptance
8 Name of person conducting the tests

B The TAB shall be conducted in the presence of the Engineer who shall endorse all test data sheets.

3.02 TAB Report Submittal

A The Contractor shall prepare bound copies of a TAB report which includes but not limited to the following:

1 Title page with project name and address; Contractor's name, address and phone number; date; TAB supervisor's name and signature who approved the report.
2 Table of Content
3 A listing of all air systems balanced, with those system highlighted that were found to be performing outside the design tolerance.
4 System schematic diagrams for all multiple outlet air and hydronic system
5 Final equipment test report forms with design data, intermediate test data when required, and final test data.
6 Include under 'Remarks' an explanation of variance of final data from design values.
7 A listing of all test instrument and calibration dates; and instrument calibration reports.

3.03 Criteria for Acceptance

A Unless otherwise specified, the acceptable tolerance of field measured data with respect to the design parameter shall be

1	Air flow at individual terminal	$\pm$10%
2	Air flow at main duct	$\pm$10%
3	Room temperature	$\pm$0.5^{o}C
4	Electrical operating parameters	$\pm$5%
5	Sound power level measurement	$\pm$5 dB

3.04 Defects and Deficiencies

A Defects and deficiencies identified during TAB shall be documented and reported to the Engineer. The Contractor shall rectify the defects and the TAB shall be repeated for the affected system or equipment until acceptable results is obtained.

3.05 Functional Performance Testing

A Scope of Test

Functional performance tests shall be conducted in the presence of the Engineer to demonstrate the performance of the Air Conditioning and Mechanical Ventilation System.

B The scope of test shall include

1 Full range of checks and tests to determine that all components, equipments, and interfaces between system operate in accordance with the specification.

2 Tests and verification of all operating modes, all interlocked, all control responses and all specified responses to abnormal or emergency condition.

C Test Reporting Requirement

All measured data, data sheets and a comprehensive summary describing the operating of the system at the time of test shall be submitted to the Engineer.

Deficiencies identified during the functional performance test shall be rectified and part or all of the functional performance testing shall be repeated.

D Final Acceptance

Upon satisfactory completion of all functional performance testings, rectification works, and final commissioning reports, the Engineer shall recommend for the acceptance of the Air Conditioning and Ventilation System.

END OF SECTION 15250

SECTION 15400

Domestic Cold Water Plumbing System

Part1 - General

1.01 Description of the Works

This section covers the material and installation requirements for domestic cold water plumbing systems, including pipes and fittings; pipe joints; valves; gate valve setting; seals, hangars and fiberglass water tanks.

1.02 Reference Standards

A	BS 1387	-	Mild Steel Pipes
B	BS 1740	-	Pipe Fittings
C	BS 3505	-	uPVC Pipes
D	BS 4346 (Part 1)	-	uPVC Fittings
E	BS 4346 (Part 3)	-	uPVC Pipe Joints
F	BS 4515	-	Soil Pipes and Fittings
G	BS 5255	-	Waste Pipes and Fittings
H	BS 416	-	Cast Iron Pipes
I	BS 437	-	Cast Iron Pipe Fittings
J	BS 10	-	Storage Tank Connections
K	BS 1010	-	Stop Valve up to 50 mm
L	BS 1218 Class 125	-	Stop Valve above 50 mm
M	BS 1953 Class 125	-	Check Valve
N	BS 1212	-	Ball Valve Brass Equilibrium
O	BS 1968	-	Ball Valve Copper Float
P	BS 1952	-	Gate Valve
Q	BS 2494	-	Rubber Seals for UPVC Pipes
R	BS 4213	-	Fiberglass Water Tank
S	BS 5572	-	uPVC & C.I. Pipework
T	BS 5391/ AS 3518 (Part 1 & 2)	-	ABS pipes and fittings
U	AS 3690	-	ABS pipe jointings and installation

1.03 Rules and Regulations

A The whole of the work covered by this Specification shall be carried out by a licensed plumber in accordance with the relevant Water Works Department (JBA) Specification and Codes of Practice and the Regulations and By-Laws of all Authorities having jurisdiction over the installation.

B The Contractor shall apply for and obtain all necessary certificates and approvals for the work done from the relevant authorities, and shall lodge it with the Engineer before final payment is made.

1.04 Permits and Fees

A The Contractor shall produce all permits and pay all fees and charges incurred in connection with this work.

1.05 Colour Scheme

A The pipework and equipment shall be identified in accordance with the following colour scheme:

1 Pumps and Motors: blue hammer tone (factory applied)
2 Control Panel: green hammer tone outside and white inside (ditto).
3 Cold water Pipes: green
4 Soil, Waste anti-siphon ventilating and drain pipes: black
5 Valves -cast iron body: red
6 Conduits for 24 volt control circuit wiring: violet
7 Conduit and trunking for phase and line voltage circuits: orange

Part 2 - Product

2.01 Materials

A All materials and equipment supplied shall be new and of the best type for each particular purpose and of the first quality as regards design, manufacture, and performance. All materials used in connection with the piped services installation shall be of quality specified and where not specified shall be in accordance with the relevant Water Works Department (JBA) Specification.

B Pipework, valves, and fittings shall be clean and undamaged by corrosion or physical face. Damaged materials will be rejected.

2.02 Materials for Pipes and Fittings

A Except where otherwise described pipes and fittings shall comply with the following: -

1 Above ground mild steel pipes shall be galvanised pipes to BS 1387, medium duty type.
2 Mild steel piping buried below ground shall be of galvanised mild steel pipes to BS 1387 heavy-duty type, with two coats hot asphaltic paint treatment.
3 Pipe fittings shall comply with BS 1740.
4 UPVC pipes shall be unplasticised PVC pipes to BS 3505 Class 'D' and fittings to BS 4346 Part 1.
5 ABS (Acrylonitrile, Butadiene, Styrene) pressure pipes and fittings shall be to BS 5391 or AS 3518 Part 1&2 for nominal sizes ranging from 15mm up to 200mm and pressure rating shall be Class 12.
6 ABS pipes and fittings shall be suitable for use with potable water and shall have passed the test of "Effect on the Quality of the Water" under BS 6920.
7 Pipes sizes shown on the drawings are the nominal bore of the pipes.

B The UPVC pipes and fittings shall comply in all respects to:

1 BS 4515 for "soil pipes and fittings" for size 82mm, 110mm and 160mm diameter.
2 BS 5255 for "waste pipes and fittings" for size 32mm, 38mm and 50mm diameter.
3 The cast iron pipes and fittings shall comply in all respects with BS 416 and 437 heavy grade for soil, waste, and vent pipe 50mm and above.
4 The galvanised mild steel pipe (light gauge) shall comply in all respects with BS 1387 for vent and waste pipes below 50mm.

C Pipes shall be examined for damage or protective coating. Minor damages shall be made good with bitumen paint, but pipes with major coating damage will be rejected.

D Exposed pipe to sanitary fittings shall be medium gauge galvanised iron pipe, heavily nickel plated and then bright chromium plated.

2.03 Pipe Joints

A The pipe joints shall comply in all respects to:

1 Unplasticised PVC pipe joints shall comply with the requirements of BS 4346 Part 3.
2 Galvanised steel piping shall generally be jointed with screwed socket joints, using screwed fittings of wrought iron or steel to BS 1740.
3 ABS pipe jointings and installation shall comply to AS 3690.
4 All piping to pumps and for storage tank connections shall be jointed with screwed flanges of wrought iron or steel to BS 10.

B Valves: All valves for cold water services shall confirm to the followings: -

1	Stop Valve UP to 50mm	BS 1010
2	Stop Valve above 50mm	BS 1218 Class 125
3	Check Valve Up to 50mm	BS 1953 Class 125
4	Ball Valve	BS 1212 brass equilibrium type, copper float to BS 1968
5	Gate Valve	BS 1952

C All hose cocks shall be 12 mm diameter and chromium plated with hose connection.

D All valves and valve fittings at pressure reducing set shall be brass to conform to British Standard and to withstand a pressure of 150 psi.

E The nominal bore of any valve shall not be less than the bore of the pipe to which is fitted, unless otherwise stated.

2.04 Gate Valve Setting

A The flow rate to each valve shall be as follows:-

1	Cisterns	-	2.0 g.p.m.
2	Lavatory Basins	-	1.5 g.p.m.
3	Sinks	-	3.0 g.p.m.
4	Hose Cocks	-	1.5 g.p.m.

B The joint between the flow control valve and the pipework shall be made by means of a brass screwed adapter. Brazing shall not be permitted.

2.05 Hanger Rods for Brackets

A Hanger rods for brackets shall be the following sizes:

1	Up to 19mm diameter pipe	6mm diameter

2	25mm – 50mm diameter pipe	8mm diameter
3	64mm – 102mm diameter pipe	16mm diameter
4	102mm diameter pipe	20mm diameter

B For hanger rods over 450mm long lateral bracing shall be provided every fourth hanger.

2.06 Rubber Seals for UPVC Pipes

A The rubber seals for seal ring joints shall be of a section that gives more than one point of contact with the pipe and shall be of the material required of BS 2494.

2.07 Fiberglass Water Tanks

A Tanks shall comply with BS 4213 and shall be rectangular or cylindrical to the sizes indicated on the drawings, complete with lid and all accessories as detailed. Tanks to be obtained from a manufacturer approved by the Architect / Engineer.

Part 3 – Execution

3.01 Workmanship

A Fully competent tradesman of appropriate grades shall carry out all work in accordance with the best engineering practice.

B All pipes shall be fixed clear of each other and shall be arranged so as to provide easy access for maintenance and repair. The pipes shall be easily replaceable for their full length. No pipes shall be installed or fixed behind other pipes.

C All pipes, which are not concealed in ducts or within false ceiling, shall be concealed in chases up to a point as near as possible to the fitting. Any delay due to rejection of materials and /or workmanship shall be the responsibility of the Contractor.

3.02 Fixing of Pipes

A The exact location of pipe lines shall be ascertained on site in collaboration with other trades. All pipework except those chased in walls and floors shall be fixed at least 31mm clear of the surfaces of the supporting structure to give free access for painting to the full external surfaces.

B Straight pipe runs shall be continuous lengths as for as practical with joints kept to the absolute minimum.

C Cutting of pipework shall be carried out with pipe cutters and thread tapings shall be made using dies. Improperly threaded pipework installed with excessive compound will be rejected.

D Where it is necessary to avoid sound transmission, a PVC insert shall be provided between the fixing and the pipe.

E Where pipes pass through walls or floors, a layer of heavy hair felt, or pipes sleeves or cardboard, millboard, asbestos cement or other suitable material shall be provided.

These shall extend through the full finished thickness of the wall or floor, and be secured against movement.

F A minimum of 25mm clearance shall be provided when a pipe passes through the wall between the pipe and the penetration in the wall. The pipe shall be supported on either side of the hole, so that the pipe does not rest on the wall. The clearance space shall be stuffed with fibrous filler material and sealed both sides with non non-setting caulking/sealing compound.

G Vertical pipe chases through in building should be located not to be located beside critical areas. If they are located beside critical areas, the pipes should be resiliently mounted from the walls of the pipe chase.

H All other supports or hangers horizontally or vertically shall be spring and neoprene in series isolation of minimum 13 mm static deflection. Double deflection neoprene in shear types isolators are allowed for vertical run pipes.

I All small water pipes shall be isolated with 13mm thick resilient felt pad under pipe strap or clamp. No tie rods shall be used to bolt the end flanges together.

J All fittings, hangers, holder bats, brackets, etc. shall be of mild steel and shall be given the same finish as the piping. A PVC insert must be provided for copper pipes. Support for pipes run together in parallel shall be grouped.

K The spacing of fixings shall not exceed the following: -

Material of Pipe	**Pipe Diameter**	**Maximum Spacing of Support**	
		Vertical Runs	**Horizontal Runs**
Galvanised Iron Water Supply	Up to 19mm	2.44m	1.83m
	25mm	3.05m	2.44m
	32mm	3.05m	2.74m
	38mm – 50mm	3.66m	3.05m
	64 mm – 76 mm	4.57m	3.66m
	110mm	4.57m	3.96m
UPVC (Water Supply) at 20 ° C	10mm	Up to twice The permitted horizontal spacing of support centers shall be accepted provided the pipe is well protected within a structure	0.76m
	12mm		0.84m
	20mm		0.91m
	25mm		1.07m
	32mm		1.14m
	38mm		1.22m
	50mm		1.45m
	82mm		1.68m
	110mm		1.91m
UPVC (Soil, Waste and	32mm	0.91m	0.46m
	38mm	0.91m	0.46m

Material of Pipe	Pipe Diameter	Maximum Spacing of Support	
		Vertical Runs	Horizontal Runs
Vent)			
	51mm	0.91m	0.61m
	76mm	1.52m	0.91m
	102mm	1.83m	1.22m
	152mm	2.29m	1.83m
Cast Iron	All sizes	3.05m	1.52m
Acrylonitrile	15mm-20mm	0.7m	0.9m
Butadiene	25mm-32mm	0.9m	1.0m
Styrene (ABS)	40mm-50mm	1.0m	1.2m
	80mm-100mm	1.4m	1.6m
	150mm	1.9m	2.1m

* At least one fixing must be provided for each unit length.

L All fixing shall be carefully aligned and spaced. In the case of horizontal drain lines, the fixings shall be so constructed as to enable proper adjustment in height of the pipelines to be effected.

M Fixings shall wherever possible is cast in the building structure. If this is not practicable, they shall be secured to the structure by means of expansion bolts or power driven bolts. Grouting of fixings to the structure shall not be permitted.

3.03 Jointing and Fittings of Pipes

A All pipes ends shall be cut square and all sharp edges and burrs removed from the bore of the pipes with a pipe reamer. A jointing compound shall be used in accordance with the maker's instruction together with a few strands of fire hemp. Care shall be taken to avoid over threading by more than 12.5mm. Any exposed threads shall be painted with a cold galvanising type of paint.

B All screwed joints shall be made watertight with best quality New Zealand hemp flux, and paint, wound spirally round the threaded section of the pipe.

C Alternatively pipes and joints over 50 mm may be jointed by electric arc welding except at sanitary fittings and valves where screwed connections shall be used. Joints and welding procedures shall be carried out in accordance with accepted welding trade practice, welders may be required to carry out test welds. Any weld failing to meet the required standard shall be replaced.

D For jointing to fitting, equipment, pumps, valves and special fittings, flanges shall be used for pipes 50mm diameter and above.

E Sufficient numbers of flanged or union joints shall be provided, adjacent to sanitary fittings and valves and where directed or shown on the drawings as to facilitate removal of pipes and sanitary fittings for inspection and repairs. Flanged, union or other type of

screwed joints will not be permitted where pipework is run in false ceiling spaces, or other inaccessible positions.

F Running joints or barrel unions will not be permitted. Flanged joints shall be made with jointing rings of best quality, smooth, hard, compressed fiber board not less than 1.56mm thick, and of such width as to fit inside the circle of bolts. The rings shall be measured thinly with graphite paste. The nuts shall be carefully tightened, in opposite pairs, until the jointing ring is sufficiently compressed between the flanges to ensure water-tightness.

G The method of jointing for UPVC pipes shall generally be that of solvent welding using approved cement or ring seal jointing according to manufacturer's instruction. Seal rings fittings shall be used where necessary to accommodate thermal movement or the sockets of standard fittings shall be converted to seal ring joints by the additional of a seal ring adapter.

H. Solvent cement jointing shall be used with spigot and socket type joints in pipes and fittings.

Adequate number of mechanical couplings flanged joints or union shall be provided, especially in plant rooms, service ducts and adjacent to equipment for inspection and repair. Such couplings, flanges and accessories shall be procured from the manufacturer of the pipe or from manufacturer acceptable to the pipe manufacturer.

Jointing shall comply with the procedure of AS 3690 or the recommendation of the manufacturer.

I Cast iron pipes shall generally be jointed by means of the spigot and socket joint.

J The spigot shall be centered in the adjoining socket by tightly caulking in sufficient turns of tarred yarn of lead strip to leave unfilled about 44mm and 50mm for 110mm and 160mm pipe respectively for lead joint. A jointing ring shall then be placed round the barrel and against the face of the socket. Molten pig lead shall then be poured into fill the reminder of the socket and the lead solidly caulked right round the joint. The molten lead shall extend beyond the socket to form triangular fillet, neatly struck off at an angle of 45º.

K Care shall be taken to see that the pipes are perfectly dry before run lead joints are made. Lead fiber may be used instead of molten lead. Cement mortar joints shall not be permitted. Galvanised steel pipe shall be jointed with screw socket joints as described for cold water system.

L Upon completion of each section the pipework shall be inspected to ensure that all pipe brackets, clips, etc. are correctly spaced and securely fixed, and that the pipework is well jointed and all access covers, caps or plugs are accessible.

3.04 Casting in of Pipes

A Pipes passing through external walls shall have a short section of pipe cast into the wall at the time of pouring the Concrete. This section shall have weld-on or cast-on blank flange at the mid-section to act as a water bar. The ends of the pipe shall project a least 150mm from the face of the wall to facilitate jointing. The ends shall be of the proper configuration for the method of jointing to be adopted.

B Where boxing-out is necessary a sufficiently large opening shall be provided which shall have incorporated at main wall thickness, along the periphery, a 6" PVC waterstop. Reinforcement shall be carried through the opening and brought up as close to the pipe as possible. After the pipe has been installed the opening shall be concreted in with a mix incorporating an approved anti-shrink admixture.

3.05 uPVC & C.I. Pipework

A When used internally holder bats shall be made of mild steel protected from corrosion by galvanised or plastic coating. They shall have a two position fixing suitable for either acting as a pipe support but allowing thermal movement or as a clamp fit on a fitting creating a fixed point. For optimum fit to pipe supports PVC packing pieces may be used.

B Pipes shall be fixed in straight runs and horizontal runs shall be laid gradients in accordance with BS 5572 and in any event not less than 19mm in 900mm unless otherwise instructed with cleaning eyes and inspection openings in accessible locations.

C Expansion joints shall be provided at a maximum of 4m centers for soil 2m centers for waste and between fixed points over 1m centers.

D Horizontal lines shall be arranged to have the maximum grade with cleaning eyes and inspection openings in accessible locations.

E The pipework in branch connections shall always be arranged to allow free drainage of the system. Connections to main or branch pipes shall be so arranged as to prevent cross flow from one appliance to another. Connection shall be made with an easy sweep in the direction of flow. Bends shall be of long radius where practicable, or alternatively two 45E short radius bends may be used provided that a 305mm straight length of pipe shall separate these.

F Ventilating pipes shall be so installed that water cannot be retained in them. Trap ventilating pipe shall be connected to the top of the branch soil or waste pipe between 82mm and 457mm from the crown of the trap and rise vertically or at any angle not more than 45E from the vertical to a point at least 150mm above the flood –level rim of the sanitary fitting it is venting before off setting horizontally or before connecting to the branch vent pipe. The branch vent pipe shall be fixed at least 250mm above the flood level rim of the highest fitting served and shall be sloped to allow for free drainage.

G The vent pipe shall be extended through the roof to the required height, with the open end protected by means of a vent cowl or automatic air admittance valve. It shall be flashed where it penetrates the roof as shown on the drawings.

H The pipework shall be located and installed so that the piping is accessible for inspection, replacement, and repair. All stop valves shall be placed in positions, which allow for convenient operation and repair.

I The pipework shall be installed so that each distribution line isolated by a stop valve is capable of complete drainage to facilitate repairs.

3.06 Cleaning Out of Pipework

A After installation and before hydrostatic tests are carried out, the piping shall be cleaned out thoroughly.

B Temporary connections shall be made from the mains to each section of piping to be flushed out. The discharge of each section of piping shall be led to a suitable gully or drain.

C Piping shall be disconnected from tanks, control valves, and equipment before being washed out.

3.07 Testing and Balancing of Services

A The Contractor shall test and balance the plumbing systems as hereinafter specified or as required by the Authorities having jurisdiction over the installation.

B The cost of providing all testing and measuring equipment and all materials shall be borne by the Contractor.

C All pipework, which is to be encased or concealed, shall be tested and approved before it is finally enclosed.

D The Contractor shall give the Engineer a full seven-day's notice if his readings to carry out acceptance tests and shall submit for his approval a complete and detailed schedule of the tests to be carried out.

E Before commencement of acceptances tests and balancing the Contractor shall have brought the installation or, where the situation favours, a section (e.g. On a floor by floor basis) to a state of practical completion and shall have completed all of his preliminary testing and adjustment of equipment to its proper running order.

F During the testing period no modification, adjustment, or other work on the installation shall be carried out without the permission of the Engineer. Should there be any contravention of this requirement the results of all tests completed may be rejected and a retest must be carried out.

G No acceptance tests shall be carried out except in the presence of the Engineer and the Contractor or their respective representatives appointed for the purpose.

H Should the installation fail to perform in accordance with the requirements of the specification and the Authorities having jurisdiction over the installation, the Engineer may reject the whole or any part of it.

I The testing period shall form part of the contract period and no extension of time will be granted by reason of any extension of the testing period to permit rectification, modification, adjustment or re-testing of the installation except where testing has been delayed or re-testing or further testing has been necessitating by circumstances beyond the control of the Contractor.

J When final test have been successfully carried out, the Contractor shall supply the Engineer with three (3) sets of the test records.

3.08 Testing for Water Tightness

A After cleaning, the piping shall be tested for water tightness. When all draw-off taps are closed, the service shall be absolutely watertight. Each tap shall be opened and tested for the rate of flow. Any fault discovered shall be made good to the satisfaction of the Engineer.

3.09 Hydraulic Pressure Test

A The pipework shall be hydraulically pressure tested and a half (1½) times the working pressure. The pressure shall be recorded over a minimum period of twenty-four hours.

B Special care shall be taken during pressure testing to ensure that controls, safety devices, meters, etc. with operating pressure ranges below the test pressure are not damaged or have their accuracy impaired.

3.10 Sterilization of Installation

A The tank shall be scrubbed down and flushed out with water containing a solution of chloride of lime.

B The tank shall then be filled with water and a sterilizing chemical containing chlorine added gradually while the tank is filling to ensure thorough mixing. Sufficient chemicals shall be used to give the water a dose of 50 parts of chlorine to one million parts of water. If ordinary bleaching powder is used, the proportions shall be 1.5Lb. of powder to 1,000 gallon of water, the powder shall be mixed with water to a cream consistency before being added to the water. When the tank is full the supply shall be shut off.

C All the taps on the distributing pipes shall then be opened successively, working progressively away from the tank. Each tap shall be closed when the water discharged begins to smell of chlorine. The tank shall then be topped up and the whole system shall remain charged for at least three hours, whereupon a test shall be made for residual chlorine: if none is found; the sterilization must be carried out again for the water storage tank.

D Finally the tank and pipes shall be thoroughly flushed out before any water is used for domestic purposes.

3.11 Painting

A All pipes chased in walls and floors are not to be painted. All other bare piping, vents, metal sheeting, pipe hangers, supports, valves, equipment, steelwork and all other work covered in this specification, except where specified to be chromium plated, shall be cleaned down and given one primer coat and two finishing coats of approved enamel paint of colour to be selected by the Engineer.

B Directional flow arrows approximately 150mm long shall be painted if required at intervals of 1800mm. The arrows shall be stenciled and painted one coat of selected colour.

3.12 Labeling

A The installation shall be comprehensively labeled to the satisfaction of the Engineer. The use of plastic labels made with "DYMO" tape writers or their equivalent will not be permitted.

B Equipment such as pumps, tanks etc. shall be comprehensively labeled in block letters of 50mm x 44mm x 10mm.

C Notices for plant room doors etc. shall be metal, enameled or painted white with block letters not less than 64mm x 44mm x 10mm.

END OF SECTION 15400

SECTION 15500

Sanitary Plumbing System

Part 1 - General

1.01 Description of the Works

A This section covers the material and installation requirements for domestic cold water plumbing systems, including pipes and fittings; pipe joints; valves; gate valve setting; seals, hangars and fiberglass water tanks.

1.02 Reference Standards

BS 1387	-	Mild Steel Pipes
BS 1740	-	Pipe Fittings
BS 3505	-	UPVC Pipes
BS 4346 (Part 1)	-	UPVC Fittings
BS 4346 (Part 3)	-	UPVC Pipe Joints
BS 4515	-	Soil Pipes and Fittings
BS 5255	-	Waste Pipes and Fittings
BS 416	-	Cast Iron Pipes
BS 437	-	Cast Iron Pipe Fittings
BS 10	-	Storage Tank Connections
BS 1010	-	Stop Valve up to 50 mm
BS 1218 Class 125	-	Stop Valve above 50 mm
BS 1953 Class 125	-	Check Valve
BS 1212	-	Ball Valve Brass Equilibrium
BS 1968	-	Ball Valve Copper Float
BS 1952	-	Gate Valve
BS 2494	-	Rubber Seals for UPVC Pipes
BS 4213	-	Fiberglass Water Tank
BS 5572	-	uPVC & C.I. Pipework
BS 3943	-	uPVC Waste Traps
BS 1125	-	W.C Cisterns
BS 1186 & 5506	-	Wash Basins
BS 1206	-	Fire Clay Sinks
BS 1213	-	W.C. Pans
BS 1254	-	W.C. Seats
BS 1010 (Part 2)	-	Taps

1.03 Rules and Regulations

A The whole of the work covered by this Specification shall be carried out by a licensed plumber in accordance with the relevant Water Works Department (JBA) Specification and Codes of Practice and the Regulations and By-Laws of all Authorities having jurisdiction over the installation.

B The Contractor shall apply for and obtain all necessary certificates and approvals for the work done from the relevant authorities, and shall lodge it with the Engineer before final payment is made.

1.04 Permits and Fees

A The Contractor shall produce all permits and pay all fees and charges incurred in connection with this work.

1.05 Colour Scheme

A The pipework and equipment shall be identified in accordance with the following colour scheme:

1 Pumps and Motors: blue hammer tone (factory applied)
2 Control Panel: green hammer tone outside and white inside (ditto).
3 Cold water Pipes: green
4 Soil, Waste anti-siphon ventilating and drain pipes: black
5 Valves -cast iron body: red
6 Conduits for 24 volt control circuit wiring: violet
7 Conduit and trunking for phase and line voltage circuits: orange

1.06 Access Openings

A Sufficient access shall be provided to enable all pipework to be cleaned and tested. Access openings of adequate size shall generally be provided on the vertical stack directly opposite a branch line, at the extreme end of a main branch line, at the junction of a subsidiary branch to a main branch and at bends.

B Rectangular access openings shall be equal in width to the full diameter of the pipe and in length too at least one and a half times the width.

C Oval access openings shall have an area of not less than the cross sectional area of the pipe to which they are fitted.

D The internal face of the cover shall be shaped to form a true completion of the bore of the pipe. The openings shall be made gas tight with good quality rubber washer, and the covers firmly secured with gun-metal or other suitable screws or studs.

E For PVC pipes, access shall be provided by means of an integrally moulded door in an access fitting with an externally fitted rubber seal and secured with two galvanised bolts and nuts or by a two piece clamp type door fitted into the pipe run.

F The rates inserted in the Bills of Quantities for the pipe fittings shall include for the access opening.

Part 2 - Product

2.01 Materials

A All materials and equipment supplied shall be new and of the best type for each particular purpose and of the first quality as regards design, manufacture, and performance. All materials used in connection with the piped services installation shall be of quality specified and where not specified shall be in accordance with the relevant Water Works Department (JBA) Specification.

B Pipework, valves, and fittings shall be clean and undamaged by corrosion or physical face. Damaged materials will be rejected.

2.02 Materials for Pipes and Fittings

A Except where otherwise described pipes and fittings shall comply with the following: -

1 Above ground mild steel pipes shall be galvanised pipes to BS 1387, medium duty type.
2 Mild steel piping buried below ground shall be of galvanised mild steel pipes to BS 1387 heavy-duty type, with two coats hot asphaltic paint treatment.
3 Pipe fittings shall comply with BS 1740.
4 UPVC pipes shall be unplasticised PVC pipes to BS 3505 Class 'D' and fittings to BS 4346 Part 1.
5 Pipes sizes shown on the drawings are the nominal bore of the pipes.

B The UPVC pipes and fittings shall comply in all respects to:

1 BS 4515 for "soil pipes and fittings" for size 82mm, 110mm and 160mm diameter.
2 BS 5255 for "waste pipes and fittings" for size 32mm, 38mm and 50mm diameter.
3 The cast iron pipes and fittings shall comply in all respects with BS 416 and 437 heavy grade for soil, waste, and vent pipe 50mm and above.
4 The galvanised mild steel pipe (light gauge) shall comply in all respects with BS 1387 for vent and waste pipes below 50mm.

C Pipes shall be examined for damage or protective coating. Minor damages shall be made good with bitumen paint, but pipes with major coating damage will be rejected.

D Exposed pipe to sanitary fittings shall be medium gauge galvanised iron pipe, heavily nickel plated and then bright chromium plated.

2.03 Pipe Joints

A The pipe joints shall comply in all respects to:

1 Unplasticised PVC pipe joints shall comply with the requirements of BS 4346 Part 3.
2 Galvanised steel piping shall generally be jointed with screwed socket joints, using screwed fittings of wrought iron or steel to BS 1740.
3 All piping to pumps and for storage tank connections shall be jointed with screwed flanges of wrought iron or steel to BS 10.

B Valves: All valves for cold water services shall confirm to the followings: -

1	Stop Valve UP to 50mm	BS 1010
2	Stop Valve above 50mm	BS 1218 Class 125
3	Check Valve Up to 50mm	BS 1953 Class 125
4	Ball Valve	BS 1212 brass equilibrium type, copper float to BS 1968
5	Gate Valve	BS 1952

C All hose cocks shall be 12 mm diameter and chromium plated with hose connection.

D All valves and valve fittings at pressure reducing set shall be brass to conform to British Standard and to withstand a pressure of 150 psi.

E The nominal bore of any valve shall not be less than the bore of the pipe to which is fitted, unless otherwise stated.

2.04 Rubber Seals for UPVC Pipes

A The rubber seals for seal ring joints shall be of a section that gives more than one point of contact with the pipe and shall be of the material required of BS 2494.

2.05 UPVC Waste Traps

A Traps shall be moulded from white polypropylene and shall have a universal compression outlet. The fittings shall comply with BS 3943 where applicable.

2.06 Sanitary Fittings

A All sanitary fittings shall be specifically stated in the Specification and /or drawings and shall be complete with all necessary accessories.

B Fittings shall comply with the following British Standard or other approved standards as applicable.

1	Taps	-	BS1010 Part 2
2	W.C cisterns	-	BS 1125
3	Wash Basins	-	BS 1186
4	Fire clay sinks	-	BS 1206
5	Ball valves	-	BS 1212
6	W.C pans	-	BS 1213
7	W.C seats	-	BS 1254
8	Wash Basins	-	BS 5506

C Sitting type W.C.'s shall have a wash down W.C. pedestal with "S" trap in one piece, a plastic seat and cover, "low level" flushing cistern of 13.5 liters capacity and lever flushing handle. Squatting type W.C.'s shall have a wash down W.C.'s trough with "S" trap in one piece, high level flushing cistern of 9 liters capacity and flushing chain. The cistern shall have a 12mm ball valve with silencer, a plastic ball, and a 19mm diameter overflow pipe. W.C.'s shall be supplied complete with down pipes, all necessary fittings, and 19mm diameter overflow pipes discharging outside the building.

Part 3 – Execution

3.01 Workmanship

A Fully competent tradesman of appropriate grades shall carry out all work in accordance with the best engineering practice.

B All pipes shall be fixed clear of each other and shall be arranged so as to provide easy access for maintenance and repair. The pipes shall be easily replaceable for their full length. No pipes shall be installed or fixed behind other pipes.

C All pipes, which are not concealed in ducts or within false ceiling, shall be concealed in chases up to a point as near as possible to the fitting. Any delay due to rejection of materials and /or workmanship shall be the responsibility of the Contractor.

3.02 Fixing of Pipes

A The exact location of pipe lines shall be ascertained on site in collaboration with other trades. All pipework except those chased in walls and floors shall be fixed at least 31mm clear of the surfaces of the supporting structure to give free access for painting to the full external surfaces.

B Straight pipe runs shall be continuous lengths as for as practical with joints kept to the absolute minimum.

C Cutting of pipework shall be carried out with pipe cutters and thread tapings shall be made using dies. Improperly threaded pipework installed with excessive compound will be rejected.

D Where it is necessary to avoid sound transmission, a PVC insert shall be provided between the fixing and the pipe.

E Where pipes pass through walls or floors, a layer of heavy hair felt, or pipes sleeves or cardboard, millboard, asbestos cement or other suitable material shall be provided. These shall extend through the full finished thickness of the wall or floor, and be secured against movement.

F A minimum of 25mm clearance shall be provided when a pipe passes through the wall between the pipe and the penetration in the wall. The pipe shall be supported on either side of the hole, so that the pipe does not rest on the wall. The clearance space shall be stuffed with fibrous filler material and sealed both sides with non non-setting caulking/sealing compound.

G Vertical pipe chases through in building should be located not to be located beside critical areas. If they are located beside critical areas, the pipes should be resiliently mounted from the walls of the pipe chase.

H All other supports or hangers horizontally or vertically shall be spring and neoprene in series isolation of minimum 13 mm static deflection. Double deflection neoprene in shear types isolators are allowed for vertical run pipes.

I All small water pipes shall be isolated with 13mm thick resilient felt pad under pipe strap or clamp. No tie rods shall be used to bolt the end flanges together.

J All fittings, hangers, holder bats, brackets, etc. shall be of mild steel and shall be given the same finish as the piping. A PVC insert must be provided for copper pipes. Support for pipes run together in parallel shall be grouped.

K The spacing of fixings shall not exceed the following: -

Material of Pipe	Diameter of Pipe	Maximum Spacing of Support	
		Vertical Runs	Horizontal Runs
Galvanised Iron Water Supply	Up to 19mm	2.44m	1.83m
	25mm	3.05m	2.44m
	32mm	3.05m	2.74m
	38mm – 50mm	3.66m	3.05m
	64 mm – 76 mm	4.57m	3.66m
	110mm	4.57m	3.96m
UPVC (Water Supply) at 20 º C	10mm	Up to twice The permitted horizontal spacing of support centers shall be accepted provided the pipe is well protected within a structure	0.76m
	12mm		0.84m
	20mm		0.91m
	25mm		1.07m
	32mm		1.14m
	38mm		1.22m
	50mm		1.45m
	82mm		1.68m
	110mm		1.91m
UPVC (Soil, Waste and Vent)	32mm	0.91m	0.46m
	38mm	0.91m	0.46m
	51mm	0.91m	0.61m
	76mm	1.52m	0.91m
	102mm	1.83m	1.22m
	152mm	2.29m	1.83m
Cast Iron	All sizes	3.05m	1.52m

* At least one fixing must be provided for each unit length.

L All fixing shall be carefully aligned and spaced. In the case of horizontal drain lines, the fixings shall be so constructed as to enable proper adjustment in height of the pipelines to be effected.

M Fixings shall wherever possible is cast in the building structure. If this is not practicable, they shall be secured to the structure by means of expansion bolts or power driven bolts. Grouting of fixings to the structure shall not be permitted.

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A All pipes ends shall be cut square and all sharp edges and burrs removed from the bore of the pipes with a pipe reamer. A jointing compound shall be used in accordance with the maker's instruction together with a few strands of fire hemp. Care shall be

taken to avoid over threading by more than 12.5mm. Any exposed threads shall be painted with a cold galvanising type of paint.

B All screwed joints shall be made watertight with best quality New Zealand hemp flux, and paint, wound spirally round the threaded section of the pipe.

C Alternatively pipes and joints over 50 mm may be jointed by electric arc welding except at sanitary fittings and valves where screwed connections shall be used. Joints and welding procedures shall be carried out in accordance with accepted welding trade practice, welders may be required to carry out test welds. Any weld failing to meet the required standard shall be replaced.

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F Running joints or barrel unions will not be permitted. Flanged joints shall be made with jointing rings of best quality, smooth, hard, compressed fiber board not less than 1.56mm thick, and of such width as to fit inside the circle of bolts. The rings shall be measured thinly with graphite paste. The nuts shall be carefully tightened, in opposite pairs, until the jointing ring is sufficiently compressed between the flanges to ensure water-tightness.

G The method of jointing for UPVC pipes shall generally be that of solvent welding using approved cement or ring seal jointing according to manufacturer's instruction. Seal rings fittings shall be used where necessary to accommodate thermal movement or the sockets of standard fittings shall be converted to seal ring joints by the additional of a seal ring adapter.

H Cast iron pipes shall generally be jointed by means of the spigot and socket joint.

I The spigot shall be centered in the adjoining socket by tightly caulking in sufficient turns of tarred yarn of lead strip to leave unfilled about 44mm and 50mm for 110mm and 160mm pipe respectively for lead joint. A jointing ring shall then be placed round the barrel and against the face of the socket. Molten pig lead shall then be poured into fill the reminder of the socket and the lead solidly caulked right round the joint. The molten lead shall extend beyond the socket to form triangular fillet, neatly struck off at an angle of 45º.

J Care shall be taken to see that the pipes are perfectly dry before run lead joints are made. Lead fiber may be used instead of molten lead. Cement mortar joints shall not be permitted. Galvanised steel pipe shall be jointed with screw socket joints as described for cold water system.

K Upon completion of each section the pipework shall be inspected to ensure that all pipe brackets, clips, etc. are correctly spaced and securely fixed, and that the pipework is well jointed and all access covers, caps or plugs are accessible.

3.04 Casting in of Pipes

A Pipes passing through external walls shall have a short section of pipe cast into the wall at the time of pouring the Concrete. This section shall have weld-on or cast-on blank flange at the mid-section to act as a water bar. The ends of the pipe shall project a least 150mm from the face of the wall to facilitate jointing. The ends shall be of the proper configuration for the method of jointing to be adopted.

B Where boxing-out is necessary a sufficiently large opening shall be provided which shall have incorporated at main wall thickness, along the periphery, a 6" PVC waterstop. Reinforcement shall be carried through the opening and brought up as close to the pipe as possible. After the pipe has been installed the opening shall be concreted in with a mix incorporating an approved anti-shrink admixture.

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C Expansion joints shall be provided at a maximum of 4m centers for soil 2m centers for waste and between fixed points over 1m centers.

D Horizontal lines shall be arranged to have the maximum grade with cleaning eyes and inspection openings in accessible locations.

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F Ventilating pipes shall be so installed that water cannot be retained in them. Trap ventilating pipe shall be connected to the top of the branch soil or waste pipe between 82mm and 457mm from the crown of the trap and rise vertically or at any angle not more than 45E from the vertical to a point at least 150mm above the flood –level rim of the sanitary fitting it is venting before off setting horizontally or before connecting to the branch vent pipe. The branch vent pipe shall be fixed at least 250mm above the flood level rim of the highest fitting served and shall be sloped to allow for free drainage.

G The vent pipe shall be extended through the roof to the required height, with the open end protected by means of a vent cowl or automatic air admittance valve. It shall be flashed where it penetrates the roof as shown on the drawings.

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C All pipework, which is to be encased or concealed, shall be tested and approved before it is finally enclosed.

D The Contractor shall give the Engineer a full seven-day's notice if his readings to carry out acceptance tests and shall submit for his approval a complete and detailed schedule of the tests to be carried out.

E Before commencement of acceptances tests and balancing the Contractor shall have brought the installation or, where the situation favours, a section (e.g. On a floor by floor basis) to a state of practical completion and shall have completed all of his preliminary testing and adjustment of equipment to its proper running order.

F During the testing period no modification, adjustment, or other work on the installation shall be carried out without the permission of the Engineer. Should there be any contravention of this requirement the results of all tests completed may be rejected and a retest must be carried out.

G No acceptance tests shall be carried out except in the presence of the Engineer and the Contractor or their respective representatives appointed for the purpose.

H Should the installation fail to perform in accordance with the requirements of the specification and the Authorities having jurisdiction over the installation, the Engineer may reject the whole or any part of it.

I The testing period shall form part of the contract period and no extension of time will be granted by reason of any extension of the testing period to permit rectification, modification, adjustment or re-testing of the installation except where testing has been delayed or re-testing or further testing has been necessitating by circumstances beyond the control of the Contractor.

J When final test have been successfully carried out, the Contractor shall supply the Engineer with three (3) sets of the test records.

3.08 Hydraulic Presssure and Water Tightness Test

A The completed sanitary plumbing system shall be tested for water and air tightness as well as for hydraulic performance.

1 water shall be applied before the appliances are connected and carried out in sections so as to limit the static head to 4.5m. All openings affected by the test shall be sealed and the system filled with water. Some time shall be allowed for absorption by the pipes and joints to take place, after which the level shall be topped up. The pipes and joints shall be inspected for leakage. If no appreciable fall in water level occurs during a period of 10 minutes the system shall be deemed to have passed the test.

2 Inserting expanding rubber testing plugs in the lower and upper ends of the main soil and waste pipe and main vent pipe and sealing the plugs with water may apply air test.

3 The testing plug at the end of the ventilating pipe shall be fitted with a tee-piece with a cock on each branch being connected by a flexible tube to a manometer.

4 Air pressure is then introduced into the system through the other branch of the tee-piece until a pressure of 64mm water gauge is shown on the manometer scale.

5 Alternatively, the air pressure may be applied by passing a flexible tube from a tee-piece attached to manometer through the water seal of the trap of the sanitary appliance, the test then being carried out as described above.

6 The system shall be deemed to have a passed the test if the pressure remains constant for a period of three minutes.

7 Hydraulic performance discharge test shall be made from all appliances, singly and collectively. Obstruction in any of the pipe line shall be traced and the whole system examined for proper hydraulic performance, including the retention of an adequate water seal in each trap.

B Any defects revealed by the tests should be make good and the tests repeated until satisfactory result is obtained.

3.09 Sanitary Fixing

A Fittings are to be correctly assembled and jointed together and connected to services and wastes. Brackets, lugs, etc. to be carefully positioned and built-in, screwed or plugged and screwed to walls and /or floors.

B W.C pans are to be screwed or plugged and screwed to the floor, and except on wood floors, bedded and pointed in cement mortar. Outlets are to be neatly jointed to stoneware drains or cast iron soil pipe with gaskin and cement and sand (1:1). Squatting closet pans and floor treads are to be bedded in cement and sand to finish flush with paving.

C On concrete upper floors and on ground floors where so specified, raised concrete plinths are to be formed with one or more steps as necessary. Outlets are to be jointed to drain or soil pipes as last specified.

D Waste outlets of lavatory basins and sinks are to be bedded in red lead putty.

3.10 Connection of Sanitary Fittings to Services

A Joints and connections of sanitary fittings to services must be made gas tight and watertight and care shall be taken to measure that no jointing materials project inside the bore of the pipe.

B Adequate number of flanged or union connection shall be provided, adjacent to sanitary fittings so as to facilitate removal of pipe and fittings for inspection and repairs.

C Ensure that the pipes properly aligned and permanently effected. Joints not properly made shall be cut out and remove.

D Upon completion of each section, the work shall be inspected to ensure that all sanitary fittings are securely fixed and are well connected to services.

3.11 uPVC Waste Boss Connections

A Waste box connections when fitted to pipes shall consists of two parts with inner and outer flanges, solvent welded as a complete unit with in built gradients for the waste pipe of 1/4E. Where it is not possible to gain access to the bore of the soil pipe, self locking bosses with integral clamping action may be used provided that the mating surfaces are suitable for and used with solvent weld cement.

END OF SECTION 15500

SECTION 15600

Fire Alarm System

Part 1 – General

1.01 General

This section provides the specification for the supply, installation, wiring, testing, commissioning and guarantee for 12 months the Automatic Fire Alarm System.

The installation shall perform to the requirement of this section under the site conditions defined as any combination of temperature, humidity within the following limits.

Temperature	20^{o}C to 40^{o}C
Relative Humidity	40% to 100%
Pressure	Normal Atmospheric

1.02 Codes and Standards

The Contractor shall supply, install, test and commission the complete fire alarm system generally shown on the drawings. The design and installation of all components and the system shall comply with the requirement of the following bodies or standards:-

(i) British Standard Code of Practice CP 327.404/402.501 current edition on Electrical Fire Alarm.

(ii) British Standard CP 1019, Installation and Servicing of Electrical Fire Alarm System.

(iii) BS 3116 : Part 4 Control and Indicating Equipment for Automatic Fire Alarm System.

(iv) IEE Regulation on Electrical Installation and to the requirements of the Chief Inspectorate of Fire Services, Malaysia.

On completion of the installation, the Contractor shall be responsible to certify in writing to the Inspectorate of Fire Services, Malaysia that the installation is in full compliance with the above mentioned regulations. The Contractor shall also be responsible for obtaining written approval from the CIFS stating that the completed installation is in proper working order.

The Contractor shall provide all labour, materials, tools and equipment required to complete the Fire Alarm System installation. All materials shall be new and unused, be of best quality of their respective kind, free from defects and have been approved for use by the CIFS.

All location of manual call points, automatic detectors and audible alarms as shown on the drawings are approximate. The Sub- Contractor shall check on site location shown on the accompanying drawings and shall adjust accordingly to suit site

conditions. No extra cost shall be allowed for the minor adjustment. Consulting Engineer's approval shall be obtained prior to installation.

The Contractor is required to submit the complete layout and wiring diagrams, fire alarm panel circuitry diagram of the whole system to the Consulting Engineers for approval at least two (2) weeks prior to the commencement of work.

The system shall consist of a master fire alarm indicating panel, manual call points, automatic detectors, alarm bells, batteries, battery charger and all associated wirings and components. The system shall operate on the 24 volt DC system.

1.03 Service

For the period of 1 year from the date of handing over of the WHOLE fire alarm system, the Contractor shall carry out six (6) Nos bi-monthly tests to consist of:

(i) One cycle of functional tests on the Main Fire Alarm Panel.

(ii) Tests on the abnormal power supplies.

(iii) Tests on the workability of the alarm sounders and all the alarm sounder circuits.

(iv) Visual inspection of all the flow switches, heat and smoke detectors and alarm sounders.

1.04 Definitions

(i) Fire Alarm Panel

Equipment the primary function of which is to response to the operation of a trigger device or to the occurrence of a fault and cause a fire alarm or fault alarm warning to be given.

(ii) Fault Warning

Operation of these parts of the system designed to give an indication of the occurrence of a fault within the system.

(iii) Sounder

A device by which electric signal are converted into audible signals. For the purpose of this Contract, the sounder shall be Fire Alarm Bell.

(iv) Trigger Devices

A device capable of being operated automatically or manually to initiate a fire alarm.

(v) Zone Indicator

A module or clearly defined part of the indicating equipment that indicates the zone or position where a fire alarm or fault warning has originated.

Part 2 – Products

2.01 Trigger Devices

(a) Breakglass Station

The alarm call unit shall be the flushed mounting type and suitable for operation on 24 Volt DC closed circuit. Each breakglass unit shall be similar to Gent Model 1198 having a shatter proof and corrosion resistant plastic case heat resistant to 130^{o}C suitable for 19 mm conduit entry. Inscription shall be

"Fire - Smash Glass".

(b) Thermo Detector

The thermo detector unit shall be the THERMISTOR "Rate of Rise" type with a fixed temperature rating of 135^{o}F complying to BS 5445, BS 5839 and BS 5750. It shall be Grade 1 type to detect in the fastest response time.

(c) Ionisation Smoke Detector

The smoke detector unit shall operate on the light scatter principle from a constant power supply and calibrated for detection 1-2% smoke density per U.L. and F.M. Standards. Normal condition is indicate by a subdued green pilot light. Under alarm condition an additional red lamp will light on the individual detector. The detector shall follow the minimum standards : BS 5445 Part 7 1984, BS 5839 Part 1, 1980 and BS 5750 Part 2. The Ionisation Smoke Detector must be approved for use by Atomic Energy Licensing Board.

(d) Optical Type Smoke Detector

The optical type smoke detector shall have an optical chamber to detect small concentrations of medium and large particles of combustion products. It shall incorporate an electronic device with binary code to signal its identity along the same loop. Upon being scanned/addressed, the detector shall issue a current pulse of appropriate duration its level of sensitivity at that time.

(e) Alarm Bell

The alarm bells shall be 150 mm diameter, surface mounting type with zinc pressure die-cast base, pressed steel gong, finished with store enamelled metallic silver suitable for 19 mm conduit entry. The alarm bell shall be installed 2000 mm above floor level. The bell shall sound continuous signal/intermittent signal after a preset delay if any of the call point is operated.

The bell shall be Gent Model 505/620B or equal meeting BS 5839 and BS 5750.

2.02 System Operational Requirements

On operation of any trigger devices, the following shall occur simultaneously.

(i) Zone indication on the panel showing the activated zone shall light up. This light shall remain lighted until the operated trigger devices is reset.

(ii) The supervisory buzzer shall sound. This may be cancelled but by so doing shall not preclude it from sounding shall trigger devices in other zone operate.

(iii) "Alert" sounding be given to the whole building.

(iv) All ventilation fans shall be cut-off. The Contractor is to do all the necessary wiring to the fans and monitor to the Fire Alarm Panel.

(v) A master switch to actuate all alarm bells shall be provided at the panel.

(vi) Test lamp facilities shall be provided on the fire alarm panels.

(vii) Alarm circuit shall be provided with series diode for checking faults and shorts in them.

(viii) All trouble contacts of the detectors shall be wired to the indication panel and each flame-proof zone shall be monitored to show that particular zone is healthy.

(ix) All zones indication shall be as shown on the accompanying drawings.

2.03 Construction And Reliability Of Control And Indicating Equipment

(a) General

Control and indicating equipment of automatic fire alarm systems for installation in protected premises shall be designed and constructed so as to be highly reliable over a service life of at least 20 years. The recommended standard of reliability of the equipment in the alarm path, is given below.

For the purpose of this clause, the alarm path is defined as that part of the circuit of the control equipment at the protected zone which is responsive to the operation of a detector in a single zone and which controls the operation of:-

(i) The sounders within the protected zone and other zones.

(ii) The buzzer and zone indicators in the control equipment.

(iii) Ancillary services ie tripping of fans and AHUs (if any).

The alarm path includes each current carrying part of the control equipment upon the integrity of which part the giving of the above fire alarms depends and the failure of which part does not initiate a fault warning.

The reliability of the alarm path expressed as the Mean Time between Failures (MTBF) should be not less than 5 years throughout the designed service life of the control and indicating equipment, assuming that the equipment is operating continuously whilst being subjected to any combination of ambient temperature from 5°C and relative humidity up to 80%.

Failure of the alarm path is defined as any failure or malfunction which prevents the correct operation of the alarm path or gives rise to a false alarm (malfunction) and does not initiate a fault warning.

(b) Mechanical Construction

All materials shall be chosen so that the deterioration resulting from normal ageing during a service life of 20 years, in an environment in which the ambient temperature is from 25°C to 40°C and the relative humidity is up to 100%, shall not cause the reliability of the equipment to fall below the acceptance requirements of Durability Tests. The design shall make allowance for the effects of long-term physical and chemical changes in materials and of atmospheric corrosion.

The possibility of ingress of moisture and/or accumulation of dust within the equipment should be minimized. Equipment cabinets should be secured to discourage unauthorised access. Control and indicating equipment should be designed and constructed so as to resist the effects of fire starting in the vicinity of such equipment and in accordance with the recommendations of CP 1019.

(c) Manual Controls

All manual controls shall be of robust construction, shall be positive in operation, and shall be designed and positioned so that accidental operation is prevented.

There shall be no manual control, normally accessible to the user of the equipment, which permanently disconnects one or both power supplies. The use of any manual control which switches off part of the system, resets it after a fire alarm panel shall be restricted by the use of switch with a key which is removable only when the system is in the normal "system operating" position. All manual control shall be clearly labelled to indicate their functions.

(d) Selection of Electrical Components

Components conforming to British Standards shall be used in every case in which a relevant specification exists.

Components of assessed reliability complying with the requirements of BS 9000 should be used when available. Where a relevant British Standard does not exist, components of commercial quality may be used but the choice should be restricted to those which are produced in large quantities since manufacturing processes are likely to have stabilised. The use of components made in small quantities to meet special requirements, such as close tolerance components, should be avoided. Solid state devices of the germanium type shall not be used. Lamps having two filaments in one envelope shall not be used. Lamps of types designed for long life shall be used for all purposes for which lamp indications are required. They shall produce sufficient light to be clearly visible under all normal indoor lighting conditions.

All friction contact surfaces should be noble metal or its equivalent. If the surfaces are plated or flashed with gold, the coating shall have a minimum thickness of 0.004 mm. In any case, the finished surface shall be sufficient to withstand normal maintenance and servicing requirements.

(e) Circuit Design

Solid state switching and logic circuits shall be used whenever there is greater reliability and better performance over the use of relays.

Circuits shall be such that there is a basic identical modular unit for each zone and connection to the system shall be such that the basic modular unit may be readily removed and replaced. This basic modular unit shall preferably be of plug-in-card and two such spare cards shall be provided.

Circuits shall be designed so that the equipment will perform all its functions in an ambient temperature of +25°C to +45°C.

All components shall be operated within the manufacturer's normal ratings at 70°C. Except where components complying with the requirements of BS 9000 are used, the following components shall be operated at not greater than the percentages of the manufacturer's normal rating (at 70°C) given below:

Type of Component	Parameter	% of Manufacturer's Normal Rating Max
Resistor, wire wound up to 3300	Power Dissipation	80%
Resistor, wire wound over 3300	Power Dissipation	80%
Resistor, other types	Power Dissipation	50%
Diode	Reserve Voltage	50%
	Power Voltage	50%
	Power Dissipation	50%

Solid-state switching device (eg transistor)	Power Dissipation	50%
Capacitor, wet electrolytic	Voltage	50% d.c. or a.c.
Capacitor, other types	Voltage	60% d.c. or a.c.

Wire wound resistors over 3300 shall be continuously operated at not less than 10% of the manufacturer's normal rating for powder dissipation. Wet electrolytic capacitors shall continually operated at not less than 20% of the manufacturer's normal d.c. voltage rating.

If the design of any circuit is such that, in the event of failure of the circuit to perform its designed function, an automatic fault warning is not given, then tests of its function shall be included in the routine test procedure.

(f) Construction of Main Fire Alarm Panel

The main fire alarm panel shall be fabricated from Min 16 SWG Mild Steel anti-corrosion treated and finish with a smooth enamel of approved colour.

Ventilating slots shall be provided and all such openings shall be fitted with anti-vermin mesh on the inside to prevent insects gaining entrance into the panel.

The facial layout of control and indicating equipment together with the mounting and physical dimensions of the panel shall be as suggested in the layout drawing of the guardroom.

The indicators, key switches, resets etc shall be mounted on a rigid light-head hinged door limited to 90^{o} swing. All the external controls shall be accessible by a normal person standing at 2'0" away from the panel. The mounting of components within the panel shall reflect the following considerations:

(i) Accessibility for routine test and part replacement

(ii) Entry of cables

(g) Lamp Indicators

Each lamp indicator for fault and alarm warning shall consist of two lamps connected in parallel arranged such that the failure of either of the lamps is apparent during the course of a routine tests.

All fire alarm indicators shall be coloured red and fault indicators coloured amber.

In addition to the above, the fire alarm panel shall also incorporate the following:

(i) Glazed screen door with lock

(ii) Charger failure indicator

(iii) Indication for hydrant pumps, pump control panel, A/C Failure and all other items as required by Fire Authority

(h) Operating Voltage

Operating voltage for all indication and all other circuit within the indicating equipment shall preferably operate at 24V DC (with no connection to earth).

Operating voltages for the trigger device circuit and sounder circuit shall be so chosen as to taken into account the distance and operational reliability and safety.

The equipment including all its components shall function satisfactorily at the nominal mains voltage +10% when tested in accordance with the FUNCTIONAL TEST:

(i) With the battery disconnected, and

(ii) With the battery connected as for normal duty and

(iii) With the battery connected and in a partially discharged condition, ie final voltage of each cell is 1.00V and normal supply disconnected.

All systems must be designed to function at the final voltage defined above.

(i) Wiring

All crossings of wirings shall be over a bridge of suitable non combustible insulating material of at least 6 mm thick securely fitted to maintain minimum part in air of 50 mm between the circuits.

The fire alarm cables shall not be run through staircases and other flue-like openings.

All wiring shall be colour coded or with identification tags and as far as possible shall comply with the manufacturer's recommendations.
All wiring shall conform to current editions of IEE Regulation and C.O. 327.404/402.501.

All wiring shall be run in g.i. conduits and conduits shall be painted in signal red.

2.04 Mimic Drawing

Mimic drawings showing the layout of zones and areas clearly indicated by colour and identified shall be fixed near the panel. It shall be reversed engraved on a plastic and fixed together with the Main Alarm Panel.

2.05 Circuitry Diagrams

A set of complete circuitry drawings of fire alarm indicator panel shall be kept near the panel, in a waterproof container. Two sets shall be deposited with the Engineers and one set shall be sent to the Jabatan Bomba. The diagrams shall be certified by PE and endorsed by Fire Department. A good quality paper and waterproof ink shall be used.

2.06 Spares

Two sets of spare fuses of each size for the fire alarm are to be provided.

Spare bulbs of numbers and types not less than the total used in the panel are to be provided.

Part 3 – Execution

3.01 Acceptance Tests

(a) Functional Tests on Fire Alarm Panel

The following tests on each zone are to be carried out on site:

(i) Momentarily operation of the trigger device, or its electrical equivalent, to ensure that the control and indicating equipment functions correctly.

(ii) Operation of key switches provided for the purposes of silencing the Supervisory buzzer and fire alarm sounders.

(iii) Momentarily operation of another trigger device, or its equivalent, connected to a different zone from that in (i) above to ensure that the control and indicating equipment functions correctly.

(iv) Momentarily simulating faults in the discontinuity of trigger device. Circuit of any zone to ensure that the control and indicating equipment functions correctly.

(v) Operation of any reset control in accordance with the manufacturer's instructions to ensure correct functioning.

(vi) A check if the audible and visible warning given on disconnection of the normal power supply to ensure their correct functioning.

(vii) Restoration to the quiescent condition before repeating the tests on other zones. When each zone has thus been tested, one cycle of FUNCTIONAL TESTS is said to have been executed.

It is to be noted that correct functioning of control and indicating equipment shall mean correct with respect to the Operational requirements.

(b) Durability Test

The equipment shall be subjected under site conditions to 10 cycles of functional tests carried out continuously. For the purpose of this test, any manual switch may be simulated electrically and trigger devices, external sounders, and external indicators may be replaced by electrical equivalent loads.

(c) Tests on Abnormal Power Supplies

One cycle of functional tests shall be carried out under the following conditions:-

(i) With normal power supply disconnected and the end voltage of each cell at 1.00V.

(ii) With the battery connected, but the main voltage fluctuates within +_ 10% of its normal value.

For the purpose of these texts, sounders and indicators may be replaced by electrical equivalent load.

(d) Tests on Battery Capacity

The battery shall be charged from discharged condition (end voltage of each cell .85V).

Automatically under its normal arrangement for 24 hours and the disconnected for the following tests:

Electrical loads equivalent to the simultaneous single tone sounding of all the alarm sounders and high rate charging of the battery shall be imposed on the battery for 30 minutes.

The capacity of the battery is acceptable if at the end of the above test, the open end voltage of each and every one of the cell is 1.00V or higher.

The Contractor shall provide in addition to physical devices such as hydrometers, a built-in battery test facility. It shall comprise a retractive switch to disconnect the charger from the battery and simultaneously impose a suitable fixed load to the battery, such that by maintaining the battery, the state-of- charge may be ascertained.

(e) Tests on Charger

The charger shall be connected to a power source whose voltage and frequency shall be capable of being manually adjustable within the range of 220 ±10% V and 50 HZ ±10%. The output of the charger shall be connected to a variable electrical load whose range shall vary from zone to maximum alarm load (ie. sounding of all alarm sounders and charging the battery at high rate).

The performance parameters shall then be checked to ensure they conform with this Specification.

(f) Tests on Trigger Device Installation and Wiring and Alarm Sounder Installation and Wiring

After the successful execution of the durability tests the following tests shall be carried out for each zone:

(i) With the main fire alarm panel in quiescent conditions the cover of each breakglass station be opened by using an Allan Key. All alarm sounders in the zone shall then be checked for correct sounding.

(ii) Heat shall be applied to each heat detector to check whether the detector operates.

The trigger device installation and wiring and the alarm sounder installation and wiring are acceptable if each "trigger device" operates correctly and each alarm sounder operates correctly.

(g) Equipment and Instrument

All equipment and instrument necessary for the acceptance tests shall be made available on site by the Contractor. All cost incurred in these tests or any re-tests shall be borne by the Contractor.

(h) Criteria of Acceptance

The main fire alarm panel is acceptable if there is not a single failure, either operation or component, during the Durability Test and the tests on abnormal power supply.

The battery and the changer is acceptable if the test results carried out in the aforesaid manners confirm with this Specification.

The battery charger shall incorporate dual charging rate, one for quick boosting and the other for trickle charging. The unit shall be completed with output voltmeter charging ampere rates, D.C. fuses, switches, relays and resistance transformer shall be semi- conductor (metallic) full wave.

The automatic fire alarm system is approved if the followings are accepted:

(i) Main Fire Panel
(ii) Battery and Charger
(iii) Trigger devices and alarm sounders installation and wiring

3.02 Fire Station Link

Facilities shall be provided at the fire alarm panel for direct fire station link to the nearest Fire Station.

3.03 Wiring System

All above ground inside the building wiring shall be in G.I. Conduit to BS. 31 and concealed Cables shall not be smaller than 3/.029 PVC insulated and rated at 250 Volts to B.S. 2004.

Fittings and accessories shall be galvanised and manufactured from steel or malleable cast iron to B.S. 31.

Conduits shall be concealed throughout. Screwed conduits buried in concrete shall have the threads coated with approved jointing compound during assembly and joints treated with a rust inhibiting paint after jointing. All conduit and accessories shall also be painted with a rust inhibiting paint wherever the exposed galvanised surface has been cut or otherwise damaged. Conduits shall be fixed securely to prevent movement and all ends, boxes shall be effectively plugged to prevent the ingress of water and dirt before concrete is poured. All bends must be made with the proper conduit bending machine so that the inner radius of any bend is not less than 21/2 times the outside diameter of the conduit. Where condensation is likely to take place, provision shall be made for the water to drain off without entry into terminations. The detailed layout of conduit will be the responsibility of the Contractor. Conduit shall be run neatly in straight lines parallel to walls, floors and ceilings wherever possible.

Where multiple conduit runs occur, metal brackets multiway saddles fixed by means of metal threads shall be used. The ends of conduits shall be cut square, filed and reamered out after screwing and care shall be taken to ensure removal or cutting oil and swarf. Conduit terminations at switches, switchboards, distribution boards, etc. are to be properly secured with coupler and male brass bushes. Conduit terminations to apparatus subject to vibration or movement shall be made off in flexible metallic conduit with brass adaptors for connection to the rigid conduit system at each end. Approved PVC flexible conduit will also be acceptable. Where conduits cross expansion joints they shall be installed so as not to resist relative movement of the sections. A suitable crossing shall comprise conduits telescoped one inside the other with the free end projecting immediately to one side of the crossing. Where long runs of conduit are unavoidable, adaptable boxes shall be provided for ease of drawing-in of cables. Draw-in wires shall be provided inside each conduit to facilitate the drawing-in of cables. Where exposed, conduits shall be painted orange.

Conduit sizes shall be selected so as to allow removal or replacement of any one cable without disturbing the others and shall not be less than 3/4" diameter without the permission of the Engineer. In no circumstances, the number of cables drawn into any one conduit shall exceed that stated in tables B5 and B6 of the 14th Edition of the I.E.E. Regulations. All conduits shall be swabbed out and free form moisture to the Engineer's satisfaction before wiring is commenced.

3.04 PVC Armoured Multi-Core Cable Installation

All external and buried underground fire alarm wiring shall be PVC armoured 4-core cable.

No joint shall be allowed for the installation of multi-core, PVC insulated steel wire armoured cables except at junction boxes as approved by Engineers.

At terminal sealing boxes, cable cores shall be carried through unbroken to the terminals and cores shall be sweated solid where they pass through cast resin.

The design of compressor glands is to be such that the cable is not twisted when the gland is tightened. It is to be possible to

erect and dismantle any cable compression gland without the use of special tools.

Each core of cable shall be identified by a number of colour code.

3.05 Excavation Of Trenches

The exact location of each cable trench will be settled on the site by the Engineer when work is ready to commence.

Trenches shall be kept as straight as possible and shall be excavated to approved formation and dimensions, and shall generally be 30 inches deep. Trenches shall have vertical sides and are to be timbered and sheeted where necessary to prevent subsidence.

The excavation of trenches shall include, by way of amplification but not of limitation, all timbering, pumping and baling required and the provision of all necessary labour, plant, tools, additional soil, fuel and motive power for such purposes and the cost of this service and of the expendable materials shall be included.

Before the cables are laid, the bottom of the trench is to be lined with sand or sifted soil which is to be punned down to a thickness of 3 inches to form a bed. After the cables are laid, the first 3" depth of cover backfill shall consist of sand or sifted soil over which shall be placed protective covers.

Backfilling and reinstatement of open trenches after placing of the cable protective covers shall also be carried out.

Particular attention shall be taken to ensure that trenches are evently graded prior to placing the bedding material.

Cables passing under roadways shall be installed in duct buried to a minimum depth of 30 inches.

Cables shall be snaked at every joint or junction box and cable shall not cross in straight runs of trench or in any other position except where a cross may be permitted if it is impossible to avoid by advance planning of the day of cables in a trench.

Routing and excavation of all trenches shall be carried out correctly and satisfactorily and at such times and places to suit the programme of cable installation work.

Only enough ground shall be opened at time such that cable laying and backfilling may proceed without delay in order to avoid having trenches opened for long periods.

3.06 Protective Covers

Cable covers shall consist of good quality house bricks and shall be laid over all cables ground so that there be no gap between the covers.

The supply and laying of cable protective covers is to be included in the rate for cable laying.

3.07 Backfilling And Reinstatement

After all cables and protective covers have been laid, the trenches shall be refilled in 6" layers, each layer being well rammed and consolidated.

The surface of refilled trenches shall be temporarily reinstated and maintained in a thoroughly safe condition until complete consolidation of the soil is achieved.

Necessary backfill material shall be supplied for the replacement of unsuitable excavation material and the cost of the material together with the backfilling and reinstatement is to be included.

3.08 Cable Markers

Cable markers shall be provided and installed with the top surface flush with ground level to identify cable routes and joints positions, other than tee joints at street lighting columns, or cables laid direct in the ground. Markers shall be inscribed with indented lettering reading "Fire Alarm Cable" and shall be installed at every 100 feet along the route and at any changes in direction.

3.09 Authorities' Approval

It is the responsibility of this Contractor to arrange for the fire alarm system or any parts of it corresponding to the phases of the building to be tested and approved by CIFS.

3.10 Radio Interference

The whole installation shall be carried out such that it shall not cause radio interference in excess of the limits stated in BS 800 and the equipment installation itself shall not be susceptible to radio interference.

3.11 Test Report

The fire alarm panel should be accompanied by a test report from the supplier/manufacturer and certified to meet performance requirements indicated for the installation.

END OF SECTION 15600

SECTION 15610

Master Indication, Alarm And Control Panel for Fire Protection System

Part 1 – General

1.01 General

The design, operation and construction of the panel shall strictly conform to the current requirements of the Local Fire Authority and the Specification herein stated.

Part 2 – Products

2.01 Construction

The panel shall be of the self-contained, extensible, wall-mounted and flush fronted metal console type. It shall house relays, contactors, indicating lamps and other necessary items of equipment specified herein and/or required for the proper function of the system to the current requirements of the Local Fire Authority.

The panel shall be designed for indoor service with an ambient temperature of up to 105^{o}F with 100% RH at maximum continuous rating without exceeding the maximum temperature permitted by the relevant BS Specifications.

Each cubicle framework shall be fabricated from rolled steel angle sections and shall be of rigid construction with all joints welded and ground. They shall be of standard size uniform in height and depth from front to back.

The door, size panels and cubicle roof shall be constructed from steel sheet with turned edges to the front panels and so formed as to provide a neat appearance. The thickness of material shall be to the approval of Local Fire Authority.

The front top and back of all cubicles shall be finished as specified with end plates and heads of any external fixing bolts or set screws similarly finished except those steel parts normally left bright which shall be cadmium plated and operating parts finished semi-gloss black. The glass door shall be provided with an Allen key lock.

All incoming and outgoing circuits and wiring shall be brought to the contractors, relays, etc. via insulated terminal strips mounted within the cubicle. All wiring between terminal strips and electrical equipment inside the panel shall be neatly run and taped in accordance with the requirements of the Local Supply Authority.

For the purpose of identification, different insulation colours shall be provided to distinguish the various circuits and each connection shall terminate at an approved type of terminate block placed in an easily accessible position for testing at site with coded ferrules of an approved type of both ends of each conductor. No connectors or soldered joint shall be permitted in the wiring. Bushes shall be provided as necessary to prevent chafing of cables.

All meters for panel mounting shall be of the flush pattern, with square escutcheon plates finished matt black and pressed steel cases. All meters and relays shall be fully tropicalised. All terminals shall be completely insulated and potential circuits shall be suitably fused.

All cubicles shall be appropriately labelled to indicate the service. Labels shall also be provided to identify all items of equipment, circuits, cables and where all items of equipment, circuits, cables and where applicable current rating of fuses and setting of relays.

Labels shall be engraved on clear perspex.

Part 3 – Execution

3.01 Operation

(a) The primary function of the control and indicating equipment shall be to automatically effect operation of one or more devices to give a fire alarm. A secondary function of the control and indicating equipment shall be to indicate the existence of faults within the system. Faults shall be indicated automatically.

An indication of the origin of an alarm is necessary where the premises are large or intricate. This requires the division of premises into zones. Indication of the origin of an alarm shall be given on mimic indicating equipment with duplicating lights indicating each respective zone on the profile of the building.

The control and indicating equipment shall be designed so that in addition to giving an indicating and an alarm on the operation of an alarm or operating device where applicable such as:

(i) Individual Fire Fighting Pump sets in operation.

(ii) Individual smoke detectors in operation in air handling/ packaged/fan unit rooms.

(iii) Breakglass points in each respective zone in operation.

(iv) All individual fixed fire automatic extinguishing installation.

(v) Other operation of operating and alarm devices where indicated and/or specified on the drawings and/or herein the specification.

(vi) Indication of all normal and standby power supply available to the above operating & alarm devices.

It shall initiate other functions where applicable such as the actuation of the operation of:

(i) Individual fire fighting pump sets.

(ii) Other equipment where indicated and/or specified on the drawings and/or the specification herein.

All indication lights and actuation devices shall be zoned to identify:

(i) Where the alarm comes from.

(ii) Type of system in operation.

All auxiliary services powered from the control equipment shall be fused or similarly protected to ensure the safety of the power supply.

(b) The operation of one or more devices shall result in a fire alarm being:

(i) At least one internal alarm sounder (indicating equipment shall incorporate a sounder or have one located near to it), and

(ii) At least one external alarm sounder, and

(iii) A visible indication in the indicating equipment, and

(iv) A visible indication for each zone in which a trigger device operates, and

(v) A signal transmitted to fire station.

In addition to the audible alarms specified in (i) & (ii), facilities shall be provided to control zone and/or sector alarm sounders.

The audible alarm specified in (i) and the visible indications specified in (iii) and (iv) shall be given simultaneously on any repeat indication equipment that may be provided.

(c) Normally a fire alarm shall be given by the continuous operation of the alarm sounders. The control equipment may be arranged to provide two-stage alarm facilities, whereby a preliminary Alert alarm may be initiated automatically by the operation of a device, and replaced if required by a distinctive Evacuate alarm initiated automatically. When this facility is provided, the fire alarms given by alarm sounders shall be:

Alert - 1 second ON) ± 50%

1 second OFF)

Evacuate - continuous (all sounders)

The audible alarms specified in (i) and (ii) shall continue until silenced by the manual operation of a biased switch or other device fulfilling the same function; they shall not be automatically silenced. The operation of the Silence Switch shall automatically result in an audible signal being given in the control equipment, until the fire alarm system is reset. The audible

signal, which may be the same as for fault warning, shall give a distinctive sound different from that of any alarm sounder used to give the fire alarm.

The equipment shall be designed so that, following the silencing of the alarm sounders, in the event of operation of a trigger device in any zone in which an alarm has not already been received and silenced, further fire alarms as specified in (i), (ii), (iii) and (iv) shall be given in all zones.

In a system having two-stage alarm facilities, the control equipment may be required to initiate automatically an Evacuate alarm in selected zones, or in all zones if devices operate in predetermined zones in combination.

Zone indicators shall be arranged to flash to indicate a newly initiated alarm. The rate of flashing shall be at 100 +-PH 30 flashes per minute, which an on/off time ratio of between 4 : 1 and 2 : 1. When the alarm sounders are silenced by manual operation of a silence switch, any flashing signal then existent shall be replaced by a steady signal.

The visual indications specified in (iii) and (iv), the signal to the remote manned centre specified in (5) once given, and the audible signal that the alarm sounders have been silenced shall all persist until the system is manually reset at the control equipment. Resetting shall be accomplished only by the operation of biased switches or other devices fulfilling the same function.

(d) Any fault warning that the control equipment may be giving shall not prevent a fire alarm being given at the same time.

(e) An immediate fault warning shall be given by:

(i) An audible warning from a sounder situated at the indicating equipment, preferably within it,

(ii) A visible indication on the indicating equipment,

(iii) A signal transmitted to a remote centre where a communication of such a centre is provided.

A fault warning as specified shall be given in the event of any of the following occurring:

(i) Failure or disconnection of the normal power supply;

(ii) Failure or disconnection of the standby power supply;

(iii) Failure or disconnection of battery charging equipment;

(iv) Failure or disconnection of the leads to alarm device(s);

(v) Failure or disconnection of any of the leads to alarm sounders;

(vi) Failure of any fuse or protective devices;

(vii) Failure of any device, such as a pulse generator, inverter or oscillator;

(viii) Others as required by Fire Authority.

The sounder used for giving fault warning shall be distinctive and of different character from the audible fire alarm. Provision may be made for cancelling the sounder only. Where such provision is made, the removal of the fault shall automatically reset the audible fault warning circuit or cause the audible fault warning to respond until silenced by the manual operation of a biased switch or other device fulfilling the same function.

(f) Facilities shall be provided for giving a fault warning on the indicating equipment in the event of a failure or disconnection of both normal and standby power supplies.

Each installer of the equipment shall supply for each installation a routine test schedule, together with a recommended time interval between successive tests, conformity with which will ensure the fault conditions are recognised before the effectiveness of the system is impaired.

(g) Each indicator lamp shall be arranged to give a audible fault warning immediately on the failure of any lamp at any time.

The arrangement of indicator circuits and the mechanical design of the apparatus shall be such that the operation of one indicator does not prevent the proper and separate operation of other indicators.

The operation of any sounder or the transmission of a signal to a remote centre shall not be prevented by any indicator defect and shall not depend on the operation of any indicator.

Each fire alarm indicator shall be clearly labelled with the work 'Fire', each fault warning indicator shall be clearly labelled with the word 'Fault'. Each zone indicator shall, on operating, give clear indication of that section of the premises from which the call originates.

In addition to labelling, each fire alarm indicator shall be coloured red and each warning indicator shall be coloured amber. The two colours shall not be used for any other indicator.

(h) The control equipment shall provide voltages appropriate to the rating of the interconnected trigger device units and the equipment shall incorporate overload cut out or limiting devices to protect the external circuit against excess current.

Where apparatus is to be operated in excess of extra low voltages, all live parts shall be enclosed in earthed metal, or non-combustible insulating material.

(i) The control and indicating equipment shall derive its power from:

(i) The mains electricity supply

(ii) A secondary battery exclusive to the fire protection system (Nickel Cadmium Battery)

A standby power supply shall be immediately available in the event of failure of the normal supply and shall be automatically connected so as to maintain the equipment in a condition such that a fire alarm arising from the operation of a device in two separate zones can subsequently be given. The standby shall be derived from a secondary battery (Nickel Cadmium) exclusive to the fire protection system.

(j) All indication and other circuits within the indicating equipment shall operate at 24V d.c.

The equipment including all its components shall function satisfactorily at the normal mains voltage +- 10% when tested.

(i) With the battery disconnected, and

(ii) With the battery connected as for normal duty, and

(iii) With the battery connected and in a discharged condition.

(k) Battery charging equipment shall incorporate automatic control features with output designed to charge and maintain the cells within the limits specified by the battery manufacturer, taking into account any quiescent load imposed by the associated system. Loss of effective battery capacity shall be recognised during the course of a routine test of the system.

Each battery of secondary cells used in the equipment, when charged by its normal charging arrangements for a period of 24 hours from a fully discharged condition, shall then have sufficient available power to supply the quiescent load together with any fault signals resulting from the disconnection or failure of the alternative power supply for a period of 72 hours. Thereafter it shall be capable of supply an additional load resulting from an alarm originating in two separate zones for a period of 1 hour, and it shall in addition be capable of supplying the full emergency alarm load for a period of at least 1 hour.

(l) The equipment shall be examined and certified by person or persons acceptable/approved by Director General, Fire Services Malaysia, to confirm that all the requirements of the clauses dealing with control and indicating equipment for protected premises have been met.

END OF SECTION 15610

SECTION 15620

Automatic Analogue Fire Alarm System

Part 1 – General

1.01 General

Supply and install the complete automatic analogue addressable fire alarm system (microprocessor type) in accordance to the specification and as shown on the drawings.

The analogue addressable fire alarm system shall be designed and installed in accordance to the relevant British Standards and in full compliance with the rules and regulation of the Building Control Division, Fire Safety Bureau and all other relevant authorities.

The system shall include all approved proprietary equipment, installation and necessary control wirings. All the components of the system shall be supplied from one proprietary manufacturer.

Part 2 – Products

2.01 General

The system shall be totally solid state, microprocessor based and shall include but not limited to the following sub-system:-

- Main control panel complete with keyboard and printer.
- Repeat panels.
- Interface units.
- Trigger units ie. sensors/detectors etc.
- Sounding devices ie. bells etc.

All the above sub-system shall be supplied from one proprietary manufacturer.

The system shall use the most advanced microcomputer technology and is aimed to have a long life with compatible product upgrading and expansions to include other advanced building management systems.

The system shall having the following features:-

- Each sensor/detector is individually addressed and shall be given a 32 character alpha-numeric label either as an individual or in group. Dip switch or code addressing is not acceptable.

- Complicated installations shall be simply and flexibly configured on site using standard hardware and software. There shall be no address switches to be sets in either sensors or sensor bases.

- The most advanced fire sensors and sophisticated signal processing shall be

used leading to the minimum possible rate of unwanted alarms.

- Sensors, sounders, interface units and fire alarm repeat panels shall all be wired on the same two-core circuit.

- It shall be possible to trace all wiring and position of all devices in the system through the main control panel and a record of these can be obtained from the printer.

- Location of where the fire first started and the latest location of the fire shall be shown on the LCD screen on the main control panel.

- All other locations where the fire has spread to shall be scrolled on the LCD screen. All these locations and events can be printed with exact date and time of the events.

- Once the system is commissioned, a sensor should not be replaced by another of a different type without a warning to the user. Sensor shall be unplugged without disabling other sensors, sounders etc on the same circuit.

- The system shall operate on the principal of pattern recognition. Analogue readings from sensor are transmitted digitally to the control panel where they are reconstructed into analogue outputs for each sensor and compared against all possible fire patterns stored in the software of the main control panel. The analogue signalling shall have 230 stages of threshold in forming the pattern.

- Full circuit security in the event of a single open or short circuit cable fault with no loss of outstations, by means of loop circuit isolators in every device.

2.02 Fire Alarm Control Panel

The main fire alarm panel shall be configured around advanced microcomputer based technology. It shall have 4 circuits or loops with each circuit capable of being wired to 200 sensors or detectors. The control panel shall have a full keyboard and printer. The keyboard shall be used to configure, programme and maintain the fire alarm system. The printer will store up to 250 events and provide a hard copy showing description, time, and date when requested to do so.

2.02.1 Addressable Optical Smoke/Combined With Heat Sensor/ Detector

The optical smoke combined with heat sensor/detector shall operate on the principal of smoke detection by light scatter "The Tyndal" effect. The optical element of the sensor uses a optical chamber designed for analogue operation. This must has a high signal to noise ratio, which allows a high sensitivity to smoke without the risk of false alarms. It shall incorporate a unique feature which continuously verifies that all of the sensor electronics, including the infra-red emitter is fully functional.

The smoke detection performance shall comply with the requirements of BS 5445 Part 7. The heat sensor shall be configured to conform to grade 2 or 3 performance requirements of BS 5445 Part 5. The optical/heat sensor must be able to detect a full spectrum of fires as defined in BS 5445 Part 9.

The optical sensor can be totally disabled during certain hours, the sensitivity can also be adjusted. The sensor shall incorporate incoming and outgoing isolators to minimise isolation of the system in the event of short circuit and open circuit faults.

2.02.2 Addressable Manual Call Points

It shall comply to BS 5839 Part 2. It shall operate on a direct mechanical linkage principal to prevent sticking problem associated with limit switch type call points. It shall have a LED and a transparent perspex cover to prevent vandalism. It shall be installed at levels shown or directed by the Engineer.

The frangible glass element shall consist of a square glass with a thin plastic film laminated to its exterior surface. The manual call point shall be tested by simply inserting the test key without disrupting the fire alarm system. The normal call point shall incorporate incoming and outgoing isolators to minimise the isolation of the system in the event of short circuit and open circuit faults.

2.02.3 Addressable Soundable

Addressable sounders shall be installed on the same pair of cables as the sensors and shall be surface mounted. It shall incorporate incoming and outgoing isolators to minimise isolation of the system in the event of short and open circuit.

Sound level shall be 100 decibel at 1 metre.

2.02.4 F/A Interface Units

The interface unit shall be a self-contained wall mounted unit with its own power supply that can control up to four sectors of AHU Trips Fan or Lift etc. The interface shall incorporate incoming and outgoing isolators to minimise isolation of the system in the event of short circuit and open circuit faults.

2.02.5 I/O Interface

The interface shall be loop driven/powered by the loop and installed on the same pair of cable as sensor and other devices. It shall be used for receiving signals such as pumps signals, AHU signals an isolation valve signals back to the main controls panels. It shall incorporate incoming and outgoing isolators to minimise isolation of the system in the event of short circuit and open circuit faults.

2.02.6 System Addressing And Configuration

The system shall use a unique method of individual addressing which can greatly simplify system commissioning and subsequent ongoing maintenance of system modification. All peripherals on the circuit are automatically addressed by their position. There shall be no switches to set, either in the sensor or sensor base hardware, thus avoiding incorrect operation as a result of incorrect setting.

During initial address allocation checks shall be automatically performed to ensure that each peripheral has a unique address. Names shall be given to all the active addressable devices during commissioning by a number of methods:-

- By a pre-programmed memory (from a knowledge of the cable plan and site plan).

- By data entry from the host computer.

- By data entry at the fire alarm panel using QWERTY keyboard option, if fitted.

- By the use of a test set in the building. This employs either the facility for plugging into a peripheral device (eg. an interface unit, sounder, or system manual call point) or the ability to receive an encoded infra-red message from each sensor. This allows the test set to unambiguously determine the sensor address. The name of the room can then be entered, in site, into the test set for subsequent downloading into the fire alarm panel.

Apart from the individual labelling of the sensors there must exist the ability to group the sensors or other peripherals for annunciation purposes. For example, sensors in a common area should be grouped for annunciation, but individually identified for faults. Grouping akin to conventional zones shall be created for zonal light displays, either numerically designated or geographically mapped.

When sensor heads are unplugged and replaced by a new head, this head is automatically given the same address. System shall be altered or extended without the need for complete re-labelling. The labels shall be stored in battery backed CMOS memory within the fire panel, together with any other essential configuration information. They shall also be stored in a non-erasable memory within the fire alarm panel or in the disc memory of a host computer to which the fire alarm panel may be connected.

Part 3 – Execution

3.01 System Operation And Control

3.02 Essential Controls

Essential controls are revealed on unlocking and opening the front cover of the control panel.

3.03 Evacuate - Start Sounders

On operation of this button all system alarm devices and system outputs are switched to evacuate mode irrespective of any pre-programmed groupings.

3.04 Stop Sounders

On operation of this button all system alarm devices and system outputs are returned to the quiescent state irrespective of their previous state. The master alarm buzzer within the control panel remains in operation in an intermittent state.

3.05 System Reset

On operation of this button the system will check the satisfactory operation of all

system devices and return to the quiescent system state before an incident. If there is smoke or heat remaining in the immediate vicinity of a sensor or if a manual call point has not been reset the system will return to a Fire condition. The system cannot be reset until the `stop sounders' button has been operated. Any faults or warnings in effect before a fire condition will be re-annunciated following a system reset.

3.06 Cancel Fault Buzzer

This button silences the internal fault buzzer while the visual indication of a fault remains on the panel.

3.07 Operation of Master Alarms

The two master alarm circuits resident within the panel can be operated using the menu-driven special function keys.

3.08 Setting the Clock

The panel includes an internal clock that operates independently of any power supply. This self-adjusting clock can be changed by using the menu-driven special function keys.

3.09 System Information

System information can be obtained from the control panel and either displayed on the four line liquid crystal display or printed out if the integral printer is fitted.

3.10 Display Test

The lamps and internal buzzer can be tested.

3.11 Other System Controls

Other system controls can be operated using the menu-driven special function keys. These controls can only be accessed by entering a user-defined access code (of up to 32 characters).

3.12 Device Isolation

The warning lights on the panel are illuminated when any device on the system is isolated. Devices, system inputs or outputs and groups of devices may be isolated manually or automatically. Automatic isolation can take place on selected days of the week and/or in up to eight pre-set time zones. In addition, the optical smoke detection channel can be de-sensitised within set time periods and/or on specific days. No warning is given as the heat-sensing element in the same head will continue to function normally. This action is however recorded in the event log.

3.13 Printer Control

The printer may be turned on or off. In the off state it cannot be used. In the on state the printer will automatically operate on occurrence of an event.

3.14 System Configuration and Labelling

Changes can be made to the configuration of the system and to device or zone labels. (See sections 2.3 and 2.4).

3.15 Operation of Sectors and Auxiliary Relays

Individual sectors can be operated in alert or evacuate modes and Auxiliary Relay circuits resident within the control panel can be activated.

3.16 Addressing and Labelling

- Allocation of Addresses

  The system has no hardware address switches in any device, all addresses are allocated automatically by the control panel when the circuit is powered up. These addresses take the form of a number and are allocated on a sequential basis. Once allocated they are referred to as the outstation number.

- Configuration and Labels Storage and Recovery

  If the system configuration and labels have not been previously entered the system will automatically default to sound all alarms in the evacuate mode in the event of a fire and will signal the location as the outstation number.

  When a configuration and labels are entered they must be stored on the battery backed RAM card. Once stored they will be automatically recovered to the circuit when addresses are re-allocated. Any system changes must therefore be stored on the RAM card.

- System Labelling

  Alphanumeric labels of up to 32 characters can be given to each of the outstation addresses. This label need not be unique. Other system inputs and outputs that do not have their own outstation address (eg. conventional manual call points and inputs/outputs from interface units) can be given their own label of up to 28 characters. If zoning is used each zone can be given a label of up to 32 characters.

  It is this label that is shown on the display and perhaps printer when an event occurs and therefore has the primary purpose of location identification. This label is not stored in an event log, the event being identified only by the outstation number.

  In order to determine how the labels should be entered the commissioning or maintenance engineer needs to know how the panel has allocated the addresses. He can find this out by requesting the loop map, a table showing each outstation number and its position within the system. The Egineer can then identify the correct label position using the loop map and a system wiring diagram.

- System Configuration

With a conventional hard-wired system, the system configuration is held within the software.

- System Zoning

  Any system trigger device or input can be grouped into a zone. Each circuit can support up to 16 zones. Each zone can be given a label of up to 32 characters. If there is a fire incident within a zone the zone label will appear on the liquid crystal display. However incidents at individual devices within the zone will be recorded separately on the event log.

- System Sectoring

  The grouping of alarm devices into sectors is different to the hard wired configurations associated with conventional system. In system both alarm devices and trigger devices are grouped together into sectors. If a fire incident occurs within a sector, the alarm devices in that sector will operate. The alarm devices within other sectors can then be linked to the original group so that they will sound alert or evacuate in response.

  Using the system a comprehensive two-stage alarm pattern can be built up throughout the site.

  Sectors can be isolated in the same way as zones or devices and can also be assigned a delay period of up to ten minutes giving an opportunity to investigate an incident before evacuation takes place.

  Up to 32 sectors can be supported by each circuit.

- Alert and Evacuate Signalling

  The alert signal and evacuate signal can be configured by the user to operate continuously, intermittently at intervals of half a second, one second or two seconds, or giving a hi/low tone at the same time intervals. All system 3400 electronic sounders are operated by pulses from the control panel and are therefore all synchronised.

- System Information

  System information can be displayed on the liquid crystal display or printed on the internal printer if fitted and in operation mode.

- Fires

  Up to 100 of the previous fires can be recalled including the time and date of occurrence, outstation number and type of event.

- Faults and Warnings

  Any current outstanding faults or warnings of device isolation can be displayed.

- Events

  Up to 255 of the previous system events including fires, faults and operational changes can be recalled including the time and date of occurrence, outstation number (where relevant) and type of event.

- Loop Map

  A table showing each outstation number, the numbers of all outstations connected directly to it and whether it is positioned on the main loop, a sub loop or spur, can be obtained.

- Status

  The operational status of any device or group of devices can be obtained.

- Principles of Operation

  The system operates on the principal of pattern recognition. Analogue readings from sensors are transmitted digitally to the control panel where they are reconstructed into analogue outputs for each sensor.

  The memory contains a large number of standard geometrical shapes (or algorithms). These shapes, either individually or in combination, may correspond to an event either fire or fault. The event is then annunciated. Using this technique, the sensitivity and operation of types of fire detection method can be adjusted and controlled, including the ability to warn before contamination build-up leads to unwanted alarm.

  The system is also capable of annunciating fires based on the reaction from a combination of point and volumetric sensors.

3.17 System Wiring

The system shall be wired with either 1.5 sq mm two-core MICC cable or 1.5 sq mm two-core screen cable run in metallic conduit. On any one circuit the maximum intercore capacitance should not exceed 0.5uF. The maximum combined resistance of both cores shall not exceed 100 ohms.

The cable length in each circuit should not exceed 1km in length. Where the outgoing and return cables of a loop which covers more than the equivalent of one zone must run together, consideration should be given to as much physical separation as possible and to the mechanical protection of the cable. Multi-core cables carrying more than one circuit are prohibited.

END OF SECTION 15620

SECTION 15630

Storage Battery And Battery Chargers For Fire Alarm And Pump Starter Panels

Part 1 – General

1.01 General

The control and indicating equipment shall derive its power from:-

a) the main electricity supply

b) a secondary battery exclusive to the fire protection system

The standby power supply shall be immediately available in the event of failure of the normal supply and shall be automatically connected so as to maintain the equipment in a condition such that a fire alarm arising from the operation of a device in two separate zones can subsequently be given. The standby shall be derived from a secondary battery (nickel cadmium) exclusive to the fire protection system. The sizing of the standby Nickel Cadmium batteries shall be approved by the Consulting Engineer and accepted by Jabatan Bomba Malaysia.

Part 2 - Products

Battery units for each engine for Hydrant pumps and sprinkler pumps shall consist of two storage units, each capable at highest room temperature recorded, of maintaining the cranking speed recommended by the engine manufacturer through a 6 minute cycle (15 seconds cranking and 15 seconds rests, in 12 consecutive cycles).

The nickel cadmium battery bank shall have a capacity such that after being charged by its normal charging arrangements for a period of 24 hours from fully discharged condition (end voltage of each cell at .85V), shall then have sufficient capacity to supply the quiescent load for a period of 72 hours and thereafter shall be capable of supply power to give single tone soundings for all the alarm sounders for a further 30 minutes, and at the end of which the end voltage of each cell shall not be less than 1.00 Volt.

The overall battery voltage shall be not less than 80% of the nominal equipment voltage.

The battery bank and charger shall be housed in a cabinet, min. 16 SWG mild steel, anti-corrosion treated and finished with signal red. This cabinet shall be located immediately below the panels. The battery cells shall be housed in a ventilated copper connectors in blocks on plastic base plates. The blocks shall be arranged in step type rock and it shall be ensured that electrotype levels are readily accessible for level checking.

2.01 Operating Voltages

All indication and other circuits within the indicating equipment shall operate at 24V DA.

The equipment including all its components shall function satisfactorily at the nominal mains voltage ±10% when tested:-

i) with the battery disconnected, and

ii) with the battery connected as for normal duty and

iii) with the battery connected and in a discharged condition

A battery shall be considered fully discharged when it is unable to maintain out put in excess or equal to the Final Voltage measured at one minute intervals, whilst it is subjected to the maximum design load of the associated system. All systems must be designed to function at the Final Voltage of the associated battery supply.

2.02 Automatic Battery Charger

The means of charging the batteries shall be by a 2 rate trickle charger with manual selection of boost charge and the batteries must be charged in position. Where separate batteries are provided for automatic and manual starting, the charging equipment must be capable of trickle charging both batteries simultaneously. Equipment must be provided to enable the state of charge of the batteries to be determined.

Battery charging equipment shall incorporate automatic control features with output designed to charge and maintain the cells within the limits specified by the battery manufacturer, taking into account any quiescent load imposed by the associated system. Loss of effective battery capacity shall be recognised during the course of a routine test of the system.

Each battery of secondary cells used in the equipment, when charged by its normal charging arrangements for a period of 24 hours from a fully discharged condition shall then have sufficient available power to supply the quiescent load together with any fault signals resulting from the disconnection or failure of the alternative power supply for a period of 72 hours. Thereafter it shall be capable of supplying an additional load resulting from an alarm originating in two separate zones for a period of 1 hour and it shall be addition be capable of supplying the full emergency evacuation alarm load for a period of at least 1 hour.

The manufacturers of the control equipment shall provide information on the basis of the derivation of those combinations of battery charging equipment and batteries that meet the above requirements for any system into which the control equipment is to be incorporated.

The solid state regulated and automatic battery charger shall have a capacity to simultaneously:-

a) Supply power to sound all the sounders continuously, and

b) Charge up the battery at a high rate

The AC and DC supply shall be connected in parallel under float charge.

Visual means of indicated to indicate battery charger is functioning shall be provided. Alarm facilities shall be provided for charger failure, battery low and high voltage, mains failure and means for detecting phase failure.

Selector switches for "Automatic" and "Off" position to enable isolation or either battery bank shall be provided.

Circuit protection in the event of reversed battery connections, current overloads or external short circuit shall be incorporated.

Part 3 – Execution

3.01 Test Facilities

In addition to physical devices such as hydrometers, a built-in battery test facility shall be provided. It shall comprise a retractive switch to disconnect the charger from the battery and simultaneously impose a suitable fixed load to the battery, such that by monitoring the battery, state of charge may be ascertained.

3.02 Requirements for Maintenance of Battery

The Contractor shall provide the following in order to facilitate the maintenance of battery:-

a) Each battery for panel shall be marked to identify the ownership.

b) Test/record book with relevant directives on the maintenance of the battery entered shall be provided. The information shall also include suppliers of battery and other components.

c) To provide pint size plastic container with solution for topping up of battery to manufacturers specification suction pump shall be provided to the approval of Jabatan Bomba to facilitate topping up.

END OF SECTION 15630

SECTION 15640

Carbon Dioxide System

Part 1 – General

1.01 General

This section of the Specification covers the supply, installation, testing and commissioning of a complete automatic fixed gas installation as shown on the accompanying drawings and as specified hereafter.

The installation shall be in accordance with rules and regulation of the latest edition of Uniform Building By-Laws or Sarawak Building Ordinance, Jabatan Bomba Malaysia and British Standard 5306 Part IV.

All materials supplied shall be new and approved for use by both Jabatan Bomba Malaysia and the Engineer.

1.02 SUBMITTALS

Product data, samples and shop drawings shall be submitted under provisions of the General Conditions of Contract.

Printouts of the following, executed by an approved computer program shall be submitted.

System sizing calculations.
Piping sizing calculations, based on shop drawings.
Nozzle selection and drilling calculations, based on as-built drawings.

Section 01300 shall be referred to and complied with in respect of product data and shop drawings, project record documents and operation and maintenance manual.

Listing/approval certificates, stating that the system and its components comply with the NFPA requirements, shall be submitted.

Part 2 – Product

2.01 Extinguishing Agent

Unless otherwise specified, the extinguishing agent shall be Carbon Dioxide of good commercial grade and free of contaminant. The carbon dioxide shall be stored in rechargeable containers designed to hold pressurized carbon dioxide in liquid form at atmospheric temperatures, corresponding to a nominal pressure of 58.6 bar at 21oC.

2.02 Cylinder

The cylinder shall consist of a safety relief valve to release agent in the event of build up of agent pressure to a dangerous level.

Cylinders shall be distinctly and permanently marked with the degree of super pressurisation.

The cylinders shall be connected to a common manifold. A check valve shall be incorporated in the flexible loop of each cylinder prevent the loss of extinguishing agent from the manifold if the system were to be operated while any cylinders are removed from maintenance. A steel union shall be incorporated with each check valve and flexible loop to facilitate the removal of cylinders.

A pressure gauge shall be provided to each cylinder to indicate pressure of the agent.

2.03 Discharge Nozzle

The discharge nozzle shall consist of orifice and any associated horn, shield or baffle and shall be listed for the intended use and discharge characteristics.

Frangible disc or blow-out caps shall be provided where clogging by foreign material is likely. These devices shall provide an unobstructed opening upon system operation.

2.04 Automatic Detectors And Alarm Bells

Heat and smoke detectors in dual circuit shall be provided in the hazard area as shown in the accompanying drawings.

The Breakglass Station shall be of the single-action type, suitable for flush/recessed type mounting. It shall be capable of operating from a 24V DC supply.

The overall colour shall be signal red, and breaking of the glass cover shall automatically trigger the Alarm.

The shell of the alarm bell shall be 150 mm (6") diameter, dome shaped, enamel finished in signal red.

The bell shall be capable of operating from a 24V DC supply.

It shall send continuous signal of at least 105 dB Sound Pressure Level (SPL) when the fire alarm panel is activated and shall be silenced manually from the panel.

The heat detector shall be the Rate-of-Rise type with a fixed temperature of 57.2 deg C and shall reset on cooling automatically. It should be rated of rise of temperature exceeding 8.3 deg C per minute.

It shall meet the requirements of BS 5445: Part 5.

The detectors shall be electronic in operation and entirely resettable. They must be suitable for connecting to a two-wire 24V central system and operate satisfactorily from 17 to 28V.

The current consumption of each unit in the standby state must not exceed 45 micro amps and in the triggered state, the current must be limited to 60 miliamps at 24V.

An LED indicator shall be provided to indicate triggered state of the detector.

The detectors shall not be affected by dust or wind.

The design and construction of photoelectric smoke detectors shall comply with BS 5445 : Part 7. The signal to noise ratio shall not be less than 2, and sensitivity can be field adjusted from a factory preset 2%. False alarm prevention feature must include and able to identify momentary interference from dust particles, insects, switching in or off of room lighting or air-conditioning. A unit in alarm or trouble shall be identified by illuminating a long life LED which shall remain latched on until reset by temporary disconnecting power and the cause removed. A trouble signal shall be sent if the LED fails or the internal circuitry fails. LED shall indicate quiescent mode, trouble mode and alarm mode. All units must be easily tested without the use of actual smoke or test button. Sufficient sets of test tools shall be provided.

2.05 Directional Valves

The cylinder bank will protect either hazard through the use of directional valves. These valves are to be of the pressure-operated type and fitted with electric control heads so that upon system operation for either space, the proper directional valve will open and the cylinder bank discharged. It shall also be possible to perform the operation manually.

2.06 Fire Curtain

The fibre-glass curtain shall be manufactured from non-combustible, high tensile glass fibre and be asbestos free. It shall have low thermal conductivity, have high heat resistance and be able to withstand temperatures up to 600^{o}C. It shall be resistant to oil, solvent and fungi.

The fibreglass curtain shall be fixed above a window or doorway and rolled up with a metal tube which shall act as support weight when the system is in operation. The curtain shall be held in position with a wire loop linked to a 24V DC solenoid release.

2.07 Carbon Dioxide Control Panel

The panel shall be supplied and installed according to the latest edition of BS 5839 Part 4 and approved for use by both Jabatan Perkhidmatan Bomba Malaysia and the Engineer.

The panel shall consist of a wall/floor mounted totally enclosed cubicle, constructed of welded 16 gauge sheet steel. The panel shall be provided with suitable vermin proof ventilators and flush hinged doors.

The panel shall be primed with two coats of red lead oil based primer and finished internally with one coat of white matt and externally with two coats of signal red matt enamel.
Labels shall be black perspex with white engraved lettering to clearly designate all zones, indications and facilities.

Power, control, fuseway, schematic, panel layout and mimic diagrams shall be provided and installed in a glazed frame next to the panel.

The mimic diagram shall come complete with LED indicators to identify the zone that is alarm mode. The mimic diagram shall also reflect the as-built locations and not the tender locations.

2.08 Power Supply

The fire alarm system shall operate on a 240V AC supply and on a 24V DC supply standby.

The battery shall be maintenance free sealed type of sufficient capacity to maintain the standing losses of the system together with any fault signal resulting from the disconnection or failure of the main power for a continuous period of at least 72 hours. Thereafter, the battery provided shall be able to supply the maximum alarm load for at least 1 hour and it shall, in addition, be capable of supplying the full emergency evacuation alarm load for a period of at least 1 hour.

The battery shall be mounted in the lower compartment of the cubicle on a rubber floor mat. The charging equipment shall be mounted above the battery and readily accessible.

The charger shall be able to provide booster and trickle charging. It shall be complete with voltmeter, ammeter, DC fuse and relays. The charger shall be capable of charging the fully discharged battery within 24 hours by its normal charging method to a fully charged condition.

The Contractors shall provide calculations on the charger and battery selection based on the equipment supplied. The capacity of the battery shown in the drawings is indicative only.

2.09 Control Panel Layout

The control panel layout shall include the following minimum items:

(i) Mains On/Off Switch
(ii) Mains On Indicator
(iii) Mains Fail Indicator
(iv) DC on Indicator
(v) DC Fail Indicator
(vi) Battery Low Indicator
(vii) Battery Load Test Switch
(viii) Booster Charge Switch
(ix) Charger on Indicator
(x) Charger Fail Indicator

(xi) AC Screw On Fuse
(xii) DC Screw On Fuse
(xiii) Individual Switch for Each Zone
(xiv) Audio and Visual Alarm for Each Zone
(xv) Audio and Visual Fault Indicator for Each Zone
(xvi) Isolator Indicator for Each Zone
(xvii) Lamp Test Switch
(xviii) Buzzer Silencer Switch
(xix) Buzzer Off Indicator
(xx) Bell Silence Switch
(xxi) Bell Off Indicator
(xxii) Alarm Reset Push Button
(xxiii) Gas Actuated Indicator
(xxiv) Gas Isolate Switch
(xxv) Gas Isolate Indicator
(xxvi) Ammeter
(xxvii) Voltmeter
(xxviii) Gas Actual Indicator Facility to FA Panel
(xxix) Label
(xxx) Spare

Part 3 – Execution

3.01 System Execution

Actuation of the system shall be:

(i) Automatic operation by the use of heat and smoke detection
(ii) Manual operation by the use of mechanism or key switch

For the automatic operation, detection of fire within the hazard area shall be by combined heat and smoke detectors. The detection shall be of dual circuit.

Upon actuation of the first circuit, the alarm shall sound and all warning devices actuated to alert personnel to evacuate the area.

Upon actuation of the second circuit and with a time delay of 10 seconds, the extinguishing agent shall be released. Actuation of the second circuit shall trip the genset, fire curtain, exhaust fans etc and to shut down all electrical equipment.

The manual operation or actuation of the system shall be either by a key switch installed in breakglass or pull box. The pull box shall be arranged such that upon pulling the handle, the interconnecting stainless steel wire shall actuate the mechanism to release the extinguishing agent. The stainless steel cable shall be run in galvanised steel conduit with pulleys provided at change of direction. The pulling handle shall be enclosed in a breakglass.

In the event of the manual control becoming inoperative, emergency manual operation shall be possible.

Upon actuation of extinguishing agent either automatically or manually, a gas discharge warning light shall flash until the system is restored to normal. This warning light shall be installed at entrances to the protected areas.

There shall be no exposed moving parts in the system so that no enclosure will be required to prevent pulling of the equipment.

3.02 Pipework, Valves And Fittings

3.02.1 General

This section of the Specification covers the supply, installation and testing of complete pipework, valves and fittings for the carbon dioxide system as detailed on the drawings and as specified hereafter.

All materials supplied shall be new and approved for use by both Jabatan Perkhidmatan Bomba Malaysia and the Engineer.

Cutting of pipes shall be carried out with pipe cutters and thread tapping shall be done with proper discs.

All bends before connection to any equipment shall be suitably anchored and the supports, guides, brackets, etc shall be adequately fastened to the structure by means of concrete inserts or expansion type devices.

All exposed metalwork in carbon dioxide systems and rising mains shall be electrically earthed.

3.02.2 Automatic Fixed Gas Installation

Item	Pipe Size	Material	Type of Joint
Pipe	40 mm and below	Seamless Schedule 40 Steel pipe to BS 3601	By screw thread to BS21
	Above 40 mm	Seamless Schedule 80 steel pipe to BS 3601	By screw thread to BS21
Fittings	40 mm and below	Forged steel, screwed complying to BS3799	By screw thread to BS21
	Above 40mm	Forged steel, screwed complying to BS3799	By screw thread to BS21

Threaded steel pipework and fittings except those complying with BS 3799 shall be galvanised inside and out. BS 3799 fittings should be painted externally after installation with a zinc based paint.

3.02.3 Pipe Joints

Teflon tape shall be used for all joints by screw thread to BS 21. Joints with excessive over threading shall be rejected. The Contractor shall ensure that the threads are fully screwed and only with a few threads protruding out is permitted.

Joint by welding is generally not permitted. Prior permission in writing should be obtained from the Engineer should it be found that welding is necessary and the

Contractor shall make provision for X-ray test of all welding joints. All unsatisfactory welds detected shall be rewelded and again X-ray tested until acceptable.

3.02.4 Pipe Supports

Pipe supports shall be installed at intervals as indicated:

Nominal Pipe Sizes	Horizontal Runs	Vertical Runs
Up to 40 mm (1 ½")	1.5 m	1.5 m

Nominal Pipe Sizes	Bolt Size
Up to 50 mm (2")	10 mm (3/8")

All pipes shall be supported such that there is a minimum of 50 mm (2") clearance around the pipe and consideration should be given to provide access to the valve or other fittings for maintenance where necessary.

Supports and hangers shall generally conform to BS 3974. Where the Contractor wishes to provide supports and hangers of his own manufacture, details and samples shall be submitted for approval prior to installation.

3.02.5 Pipe Sleeves

All pipes passing through floor slabs, walls or beams which form part of the fire barrier shall be enclosed by embedded pipe sleeves.

The pipe sleeve shall be of galvanised iron and of diameter one size bigger than the pipe. A separate pipe sleeve shall be provided for each pipe and the Contractor shall position the sleeves and boundaries of the void between the sleeve or sleeves and boundaries of the opening can be sealed by the Builder.

The space between the pipe and its sleeve shall be packed with fire proof material such as asbestos packing to form an effective fire seal without hindering pipe expansion or contraction.

3.02.6 Valves

All valves shall have a rated working pressure of not less than the test pressure of the respective installation concerned.

The valves shall be of make approved for use by local water work authority and fire department.

Gate valves of dimensions up to 65 mm (2 ½") shall conform to BS 1952. Gate valves of 65mm (2 ½") and larger shall conform to BS 3664.

Swing check valves shall generally conform to BS 1953 and where indicated, non-slam spring assisted check valve shall be used to reduce the effect of water hammer due to valve closure.

Butterfly isolating valve shall be of cast steel body with bronze disc, stainless steel shaft and nitrite rubber seal construction.

Strainers shall be "Y" pattern type and of same material as the valves used. The filter element shall be of stainless steel, robust in construction and with correct designed perforation for the fluid handled. The Contractor shall ensure that the strainer is installed in a position for easy removal and cleaning of the filter element.

Pressure relieving valves shall be installed where required by applicable codes or when there is a possibility of liquid carbon dioxide entrapment in pipework. The valve shall be set to relieve excessive pressure built up in the piping system. The device shall be set to operate at 150 bar ±%. All discharge outlets shall be piped to the nearest drain.

3.02.7 Flexible Connectors

Flexible connectors shall be of wire and fabric with high pressure moulded rubber construction, clamped in place by split steel flanges. The connector shall have a pressure rating not less than the test pressure of the system.

3.02.8 Pressure Gauges

Pressure gauges shall be of bourden tube spring type with a dial size of not less than 100 mm (4"). Each gauge shall have a brass, dust and moisture proof case with thick protective glass and legible white face and black figures. The calibration of dial reading shall be in both Bars and PSI with maximum scale reading not less than 20% above the maximum working pressure.

Gauges shall be mounted so as to be free from vibration and a gauge cock shall be provided between the tap-off point and the gauge.

3.03 Painting And Labelling

3.03.1 General

In general, all surfaces of materials and equipment installed shall be suitably cleaned, degreased and painted.

No painting work shall be carried out on site without adequate precautions taken to prevent spoiling the appearance of the walls, floors and other equipments. The Contractor shall be responsible for making good any such spoiled surfaces to the entire satisfaction of the Engineer.

Only the best quality primers and paints shall be used.

On non-metallic surfaces, the paint used shall be acrylic emulsion with mildew inhibitor additive.

Metal work which is normally painted in the factory before despatch, shall be prepared by filling in or wire brushing and rubbed down to a smooth finish and then given one priming coat, one or more undercoats and one or more top coat shall be of a different shade of colour.

Metal work which is normally painted on site shall be prepared as above and given one coat of approved preservation paint before leaving the factory.

Metal work which will be erected in the open shall be given top coats of bitumastic based paint with appropriate approved primer and undercoat.

Where aluminium paint is specified the paint used for the undercoat shall be of the quality as the top coat but slightly coloured by the addition of washing blue.

The inside of control cubicles, cabinets, etc where condensation is liable to occur shall be coated with approved anti-condensation composition.

All bright metal parts shall be covered before shipment with an approved protective compound and protected adequately during shipment to site.

All pipework, valves, fittings, hangers, conduits, and other equipment shall be painted.

Paints, primers and enamels shall be of the best quality, ready mixed and brought to the site in unopened containers.

All surfaces or materials and equipment installed shall be suitably painted. All painting shall be done by experienced tradesmen with first class quality primers and paints brought to site in the manufacturer's sealed containers. All coats of paint on any one item shall be of the same type and manufacture and shall be applied as recommended by the manufacturers.

No paint work shall be carried out on site without adequate precautions taken to prevent spoiling the appearance of walls, floors and other equipment. The Contractor shall be responsible to make good any such spoiled surfaces to the entire satisfaction of the Engineer.

Metal surfaces within the building shall be thoroughly cleaned of all grease, rust, scale, welding flux and the like. The surface shall then be given one chromate type priming coat and two (2) finishing coats of the specified colour. The finishing coats shall be full gloss enamel and shall be as smooth and free of brush mark as possible. All exposed pipes including pipes in enclosures and ceiling voids shall be painted.

Metal surfaces exposed to weather shall be thoroughly cleaned of all grease, rust scale, welding, flux and the like. The surface shall then be given one coat of heavy duty anti-corrosive primer. The second coat shall be an anti-corrosive protecting coating. The final coat shall be a heavy-duty anti-corrosive gloss enamel of the specified colour.

Switchboards and control panels shall be supplied on site, factory finished with one coat of anti-corrosive primer and two coats of full gloss enamel of the specified colour. The faces shall be suitably protected during installation. Any

chips, marks or scratches of the paintwork shall be retouched to the satisfaction of the Engineer.

On insulated surfaces, primers and paints used shall be as recommended by the insulation manufacturers.

3.03.2 Colour

All pipework, conduits, control panels, valves and other equipment shall be painted in accordance to the colour codes given hereunder.

Pipeworks, conduits, trunkings, etc that are exposed may be painted with colours to match the surrounding décor but must be identified with colour band markings located at intervals of not more than 4.5 m apart.

Pipeworks, etc that are exposed but enclosed in ceiling spaces, etc shall be painted with their basic colour code and also identified with colour bands.

The finishing colours of the installation shall be as follow:

(i) Control panels – Red hammer tone outside and white inside
(ii) Pipework – Signal Red
(iii) Pipework indication arrows – White
(iv) Drain pipes – Black
(v) Supports, brackets and hangers, etc – Black
(vi) Valves indication arrows – Red
(vii) Conduits/Trunking for 24V Control circuit wiring – Red
(viii) Conduits/Trunking for phase and line voltage circuits – Red

3.03.3 Labelling

The installation shall be comprehensively labelled to the satisfaction of the Engineer. The use of plastic labels made with "DYMO" tape writers or their equivalent will not be permitted.

All pipes shall be provided with arrows on the pipeline indicating the direction of flow. Arrows shall be not less than 100 mm x 20 mm (4" x ¾") and shall be provided at every 9 m (30") interval on horizontal pipes and every floor on vertical pipes.

All equipment such as pumps, tanks, etc shall be comprehensively labelled in block letters of 50 mm x 40 mm x 10 mm (2" x 1 ½" x 3/8").

All fire protection cabinets shall be labelled according to the relevant parts of the latest edition of BS 5306 and BS 5499 and to the entire satisfaction of the Engineer.

3.04 TESTING AND COMMISSIONING

3.04.1 General

The Contractor shall at his own expenses supply the labour and provide the facilities for the testing, adjusting and balancing of the system.

When directed by the Engineer or when situations at the site favours tests to be carried out on completed sections or parts as the installation works progress, the Contractor shall carry out such tests. Advance notice for such tests shall be given.

When all installation works have been completed the Contractor shall carry out system testing, adjusting and balancing before the appointment date for the Engineer to witness the final tests.

Advance notice at least ten days in advance shall be given for final testing.

When the final tests have been successfully carried out the Contractor shall supply the Engineer with three sets of the test records.

Should any failure occur due to, or arising from faulty materials or poor workmanship, the Engineer shall decide if further tests will be required after remedial works have been successfully carried out.

3.04.2 Factory Assembled Equipment

All factory assembled equipment shall be factory tested.

The Contractor shall supply design data and test certification of all factory assembled equipments at his own expense.

The carbon dioxide cylinder and valve manifolds shall be hydraulically tested at the manufacturers' works to a minimum pressure of 190 bar. The supplier shall provide for the issue of a test certificate.

Failure of equipment to perform the required functions or failure of the Contractor to supply design data and test certifications of the equipment, if so requested may result in the rejection of the equipment.

3.04.3 Tests and Acceptance

The Contractor of the equipment shall arrange tests of the completed installation to the satisfaction of the relevant authority, to show that it complies with BS 5306 Part 4.

The tests shall include the following:

(i) A check that all components of the system have been installed in the correct manner.

(ii) A check that all nuts, bolts and fittings have been correctly tightened.

(iii) A check that all electrical connections are safe and in working order.

(iv) All pipes shall be thoroughly flushed before installation of control valves, pressure gauges and other instruments.

(v) Carbon dioxide piping shall be pressure tested at 1.5 times the normal working pressure.

(vi) Carbon dioxide gas tests to check the tightness of closed sections of pipework. Separate gas discharges shall be made into each space to ensure that the piping is continuous and that the nozzles have not become blocked.

A minimum of 10% of the required quantity of gas should be discharged through the system pipework into each space.

The Contractor of the equipment shall provide a comprehensive check list to enable the authority to witness that the tests are being carried out in a satisfactory manner.

The minimum content of the list shall include the following:

(a) Check that the system has been installed according to the relevant drawings and documents.

(b) Check as follows that all detection equipment functions correctly.

(i) In fusible link systems, ensure that control cable lines are free and that operating control weights develop sufficient energy to operate container and/or direction valve control mechanisms.

(ii) In pneumatic rate of rise systems, check with manometer to ensure correct breathing rate and leak-free capillary lines. Also apply heat to detectors to ensure correct operation and subsequent activation of control mechanisms.

(iii) In electrical detector systems, check electrical circuitry and supply voltages for integrity. Apply heat, flame and smoke to detectors to check operation of control mechanisms.

(c) Operate manual release devices to ensure correct functioning.

(d) Check operation of all alarm devices.

(e) Check correct operation of all safety devices.

(f) Carry out a test CO_2 gas discharge using an adequate percentage of the total CO_2 capacity to check:

(i) that the direction valves, when shut, hold back gas;

(ii) that feed pipes lead to the correct protected space;

(iii) that no leaks occur where equipment is fitted to pipework and at pipe fittings;

(iv) that pressure operated devices function correctly and the items they control, such as shutters and alarms; function correctly;

(v) that, where possible discharge nozzles pass gas and that none are blocked

(g) Ensure test containers are replaced and that all containers are filled with the correct quantity of carbon dioxide

(h) Check that nameplate and instruction plates are correctly worded

When the installation has been completed and tested, the purchaser shall be provided with a completion certificate (together with one copy for the authority) and a complete set of instructions and "as installed" drawings.

The test pressure shall not drop more than 5% after correction for temperature when maintained over a period of 24 hours. Special care shall be taken during pressure testing to ensure that the controls, safety devices, meters etc whose operating pressure ranges are below the test pressure are not damaged or have their accuracy impaired.

After the testing is carried out, all liquids should be drained from the pipework, valves and fittings and the system thoroughly dried to eliminate subsequent corrosion or interference with the correct operation of the system.

3.04.4 Inspection and Testing by Fire Department

The Contractor shall make all the necessary arrangements for testing of the installation by the Fire Department, inclusive of submission of all materials, forms, catalogues, samples, etc as required, and payment of all necessary fees. All costs pertaining to these tests and culminating in the final approval of the installation by the Fire Department shall be included in the Tender Price.

END OF SECTION 15640

SECTION 15650

First Aid Hose Reel System

Part 1 – General

1.01 General

The works to be carried out under this section of the Specification shall comprise the supply, installation, testing, commissioning and maintenance of the complete fire hose reel system as herein described and/or as indicated in the accompanying drawings.

1.02 Hose Reel System

The complete hose reel system shall include all necessary pipework, hoses, nozzles, reel assemblies, valves, pressure switches and hose reel pump sets, all in accordance with the requirements of the Local Fire Authority and with British Code of Practice BS. 5306 Part 1 (CP 402.101).

All minor and incidental works necessary for the satisfactory operation of the system shall be supplied and installed whether specifically mentioned or not.

Part 2 – Products

2.01 Hose Reel Assemblies

The hose reel assembly shall be of either fixed or recessed swing-out type as indicated, being suitable for swift withdrawal of the hose in any direction.

Each hose reel assembly shall consist of a rubber hose, a metal reel, a stop valve, a hose guide and nozzle, the whole of which is permanently connected to the water supply.

The reel shall be of metal construction of not less than 8 in. (200 mm) inner case diameter and not more than 30 in. (750 mm) rim diameter. It shall extend not more than 18 in. (450 mm) from the wall or mounting surface. The side plates shall extend at least $^{1}/2$ in. (12 mm) radially beyond the wound-up hose.

The hose shall be of non-kink smooth bore construction, conforming with the specifications of BS. 3169, and rates for a bursting pressure of not less than 600 psi (4.14 MPa). Each hose shall be 1 in. (25 mm) in diameter and of minimum length 100 ft. (30 mm) terminating in a nozzle assembly of bore $^{1}/4$ in. (6.4 mm). The nozzle assembly shall be constructed of gunmetal brass or other sufficiently robust and corrosion-resistant material. The nozzle shall be permanently marked to indicate the open and shut position.

The whole of the hose reel assembly shall rotate on the horizontal axis and the water supply connection to the hose shall be arranged such that the hose is not obstructed or kinked when the hose is wound up. The piping from the stop valve to the hose reel shall be of non-ferrous material or galvanised.

Wherever necessary, a pressure reducing valve or orifice plate shall be provided for the hose reel for controlling the static pressure to within 18 - 30 psi (0.12-0.2 MPa).

Every hose reel assembly shall bear the name of the manufacturer and the instructions for operation. Where hose reels are located in recesses or in non-prominent positions, a notice bearing the words "FIRE HOSE REEL" in red letters on a white background shall be provided.

2.02 Hose Reel Pump set

The hose reel system shall be provided with hose reel booster pumps as shown in the drawings. These shall comprise one duty electrical pump set and one standby diesel pump set. Where standby power is available, both duty and standby pump sets shall be electrically driven.

Pumps shall generally be centrifugal constant speed, end suction type, being directly coupled to the engine/motor and mounted on a common base plate bolted onto a concrete plinth. The plinth shall be provided to suit the manufacturer requirements and shall raise the pumps to at least 6 in. (150 mm) above the known flood level of the pump set location. Mounting of the pump sets on the plinth shall be complete with adequate padding or vibration isolators.

Suitable, approved type splash guards, flexible connections, strainers and pressure gauges shall be provided with the pump set installation.

Each pump shall also be fitted with an air valve, grease lubrication, water shaft seal connection, copper gland drain fitting and tappings in the pump head casing for discharge pressure gauge. Proper drainage shall be provided for all points around the pump set mounting.

The capacities and performance requirements of the pump sets shall not be less than the minimum indicated in the schedules and drawings.

2.03 Electric Motor For Hose Reel Pump

The electric motor for the hose reel pump shall be a totally enclosed fan cooled squirrel cage-induction motor, of sufficient capacity to efficiently fulfill the pump horsepower requirements. The continuous maximum motor rating shall be to BS. 2613 and shall have a minimum over load factor of 15% in excess of the power requirements at maximum pump discharge and minimum total head condition.

The pump motor shall generally be flanged motor and suitable for horizontal operation. Stator frames, end-shields and terminal box and cover shall be cast iron or other approved material. Fan and fan cowl shall be of corrosion-protected material.

The motor windings shall be insulated to BS. 2757, Class 'F' and suitably impregnated to withstand damp tropical conditions.

The motor shall be suitable for 415 V, 3 phase, 50 HZ power supply. All electrical works pertaining to the motor installation shall be provided. The motor shall be suitably earthed and provided with overload trip protection.

All cabling shall be PVC insulated cable run in conduit or trunking. Power supply for the pump set shall be provided with a permanent label to the displayed at the isolation switch marked "POWER SUPPLY FOR FIRE PUMP, DO NOT SWITCH OFF".

2.04 Operation Of Hose Reel Pump sets

The hose reel pump sets shall operate automatically in response to a drop in pressure and/or a flow of water in the piping mains using pressure and flow switches.

The first pressure switch shall bring the duty pump set into operation and if due to electrical or mechanical failure, the duty pump set fails to function satisfactorily and the pressure in the piping mains shall continue to fall, the second pressure switch (set at a lower pressure than the first) shall then bring the standby pump set into operation.

The pumps shall automatically stop when "no flow" condition is detected by the flow switches.

Activation and running of the pump sets shall be indicated at the main fire alarm control panel by means of both visual and audible signals. Both pumps shall be capable of being started or stopped manually.

2.05 Hose Reel Tank

The hose reel water tank shall comprise a pressed steel tank of minimum capacity as shown in the drawings and installed complete with supporting structures, pipework, valves and fittings, access ladder, roofing, ventilator, flat valve, level indicator and all other necessary accessories.

The tank shall be made from pressed steel sectional plate with external flanges and shall be supplied complete with all internal bracing, pipe pads, cleats, nuts, bolts, washers, jointing compound, cover bearers and stiffeners. The tank shall comply where applicable with BS.1564, braced and assembled in accordance with manufacturer's instructions.

In the case where the water supply for the hose reel system is tapped off from a dual-purpose water storage tank such as a domestic tank, the tapping-off paint for the hose reel system shall be below the tap off for other purposes. The effective storage capacity available to the hose reel system shall not be less than the minimum specified.

2.06 Piping Materials

Unless otherwise specified, all pipes used for the hose reel system shall be of galvanised steel pipes to BS. 1387, Class 'C'. All piping shall be new and free from defects.

Pipe joints shall, except otherwise indicated, be screwed joints. Welded joints shall not be used. All screw threads shall be made up to the full depth of the socket and shall be clean and square with the axis of the pipe bore. Only Teflon or equal approved p.t.f.e thread sealing tape shall be used in jointing. Hemp or similar organic substances shall not be permitted.

In all piping, bends shall be long radius bends with turning radii not less than five times the pipe diameters. If this cannot be achieved, alternative bends of approved type shall be used.

Reductions in the diameter of through-flow pipes shall be by means of reduction sockets. Eccentric reducing sockets shall be used on horizontal pipes and concentric reducing sockets on vertical pipes only.

2.07 Valves And Fittings

All valves and fittings shall conform to the relevant British and Malaysian Standards.

Except for control valves, pressure reducing valves and similar valves which have been specifically sized for the duty concerned, all valves shall be of nominal size as the pipeline. Valves shall be installed in accessible positions, located as near as possible to supports and equipment. The connection between each valve and adjacent equipment or piping shall be of screwed connection.

Valves shall be installed in strict compliance with the manufacturer's recommendations. Every valve shall be blown out before installation to remove any foreign matter lodged in the valve.

(a) Isolating valves sized up to and including 2" (50 mm) shall be of the gate type to BS. 1952 with bronze body, bronze solid wedge, rising stem and screwed bonnet being flanged to BS.10 Table E or screwed to BS.21 as applicable. Valves shall be complete with a locking facility.

(b) Balancing valves shall be globe or ball valves of approved pattern and manufacture. They shall be of bronze body for valve sizes up to 2 in. (50 mm) and of cast iron or steel for sizes above. Valves shall have bronze or brass spindles, replaceable seats and steel handwheels.

(c) Non-return valves sized up to and including $1^1/2$" (40 mm) shall be of the swing check type to BS.1953 with bronze bodies screwed bonnet and bronze metal to metal seat. The connections shall be flanged to BS.10 Table E or screwed as applicable.

(d) Non-return valves sized at 2" (50 mm) and over shall be of the swing check type to BS.4090 with cast iron body, cover plate and bronze metal to metal seat. The connections shall be flanged to BS.10 Table E. A vent cock shall be incorporated in the cover.

(e) Strainers of sizes up to 2 in. (50 mm) diameter shall be bronze body strainers. Sizes 2 in. (50 mm) and larger shall be cast iron body type fitted with removable bronze screens.

(f) Automatic air release valves shall be installed on all high points of piping whether shown on the drawings or not. They shall be of bronze body with brass ball, and stainless steel valve and seat.

(g) Drain valves shall be fitted at the base of pipe risers, headers and all low points of the piping system. The valves shall be brass bibcocks with hose connections.

(h) Pressure gauges shall conform to BS.1780 and shall be minimum 4 in. (100 mm) diameter dial type of approved pattern and manufacture. The scale value shall be calibrated up to 150% of the maximum known pressure. Gauges connections shall be complete with an isolating gauges cock as well as anti-vibration cork snubbers.

(i) Pressure switches shall be of the electrically operated type and shall be selected to suit the system installed.

Part 3 – Execution

3.01 Pipework Installation

All piping shall be run as directly as is practicable from one point to another, and with as few ells and bends as conditions permit. Piping shall be well supported and protected against damage. Overhead lines shall be securely fastened to structural members of adequate strength and supported with approved type brackets and hangers at suitable intervals. Supports, brackets and hangers shall allow for pipe adjustments to be made for securing proper grade and alignment.

Provision shall be made in the piping system to compensate for expansion, contraction, settling and vibration. Supports shall be provided at each change of direction.

All piping shall be graded to ensure venting and all piping and fittings arranged so that the complete system can be thoroughly drained. Separate drain valves or drain plugs shall be installed for all piping that cannot be drained back to the piping main. Air locking shall be prevented by the use of air cocks fitted where necessary located for convenient operation.

All services shall be installed in an approved manner to meet the Structural and Architectural Conditions and to avoid interference as far as possible with the work of other trades.

Where pipework passes through building structures G.I. Pipe sleeve shall be provided, sized to give a minimum of $^{1}/2$" (15 mm) gap full around the pipe. The length of sleeve is to suit the thickness of the structure. Where the pipes pass through steel beams a 1" (25 mm) spacer shall be allowed between the sleeve and the reinforcing plate around the hole. This sleeve shall be packed with asbestos fire proofing compound in an approved manner.

All pipes passing vertically through floor shall have sleeves extending 1 in. (25 mm) above the floor. All sleeves shall be supplied by the fire contractor and handled to the Contractor, together with detailed drawings showing exact locations required in sufficient time to avoid building delay.

0Pipe supports and hangers shall be spaced at intervals not exceeding the following. The means of supporting and anchoring of hangers and brackets shall be approved by the Engineer before installation.

Nominal Pipe Size	Hanger Rod Size	Maximum Span
Up to dia ¾" (20 mm)	dia ¼" (6.4 mm)	6 ft. (1.8 m)
dia 1"(25 mm) to dia 1 ¼" (50 mm)	dia ¼" (6.4 mm)	6 ft. (1.8 m)
dia 1 ½" (40 mm) to dia 2" (50 mm)	dia 3/8" (9.5 mm)	10 ft. (3 m)
Above dia 2 ½"(65 mm)	dia ½" (12.5 mm)	12 ft. (3.6mm)

Vertical pipes shall be supported at least at the top and bottom of each riser, at each floor level, and at each isolating valve. In addition, a further support shall be provided between floor levels for pipes smaller than dia $1^1/4$ in. (32 mm).

A minimum of 2 in. (50 mm) clearance shall be maintained between the pipe and the nearest wall or ceiling surface.

3.02 Testing And Balancing

Upon completion of installation the Contractor shall notify the Engineer and proceed to undertake the balancing, testing, calibration and setting of all equipment and controls. Prior notification shall be not less than 48 hours in advance of any testing to be done.

All components shall be systematically tested for correct operation to ensure an approved installation as follows:

(a) All pumps shall be checked for flow rates, pressure head and r.p.m.

(b) All pipework shall be hydrostatically tested to 150 p.s.i. or $1^1/2$ times the working pressure whichever is greater. This shall be maintained for a period not less than 24 hours.

(c) Hose reel tanks shall be tested for leaks.

(d) All pressure and flow switches shall be set and tested to the satisfaction of the Engineer.

(e) All control board circuitry, indicators and alarms shall be checked for correct setting and operation.

(f) The two highest or most hydraulically remote hose reels shall be discharged simultaneously and checked for discharge rates and cut-in and cut-off limits of the duty pump set.

If as result of these tests any defects are found these shall be remedied as necessary and a retest of the system shall be carried out.

When the contractor is satisfied that the installation is complete, fully operational and meeting the requirements of the code, he shall notify the Engineer in writing for an appointment to inspect the works and to arrange for attendance by a representative of the Local Fire Authority to test and inspect the installation. The Contractor shall prepare all necessary certificates certifying the installation as meeting with all the relevant requirements of the Local Fire Authority. Four (4) copies of the completion and acceptance of certificates shall be submitted.

3.03 Painting And Corrosion Protection

In general, all items of equipment, piping, sheathing, hangers and supports shall be painted and protected against corrosion. Painting shall generally comprise of one coat of suitable primer, one undercoat and two finishing coats of high gloss enamel. Only the best and approved type primers and paints shall be used. All surfaces shall be thoroughly prepared prior to painting and the primer used shall be suitable for the relevant surface.

Each coat of paint shall be applied by brush and when thoroughly dry, be smoothed with suitable abrasive paper or cloth before the next coat is applied. Painting shall be done only during suitable weather.

All final coatings shall be to the approval of the Fire Authority. The basic colour for fire service shall be signal Red 537 B.S.1958.

END OF SECTION 15650

SECTION 15660

Portable Fire Extinguisher

Part 1 - General

1.01 Description of Works

The Contractor shall supply and install portable fire extinguishers. All materials shall be new and unused, be of best quality of its respective kind, free from defects and approved for use by the Engineer.

It shall conform to CP 402 Part 3: 1964 as approved by Fire Officers Committee and/or comply to the following Malaysian Standards:

MS. 1179	-	Specifications for Portable Extinguishers
MS. 1180	-	Fire extinguisher's media
MS. 1181	-	Recharging fire extinguishers
MS. 1182	-	Classification of fires

Portable extinguishers shall be maintained in a fully charged and operable condition and kept in their designated places as shown in the drawings.

Part 2 Product

2.1 Dry Chemical Type Portable Extinguishers

Dry chemical powder shall be of the 9 kg capacity capable of extinguishing Class A, B and C fire. The dry chemical shall be non-toxic, non-corrosive, non-abrasive and non-freezing. It shall not solidify or evaporate and conform to B.S. 3465.

Dry chemical powder shall be expelled by compressed gas or air.

2.2 CO2 Type Portable Extinguishers

CO2 type extinguishers where shown shall be of the 4.5kg capacity capable of extinguishing Class E type fires..

Part 3 Execution

3.1 Installation

Extinguishers shall not be obstructed or obscured from view. In large rooms and in certain locations where visual obstruction cannot be completely avoided, use of extinguishers intended for different classes of fire are grouped, their intended use shall be marked conspicuously to insure choice of the proper extinguisher at the time of a fire.

Extinguishers shall be installed on hangers or brackets mounted on to the wall.

Extinguishers having a gross weight not exceeding 40 pounds and shall be install so that the top of the extinguisher is not more than 5 feet above the floor. Extinguishers having a gross

weight greater than 40 pounds (except wheeled types) shall be so installed that the top of extinguishers is not more than 3½ above the floor.

Extinguisher installed under vibrating condition where they are subject to severe vibration shall be installed in brackets specifically designed to cope with this vibration.

Extinguishers shall be suitable for use within a temperature range of at least, plus 40^{o} to 120^{o} F. Where extinguishers are installed in location subjects to temperature outside the range prescribed, they shall be of a type approved or listed for the temperature to which they will be exposed.

Extinguishers shells, cartridges or cylinders which show leakage or permanent distortion or are ruptured shall be removed from service and replaced with the new extinguishers. The Contractor shall bear the cost for replacement.

3.2 APPROVALS

The Contractor shall be responsible for submitting all the portable extinguishers to be installed for inspection by the Local Fire Authority and pay all the inspection fees.

END OF SECTION 15660

DIVISION 16.

ELECTRICAL WORKS

Section 16010

General Provisions for Electrical Installations

Part 1 General

1.01 Description

A The Electrical Installation Contractor, herein referred to as the 'Electrical Contractor' within this section and all other Division 16 Sections of this specifications shall carry out all electrical works complete in accordance with the requirements of the Contract Documents.

B The Contractor shall be solely responsible that the electrical works as a plant system should function properly. The Electrical Contractor shall carry out the detailed design, supply, install, test and commission the system taking into account also the requirement for other trade/discipline such as civil works, structure works and mechanical works based on the drawings, the technical specifications and the particular specifications; provided, however, that it shall not waive the responsibility of the Contractor to be fulfilled under the Contractor.

C Scope of Work

1 The design, supply and installation of all services, equipment, components, accessories and fittings required for the operation of the facility to the extent specified and detailed on the Drawings and Specifications including one year maintenance after provisional hand-over.
2 Builder's work in connection with the electrical installations, including supply, necessary inserts and sleeves.
3 Any work which can be reasonably inferred as necessary for the safe, satisfactory operation of each system, whether such work is specified or shown on drawings or not.
4 The supply and installation of cables, conduits, boxes and termination points, for the motors, starters, controls and the like for the process equipment, heating, ventilation and air-conditioning and plumbing services.
5 Arranging for installation of permanent electrical supply by the supply authority, including submission of all necessary documents and carrying all necessary approvals.
6 Attending upon the supply authority installing mains power supply and carrying out primary and secondary injection tests.
7 Arranging and carrying all necessary approvals with the telecommunications authority for the telephone system.

D Documentation

1 The indication and/or description of any item on the Drawings or in the Specification, unless otherwise specifically stated, implies an instruction to supply and fix such items.
2 Drawings show the general run of cables, raceways, etc. and the approximate location of equipment and utilities symbols and schematic diagrams of no dimensional significance.

1.02 Quality Assurance

All supplies and services offered in response to this specification shall conform to the latest standards. The design, equipment and installation requirements shall comply with the standards and recommendations indicated hereunder:

1 Regulations for Electrical Installations as issued by the supply authority.
2 Regulations for Electrical Installations as issued by the Institution of Electrical Engineers, London.
3 Recommendations for Lighting Installations as issued by the relevant power supply authority and the Chartered Institute of Building Services, London.
4 Standards relating to Electrical Installations and equipment as issued by International Electrotechnical Commission and British Standards Institute.

1.03 Submittals

A Shop Drawings

1 Provide shop drawings, to a scale not smaller than the corresponding layout drawings, showing the following:
   a Exact runs and sizes of conduits, ducts, cables, cable trays and trunking.
   b Layout drawings for each separate electrical installation showing the actual locations of points, suitably identified, the locations of switchgear, switchboards, motor control centres and distribution boards, details and types of fittings.
   c Plans showing the equipment assembly, space requirements, clearances and locations for cable entrances and anchor bolts.
   d Elevations showing all parts, devices, components and nameplates, positions and arrangements of the equipment. Show as many elevations as necessary to clearly depict component and device arrangements.
   e Schedules of points, indicating how the various outlets are connected to the distribution boards, size of circuit wiring, the rating of the protective device and the type and size of appliance of fitting.
   f Schematic diagram of connections of distribution boards, and equipment to main switchboards showing sizes of feeders, etc.
   g Schematic and elementary wiring diagrams, of each unit of each equipment, showing numbered terminal points, numbered wires and numbered interconnections to other equipment and remote devices.
   h Connection wiring diagrams, of each unit of each equipment, showing numbered terminal points, numbered wires and numbered interconnections to other equipment and remote devices.
   i Complete catalogue information of all parts and components of electrical equipment.
   j All cable routings and layouts for the different electrical services, feeders and branch circuits showing routes, sizes and types of cables.
   k Any other data necessary for the proper maintenance of the installations.
2 An overcurrent protective device coordination study that shows all protective devices to be properly coordinated shall be submitted with the equipment shop drawings for approval.
3 Final coordination of electrical works with mechanical, structural and architectural work shall be carried out from complete shop drawings and sufficient time shall be allowed for coordination and checking of shop drawings and calculations after shop drawings are submitted.
4 Individual shop drawings shall bear a stamp indicating that the work has been coordinated with other trades.

B Progress Drawings

1 Provide and keep on the job at all times, one complete and separate set of blackline prints of the electrical work on which shall be clearly, neatly and accurately noted, promptly as the work progresses, all architectural and electrical changes, revisions and additions to the work. Whatever work is installed otherwise than as shown on the Contract Drawings, such changes shall be noted.

2 Indicate daily progress on these prints by colouring in the various conduits, ducts, trunking, cable trays, fixtures, apparatus and associated installation works erected.

1.04 Job Conditions

A. Lay electrical works in advance of pouring concrete slabs and construction of walls. Obtain Engineer's approval before commencing builder's work in connection with electrical installation, related shop drawing, coordinated drawing and materials should be approved prior to the work commencement.
B. Before the permanent electricity supply is connected the electrical installations must be complete, tested and approved by the Engineer and the supply authority.

1.05 Segregation of Services

A Electrical services shall be segregated as specified throughout the installation to obviate the following:
1 Electrical interference from one circuit to another.
2 A fault on one circuit affecting another.
3 Unnecessary fire damage.
4 Difficulties in circuit identification.
5 Voltage limits for general safety.

B All raceways shall be kept clear of other services except where intentionally earthed or bonded. Generally, raceways shall be kept 150 mm away from and above hot water and 75 mm away from other services.

C Unless specifically indicated otherwise, normal, emergency, low voltage cables and wiring shall be segregated throughout the installation generally in the following manner:
1 Armoured and Sheathed Catalyst : Where more than one tray has been specified or is necessary to accommodate the number of cables on a run, where practical, segregation shall be achieved by dedicating each tray to either normal or emergency services. Where normal and emergency cables have to run together in trays, ducts or trenches, they shall be formed in two groups, one normal and one emergency.
2 Insulated Conductors: Insulated conductor circuits shall, where possible, be segregated throughout by enclosing in separate conduits, trunking or trunking compartments.

1.06 Delivery, Storage and Handling

The Contractor shall include for packing, shipment and delivery to site of all equipment and materials necessary for the completion and satisfactory working of the installation. Each item shall be adequately protected and packed and be clearly marked to ensure the safe conveyance and delivery to site.

Part 2 Products

2.01 Materials

A All equipment and materials used in the electrical installation work shall be new and of the highest quality to the best modern practices. All materials shall be approved types, supplied by approved manufacturers and shall be fully suitable for use in the conditions stated.

B All electrical materials and equipment shall comply in all respects (design, properties, qualities, testing, etc.) as a minimum with the latest International Electrotechnical Commission recommendations and/or the latest British Standards. Should there be and difference between the IEC/BS and this Specification, then the most stringent requirements shall apply.

C Component parts of similar use and rating shall be interchangeable with each other.

D All manufactured items shall be the product of manufacturers regularly engaged in producing works of the types specified and be constructed and finished by the same manufacturer.

E All manufactured items shall be free from imperfections and defects which may impair their durability and serviceability or affect their appearance.

2.02 Labels

A For substations, switchgear, switchboards, motor control centres and panel boards engraved lamacoid name plates, black with minimum 6 mm high white lettering.

B For Distribution Boards and Circuit Breakers:

1 Where individually enclosed or in substations, switchgear, switchboards, motor control centres and panel boards without doors engraved lamacoid nameplates, black with 3 mm high white lettering.

2 In panel boards with doors mount directories in transparent plastic covers in metal frames.

C Wiring Identification

1 Identify wiring with permanent indelible, wrap-around, identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.

2 Maintain phase sequence and colour coding throughout.

3 Colour code to standards above as specified elsewhere.

4 Use colour coded wires in communication cables, matched throughout system.

D Conduit and Cable Identification

1 Colour code conduits and metallic sheathed cables.

2 Code with plastic tape or paint and points where conduit or cable enters wall, ceiling or floor, at 15 m intervals.

3 Colours to be 25mm wide prime colour and 20mm wide auxiliary colour to standards above.

4 Number code, per Circuit Schedule, all feeder and branch circuit cables at both connection points and in manholes, handholes, pull-boxes and junction boxes with fibre or non-ferrous metal tags, fastened with non-ferrous wire.

E Device Plates

For Device Plates of local toggle switches, toggle switch type motor starters, pilot lights and the like, whose junction is not readily apparent plates to be engraved with 3mm high letters describing equipment controlled or indicated.

F For Busbars

1 Phase identification letters shall be stamped into the metal of the busbars of each phase of the main buses in each substation, switchgear, switchboards, motor control centre and panel board in addition to colour identification.
2 Letters shall be visible without disassembling current carrying of supporting elements.

G For Doors
Where switchboard rooms, cable chambers, metal screened spaces and the like contain electric power cables, bus bars or equipment operating at voltages exceeding 600 V: enamelled sheet metal, red on white, reading "Danger - High Voltage".

H For Rooms
To switchboard rooms, electric closets, metal screened spaces assigned to electrical equipment, and the like: enamelled sheet metal, red on white, reading "Electrical Equipment Room - No Storage Permitted".

2.03 Fabrications

Steel frames and like components shall be thoroughly cleaned to remove all scale, rust, oil and grease, treated with an approved rust inhibiting solution and painted with two undercoats and one coat gloss finish before leaving the factory. Supply an adequate quantity of paint for final touching up on site.

2.04 Standard Products

Where two or more units of the same class of equipment are required, these units shall be product of a single manufacturer.

2.05 Mounting Height of Accessories

A Unless indicated otherwise, the mounting height of accessories shall be as indicated below. Mounting heights shall be measured between the centre line of the item concerned and the finished floor level.

B The following is the schedule of mounting height:
1 Lighting switches, equipment and appliance control switches and regulators, including the manual controls of heating and ventilation systems, pushbuttons, and any other item containing manual controls for the operation or regulation of any system or facility, shall be mounted at 1200 mm above finished floor level, unless indicated otherwise.
2 Socket outlets shall be mounted at 300 mm other than in kitchens and switchrooms. The sockets above any work bench, where socket outlets shall be mounted at 1200 mm above finished floor level.
3 Telephone outlets shall be mounted a height of 300 mm wall mounted telephone instrument outlets shall be mounted at a height of 1200 mm above finished floor level.

2.06 Accessories

A Accessories installed throughout the Contract Works shall, unless indicated otherwise, match in colour, style and manufacture. Situations where this is impracticable shall be brought to the Engineer's attention prior to work being put in hand.

B The cover plates of flush-mounted accessories shall be fixed square and flush with the building surface.

2.07 Finishes

Shop finish metal enclosure surfaces by removal of rust and scale, cleaning, applications of rust resistant primer inside and outside and at least two coats of finish enamel.

2.08 Fixings

A Unless indicated elsewhere in the Specification or on the Drawings, the Contractor shall provide and make all fixing to the Facility for all services included in this Contract.

B Rawlbolts or similar approved fixings shall be used for heavy loads. Plastic or fibre plugs shall be used for light loads. Other proprietary methods may be specified later in this Specification. The Contractor may offer alternative methods to those specified but the Engineer reserves the right to reject such alternative and call for the use of the specified methods only.

C All metal fixing devices shall be zinc or cadmium plated, sheradized or hot dipped galvanized including any expansion shields, plugs, nuts, washers, etc., associated with the fixing devices.

D The Contractor shall carry out any drilling and plugging for screw fixings of pipework, raceways, cable trunking, ducting, wiring, conduit fittings, accessories and finishing trims supplied under this Contract.

E Generally equipment and supports shall be fastened to:
1 Solid masonry or plastered surfaces by suitable anchors, screws and bolts.
2 Poured concrete by expandable inserts.
3 Hollow masonry walls or suspended ceilings by patent retention type fastenings. The Contractor shall establish that there is adequate strength in such hollow material before fixing to same.

F Supports or equipment installed by other trades shall not be used except with the permission of the other trades and approval of the Engineer.

G. Purpose made fixing clips and brackets may be necessary in certain areas and the Contractor shall be deemed to be aware of this at the time of tendering and to have included for the supply and fixing of same in this Tender Bid.

H Details of proposed clips and/or brackets shall be submitted to the Engineer for approval, prior to the manufacture of same being commenced.

I Holes shall not be drilled in any structural steelwork or prestressed concrete without first obtaining the approval of the Engineer.

J Where it is proposed to use cartridge fired bolts for fixing to blockwork or concrete, approval shall first be obtained from the Engineer. The ruling also applies to stud welded fixing on steel structures.

K All supports or mountings described above, shall be steel, hot dipped galvanized after fabrication wherever practicable. In cases where the Engineer agrees that it is not practical

to provide galvanized steel, supports and mountings shall have two coats of rust resistant paint applied.

Part 3 Execution

3.01 Labelling

A For switchgear, switchboards, motor control centres and panel boards, fix on front, externally by riveting.

B For distribution switches, motor starters and circuit breakers
1 Nameplates on individually enclosed units and units in switchgear, switchboards, motor control centres and panel boards without doors, fix on front externally.
2 Directories in panel boards with doors, fix on inside frame of door.

C "Danger - High Voltage" Signs - fix on external face of doors of switchboard room, cable chambers, metal screened spaces, and the like containing electric power cabling.

D Primary Gear
1 Fix a stencilled "mimic bus" diagram on front face.
2 Diagram shall show schematically the primary bussing and switching arrangement.
3 Primary gear containing switching equipment whose blades are alive when open shall have warning signs to that effect.

E Outlet boxes, junction boxes and cabinets - when used in conjunction with empty raceways for wires of a future system, mark indelibly on the inside denoting the system.

3.02 Workmanship

A The entire work provided in this specification shall be constructed and finished in every respect in a workmanlike and substantial manner. The Contractor shall provide the system in accordance with the best trade practice and to the satisfaction of the Engineer.

B Keep others fully informed as to the shape, size and position of all openings required for apparatus and give full information sufficiently in advance of the work so that all openings may be built in advance. Provide and install all sleeves, supports, etc., hereinafter specified or required.

C Obtain detailed information from the manufacturers of apparatus as to the proper method of installing and connecting same. Obtain all information from others which may be necessary to facilitate work and the completion of the whole project.

D Provide the services of an experienced foreman, who shall be continuously in charge of the erection of the electrical work, together with all necessary skilled workmen, helpers and labourers, required to properly unload, transfer, erect and connect up, adjust, start, operate and test the system.

E Before installing any work, verify that it does not interfere with clearance required for other work. Notice of adverse conditions shall be forwarded in writing to the Engineer before any work in question is installed. If notification is not made, and work installed causes interference with the contemplated design, make such changes in his work as directed by the Engineer to permit the installation of all work of the project, at no additional cost to the Employer.

F Raceways shall be run as straight and direct as possible in general forming right angles with or parallel with walls or piping and neatly spaced, with risers erected plumb and true, maintain a clearance of at least 25mm between finished coverings and adjoining work. Approved ceiling height shall be obtained from Architectural Drawings.

G All equipment and accessories shall operate without objectionable noise or vibration. Should operation of any of the equipment or systems produce noise or vibration which is, in the opinion of the Engineer objectionable, make change in equipment and do all work necessary to eliminate the objectionable noise or vibration at no additional cost to MPW.

H Wherever possible services shall not cross expansion joints. Where this is unavoidable the services shall accommodate the design movement without damage, by use of approved expansion couplings/flexible conduit arrangement.

3.03 Protection

A The Contractor shall be responsible for his work and equipment until finally inspected, tested and accepted, carefully store materials and equipment which are not immediately installed after delivery to site. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing material.

B Protect work and material of other trades from damage that might be caused by his work or workmen and make good damage thus caused.

3.04 Layout of the Work

A The electrical drawings show the general arrangement of the work and the approximate locations of equipment. Refer to all other drawings to verify all spaces and conditions affecting work of this section. The construction of the facility in certain places may disclose the inaccessibility of equipment apparatus if placed in locations shown on the drawings.

B Where departures from the drawings are deemed necessary, details of such departures and reasons therefore shall be submitted to the Engineer for approval.

C No such departures shall be made without prior written approval of the Engineer.

D Conduit and ducts shall be run in wall chase, recesses, pipe shafts and ceilings except where indicated otherwise. Arrange work accordingly.

E All equipment and apparatus such as motors, switchgear, switchboards, motor control centres, panels, controls etc., shall be installed as to be readily accessible for operation and maintenance.

3.05 Protection

A Protect exposed live equipment during construction for personnel safety.

B Shield and mark live parts "LIVE 240 VOLTS"

C Arrange for installation of temporary doors for room containing electrical distribution equipment. Keep these doors locked except when under direct supervision of an electrician.

3.06 Fireproofing

A Establish from Drawings where fire and smoke barriers exist, and make adequate provision of fire and smoke barriers in and around trunking, conduits, cables, etc., where they pass through floors and fire rated walls, and where inert gas smothering systems are installed pack space between wiring and sleeve full with suitable material and seal with caulking.

B The Contractor shall ensure that this work is carried out such that the integrity of any such fire barrier is properly maintained where pierced by electrical services.

3.07 Spare Parts

A General
1. Submit to the Engineer a list of, and provide, all spare parts to be required for a further one year operation from the issue of the Taking-Over Certificate.
2. Spare parts required include but not necessarily limited to those listed below and shall be increased where increased quantities for each item or equipment are recommended by the manufacturer.
3. Store spare parts in a location designated by the Engineer.

B Main Low Tension Boards
1. 2% spare moulded case circuit breakers of all different frame sizes, but in any case not less than two circuit breaker of each size.
2. 5% spare indicating lamps for each indicating lamp in the switchgear.
3. One set of tools required for switchgear maintenance.
4. Provide complete spare parts as recommended by the manufacturer for different sizes of A.C.B.

C Switchboards, Motor Control Centres and Distribution Boards
1. 5% spare combination magnetic motor starters.
2. 5% spare circuit breakers for different rating of MCCBs.
3. 5% spare HRC fuses for different rating.
4. 5% spare of load break switch (isolators) of each size.
5. 5% spare of c.o.E/L/c.b. of each size

D Disconnecting Switches - 5% spare switch of each size.

E Circuit Accessories
1. Plug Fuses - furnish ten percent of the number of each size and type of fuses installed, but in any case not less than six fuses of each sizes.
2. Wall Switches - provide five percent of the number of each size and type of wall switch installed.
3. Socket Outlets - provide five percent of the number of each size and type installed.
4. Lamps - provide five percent lamps of each size and type for indicating panels and pilot lights installed for different systems.

F Lighting Fixtures
1. 2% of the total quantity of each type of lighting fixture. This quantity shall not be less than one fixture of each type.

2. Additional diffusers for 5% of the total quantity of each type of lighting fixture provided with acrylic, plastic or glass enclosures. Diffusers shall be identical to those of the installed fixtures. This quantity shall not be less than two diffusers of each type.
3. 10% spare lamps of each wattage of different type.
4. 5% of the total quantity of control gear (ballasts) of each type and size but in no case less than (6) ballasts of each size and type.

G Emergency Generating Sets - complete itemised list of different spares to be included and priced by the tenderers to maintain it for two years.

H The Tenderer shall submit with his offer detail prices of the spare parts he is required to provide under the Contract indicating the quantity and the unit rate of each item.

3.08 Testing and Commissioning

A General

1. The Engineer shall be authorised to inspect, examine and test at any reasonable time and in the premises of the manufacturer the quality of the material used for the equipment to be supplied.
2. Should part of the equipment be subcontracted to another manufacturer, the Contractor shall ensure that the Engineer is authorised to inspect, examine and test the equipment in the premises of the Sub-Contractor.
3. These inspection, examinations and tests shall not relieve the Contractor in any case from this contractual responsibility and commitments.
4. The Contractor shall notify the Engineer in writing at least 15 days beforehand of the date and place at which any equipment shall be available for tests to be made according to the provisions of the Contract. Should the Engineer not have appeared at the place indicated within ten days following the date indicated by the Contractor, the latter shall proceed with the tests and it shall be deemed that they had been witnessed by the Engineer. The Contractor shall send the Engineer duly certified copies of the results of the tests.
5. The Engineer shall notify the Contractor of his intentions to attend the test 24 hours beforehand.
6. Should the Contract provide for tests to be made in the premises of the Contractor or any Sub-Contractors or suppliers. the Contractor shall afford any assistance, labour materials, electricity, fuel supplies, equipment and instrument required and which can be reasonably requested for these tests.

B Testing

1. On completion of the entire electrical installation work or any separate or distinct part thereof, notify the Engineer, in writing, that the complete part of the electrical work is ready for inspection. Before doing so, perform initial trial tests. Test, correct, adjust, balance, regulate, etc., the section concerned as necessary until required conditions are obtained.
2. The inspection of the Contractors work shall be carried out in the presence of the Engineer and in accordance with the requirements of Section 'E' of the IEE 'Regulations for Electrical Equipment of Buildings' and shall comprise of, but not limited to, :
   a Verification of polarity
   b Effectiveness of earthing

c Insulation resistance test
d Test of ring circuit continuity
e Phase rotation
f Operation tests of relays, interlocks and any other protective and control device to ensure correct functioning.

The results and readings obtained shall be equal or better than the requirements of the IEE and the supply authority regulations and these shall be recorded on forms similar to the ones described in the IEE Regulations.

3. Supply all instruments and tools required for carrying out the tests.
4. Follow-up and make all necessary arrangements with the supply authority for the purpose of providing permanent electricity supply. Also provide all facilities and attendance to the supply authority for any other tests carried out before energising the installation.

END OF SECTION 16010

Section 16050

Basic Materials and Methods

Part 1 General

1.01 Description

The work of this section is integral with the whole of the contract documents and is not intended to be interpreted outside that context. All work shall be coordinated with all other services affecting the work of this section.

Part 2 Products

2.01 Materials

A. All equipment and materials used in the electrical installation work shall be new and of the highest quality to the best modern practices. All materials shall be approved types, supplied by approved manufacturers and shall be fully suitable for use in the climatic conditions stated and on standard frequency and voltage of the project site.

B. All electrical materials and equipment shall comply in all respects (design, properties, qualities, testing, etc.) as a minimum with the latest International Electrotechnical Commission (I.E.C) recommendations and/or the latest Japanese Industrial Standards (JIS) or British Standards (B.S.)

C. Should there be any difference between the IEC/JIS/BS and this Specification, then the most stringent requirements shall apply.

D. Component parts of similar use and rating shall be interchangeable with each other.

E. All manufactured items shall be the product of manufacturers regularly engaged in producing works of the types specified and be constructed and finished by the same manufacturer.

2.02 Materials Installed in Hazardous/Corrosive Environments

A. If any of the areas and process buildings of the project site are classified as hazardous areas, all electrical equipment, cable glands and installation materials installed in these areas shall comply with Class 1, Division 1, Group D requirements. Cable wiring systems such as conduits, trays, ladders and trunkings which are located in these areas shall be manufactured from heavy duty stainless steel grade 316, including all associated supports, drop rods, brackets, etc.

B. All electrical equipment inside the process buildings and external electrical equipment, including switch disconnectors, local control switches etc. shall be protected against dust and water to IP 65. The process buildings are often exposed to the ingress of dust and equipment and floors are hosed down. This applies to all the process buildings and areas and not just the hazardous areas above.

2.03 Ordering of Materials

A. The detail of equipment and materials shall include the following:
   1. Full technical specifications of equipment including construction, materials, degree of protection, characteristics, curves, diagrams, ratings, dimensions, fixing details etc.
   2. Relevant sheets of manufacturer's catalogues, specifications, technical data, etc.
   3. Confirmation that equipment and materials offered complies fully with relevant Clauses of the Specification and, in case of deviation from the Specification, a schedule of deviations listing all points not conforming to the Specification shall be submitted for Engineer's approval.
   4. Short circuit study including all components shown on the Schematic Diagrams.

B. Submit, at the request of the Engineer, a sample of any equipment or material for further study before approval.

C. Manufacturers specified by name are not relieved of the responsibility for meeting Specification requirements and submittal for approval.

Part 3 Execution

3.01 Fixing

A. Unless indicated elsewhere in the Specification or on the Drawings, the Contractor shall provide and make all the fixings for all services included in this Contract.

B. Rawlbolts or similar approved fixings shall be used for heavy loads. Plastic or fibre plugs shall be used for light loads. Other proprietary methods may be specified later in this Specification. The Contractor may offer alternative methods to those specified but the Engineer reserves the right to reject such alternative and call for the use of the specified methods only.

C. All metal fixing devices shall be hot dipped galvanised or stainless steel grade 316 including any expansion shields, plugs, nuts, washers, (minimum A4 - 70 to BS 6105) etc., associated with the fixing devices. The material used for fixing devices shall comply with Clause 2.02 above.

D. The Contractor shall carry out any drilling and plugging for screw fixings of pipework, raceways, cable trunking, ducting, wiring, conduit fittings, accessories and finishing trims supplied under this Contract.

E. Generally equipment and supports shall be fastened to:
   1. Solid masonry or plastered surfaces by suitable anchors, screws and bolts.
   2. Poured concrete by expandable inserts.
   3. Hollow masonry walls or suspended ceilings by patent retention type fastenings. The Contractor shall establish that there is adequate strength in such hollow material before fixing to same.

F. Supports or equipment installed by other trades shall not be used except with the permission of the other trades and approval of the Engineer.

G. Purpose made fixing clips and brackets may be necessary in certain areas and the Contractor shall be deemed to be aware of this at the time of tendering and to have included for the supply and fixing of same in his Tender.

H. Details of proposed clips and/or brackets shall be submitted to the Engineer for approval, prior to the manufacture of same being commenced.

I. Holes shall not be drilled in any structural steelwork or prestressed concrete without first obtaining the approval of the Engineer.

J. Where it is proposed to use cartridge fired bolts for fixing to blockwork or concrete, approval shall first be obtained from the Engineer. The ruling also applies to stud welded fixing on steel structures.

K. All supports or mountings described above shall be hot dipped galvanised or stainless steel grade 316, as stipulated in Clause 2.02 above. All galvanized supports or mountings which have to be cut on site shall have two coats of rust resistant paint applied. Note: galvanized steel shall only be cut on site if approved by the Engineer.

END OF SECTION 16050

Section 16111

Cable Trays

Part 1 General

1.01 Description

Provide all labour, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in the Contract Documents and as specified herein.

1.02 Reference Standards

Applicable standards referred to in this Section:
BS 729 Hot dip galvanized coating on iron and steel articles.
BS 1767

Part 2 Products

2.01 General

A The cable tray system shall be of one manufacturer and shall include factory-made trays, tray fittings, connectors and necessary accessories and supports to form a complete cable support system. The cable tray system shall include the following factory-made tray elements:
1 Straight cable trays and ladders.
2 Fittings as horizontal and vertical bends of various angles, crosses, tees, wyes, reducers, vertical riser elements.
3 Connectors.
4 All necessary fixing accessories.

B Manufacturer's standard accessories shall be used and site fabrication shall only be allowed where special sections are required subject to the approval of the Engineer.

C Horizontal run of cables laid on cable tray and exposed to direct sunlight on roof or platforms shall be provided with covering at higher level to allow for ventilation. Cable tray shall be raised 150 mm from finished floor level.

2.02 Materials

A The whole of the tray work, trays, fittings, supports shall be of mild steel hot dipped galvanized after manufacture. The thickness of the protective sheath on any element shall not be less than 55 microns.

B Cable trays shall be constructed from mild steel hot dip galvanized and of minimum thickness of 2 mm.

C Insert elements, bolts, screws, pins, etc., shall be mild steel cadmium plated.

D Traywork shall have oval perforations. Ladder type trays shall be used for all vertical runs as approved by the Engineer.

E All trays (straight and fittings) shall be welded construction and be a heavy duty returned flanged, perforated type, unless specified otherwise.

F Tray components shall be accurately rolled or formed to close tolerances and all edges rounded. Flanges shall have full round smooth edges.

G. Ladder racks shall be of similar construction. The rungs shall be spaced at maximum 300 mm. The system shall allow for installing additional rungs and for resisting rungs.

H For all trays, flanges shall be a minimum of 50 mm deep, unless otherwise specified.

I Cable tray width and radius of curved sections shall be selected to suit the number of cables as shown on drawings and to the approval of the Engineer.

Part 3 Execution

3.01 Installation

A Drilling, machining or cutting shall not be carried out after application of protective coat, unless previously agreed by the Engineer. If cutting or drilling is necessary, edges shall be cleaned up and painted with zinc based paint before erection.

B Installation of vertical runs of tray along the line of vertical expansion joints in structure of the facility shall not be allowed.

C Cables shall be fixed to the trays by means of PVC covered saddles or straps secured with brass or cadmium plated bolts, nuts and washers.

3.02 Erection

A Cable trays arranged one above the other shall have spacing in relation to their width not exceeding a ratio of 1:2 with a minimum distance of 150 mm.

B Install fixings and supports:
1 At 3 m centres
2 150 mm from bends, tees, intersections and risers
3 As close as practicable to joints
4 Each side of expansion joints

C The cable trays shall be fixed in accordance with site conditions and manufacturer's recommendations.

D Join cable tray and accessories with hardware per manufacturer's recommendations.

E Avoid mid-span joints.

F The Contractor shall submit, as required, all calculations relating to traywork and tray supports demonstrating acceptable mechanical stresses and sag.

3.03 Earthing

A Cable trays and accessories shall be electrically and mechanically continuous throughout their length. The entire cable tray system shall be bonded and 12 mm x 2.5 mm tinned copper links shall be bolted across each joint in the system by means of bronze nut and bolts, complete with flat and spring washers.

B All cable trays shall be provided with earth continuity copper tape along the whole route of cable trays which shall be bonded to the main earthing system of the facility. The earth continuity copper tape shall be fixed on cable tray by means of PVC covered saddles or by other means approved by the Engineer.

END OF SECTION 16111

Section 16112

Conduits

Part 1 General

1.01 Description

A. Provide all labour, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in the Contract Documents and as specified herein.

B General

1 Light and power circuits, telephone, signal and other low current system wiring and cables feeding equipment and distribution boards shall be drawn in conduits unless otherwise indicated.

2 Conduit system shall generally be concealed and installed as indicated, unless otherwise indicated.

3 Normal light and power circuits, emergency light and power circuits, telephone wiring, signal wiring and low current system wiring shall each be run in separate conduit and wireway.

4 Cable insulated for two different categories of circuit shall be segregated irrespective of service.

5 Conduit and fitting used shall be :

a Where embedded : heavy gauge rigid PVC;

b Where surface mounted, exposed conduit : galvanized steel;

c Where installed above false ceilings and in voids: galvanized steel shall be used throughout the circuit.

d Where installed in flame proof and hazardous areas : galvanized steel

e From terminal box to machine: Flexible conduit

1.02 Quality Assurance

Applicable Standards referred to in this Section:

BS 731: Part 1)	Flexible steel conduits and adaptors for the protection of electric
IEC 60614-2-5)	cable.
BS 4607: Part 1	Non-metallic conduits and fittings for electrical installations: rigid PVC conduits and conduit fittings, metric units.
BS 4568; IEC 60614-2-1	Steel Conduits and fittings, metric units.
BS 2782:	Method of Testing Plastics
BS 6053, IEC 423-A:	Conduit diameters and threads for conduit and fittings.
JISC C 3653	Corrugated rigid polyethylene conduit.

1.03 Submissions

A Cut-away samples of all sizes of conduits, conduit boxes and fittings of each type shall be fixed to a board and submitted to the Engineer.

B At the time of submitting samples submit manufacturer's details, catalogues and copies of test certificates confirming that offered types comply with the Specification.

C Submit drawings of proposed conduit layout and obtain approval before commencing work.

Part 2 Products

2.01 Rigid PVC Conduit and Fittings

A Physical Properties

1 PVC Conduits shall be high impact, non-hygroscopic, rigid PVC, unthreaded push type. Conduit and conduit fittings shall be in accordance with BS 4607 and CEE Publication 26. The conduit and conduit fittings shall be suitable for installation at temperature -5°C to +85°C and they shall not soften or suffer any degradation at these temperatures, conduit and conduit fittings shall be self-extinguishing type.

2 All joints shall be made with proper fittings and by using sealing cement (Vinyl Solvent Paint) to ensure a watertight joint. The cement shall be of a type that remains in a sticky condition.

3 Rigid PVC Conduit and conduit fittings shall be fully suitable for installation, storage or transport at the temperatures encountered at the job site and at this temperature the material shall not soften or suffer any structural degradation.

4 All PVC Conduit and conduit fittings shall be suitably marked and identified by the Manufacturer. Conduits used throughout shall be of one manufacturer and marking on the conduit shall include the nominal size. All markings shall be indelible and easily legible.

5 The inside and outside surfaces of conduits shall be smooth and free from burrs, flash and other similar defects.

6 The interior and ends of conduit fittings shall have no sharp edges and surfaces and corners over which the cables are likely to be drawn shall be smooth and well rounded.

7 The conduit entries of fittings shall be so designed that reliable water tight joint can be made between the conduit and fitting. It shall be constructed in such a way that it will be possible to bend the conduit easily with the aid of a sample tool e.g. bending spring.

B Nominal sizes and dimensions

1 Rigid PVC Conduits shall be of one of the following nominal sizes. 20, 25, 32, 38 and 50mm dia. Rigid PVC slip type coupler and coupling bends shall be of the same nominal sizes as the conduits and shall fit to the conduits properly.

2 Where size is not indicated, select in accordance with the Regulations and as a function of the number and size of conductors.

C PVC Conduit Boxes

1 PVC Conduit Boxes can be used through PVC Conduit raceway system and shall comply with BS 4607.

2 Metallic conduit boxes as specified elsewhere in this section can be used alternatively if required for PVC conduit raceway system.

3 All boxes shall be provided with tapped brass inserts for fixing the screws.

4 All boxes for switches, sockets, outlets, etc., shall be rigid PVC or metallic type and their dimensions shall be suitable for fixing the switches, sockets and other accessories.

2.02 Rigid Steel Conduit & Fittings

A Rigid Steel Conduit

1 All metallic conduits shall comply with BS 4568 and of Class 4 rigid steel screwed type having an interior and exterior zinc coating of uniform quality and appearance throughout all surfaces.

2 Conduits shall not be less than 20mm diameter size, and shall be complete with all necessary threaded fittings, couplings and connecting devices having galvanized equivalent finish.

3 Conduits and fittings shall be manufactured specially for electric wiring purposes. When manufactured by a continuous weld process, weld heads both inside and outside the tube shall be completely removed prior to galvanizing.
4 All conduits and fittings shall be free from rust or other defects on delivery to the site and shall be properly stored in covered racking so that it is protected from mechanical damage and damage by weather and water whilst stored on the site.
5 All conduits shall be coupled to boxes and trunking wires using brass male bushes. All such bushes shall be hexagon headed, heavy duty long threaded type.
6 All conduit expansion couplings used shall be fabricated from material equal or equivalent to that of the conduit with which the coupling is to be used, having factory installed packing ring and pressure ring to prevent entrance and moisture. All coupling shall be equipped with earthing ring or earthing conductor.
7 All conduit runs shall be fixed using spacer bar pattern saddles giving not less than 3mm clearance between the conduit and the surface to which it is fixed. Saddles shall have finish to match the conduit and saddle clips shall be secured to the bar by means of brass screws.

B Metallic Conduit Boxes
1 Metallic Conduit Boxes shall be used throughout metallic conduit raceway systems, and shall comply with, or be of demonstrated equivalent quality and performance to BS 4568 requirements. All boxes and covers shall be galvanized, zinc plated or equal rust-proof finish equivalent to conduit finish.
2 Circular and/or rectangular boxes shall be used for pull boxes and terminating boxes, according to size and number of conduits connected to box. Boxes shall be either malleable iron or heavy duty steel construction with welded joints and tapped holes to receive metal threaded cover retaining screws. Self-tapping screws will not be permitted.
3 All boxes, other than those to which a fitting or accessory is to be directly mounted shall be fitted with covers screwed to the box by brass screws. Malleable iron covers shall be used with malleable iron boxes and heavy gauge steel covers shall be used with sheet steel boxes.
4 All cover and accessory fixing provisions shall be so positioned that the fixing screws lie completely clear of cable entering the box. All fixing screws shall be of brass.
5 All boxes installed in exterior locations, plantrooms, ducts, etc., shall be fitted with approved type gaskets to provide a waterproof seal between box and cover or other items fitted to the box.
6 All boxes provided as junction boxes where cable joints are specified or permitted, shall be provided with fixed terminal blocks. Such boxes shall be of suitable size to contain the terminal block and sufficient cable to allow neat connections to be made. The terminal blocks shall be fixed to the box by brass screws and shall comprise brass conductor connectors, with brass clamping screws enclosed in porcelain or other heat resisting insulation material which will not distort or otherwise have its properties damaged by temperatures below the highest temperature at which the insulation of any cable connected to it is destroyed.

2.03 Flexible Conduit and Connections

A Flexible Conduit
1 Flexible conduit shall be to BS 731, Part 1, watertight, PVC sheathed, spiralled metal type. The conduit shall be terminated at boxes and equipment by means of approved compression glands.
2 Flexible conduit shall be of the unpacked type for normal atmospheric conditions and non-asbestos packaged for damp situations. Adaptors shall be of the solid type.

3 Flexible conduit shall be used for the final connection of rigid conduit to the terminal boxes of machines fitted with a means of drive adjustment and/or where vibrations is likely to occur.

B Where connections to electrical machines are to be by multicore glands, the final termination shall be by ring type universal glands and locknuts, and adequate slack cable in the form of a loop or spiral being left to allow for the movement of motors necessitated by belt re-tensioning, vibration, etc.

2.04 Corrugated Rigid Polyethylene Conduit and Fittings

A Physical Properties

1 Corrugated rigid polyethylene conduits shall be high impact, non-hygroscopic, rigid polyethylene type. Conduit and conduit fittings shall be in accordance with JIS C 3653. The conduit and conduit fittings shall be suitable for installation at temperature -5°C to +85°C and they shall not soften or suffer any degradation at these temperatures, conduit and conduit fittings shall be self-extinguishing type.

2 All joints shall be made with proper fittings and by using sealing cement (Vinyl Solvent Paint) to ensure a watertight joint. The cement shall be of a type that remains in a sticky condition.

3 Corrugated rigid polyethylene conduit and conduit fittings shall be fully suitable for underground installation, storage or transport at the temperatures encountered at the job site and at this temperature the material shall not soften or suffer any structural degradation.

4 All corrugated rigid polyethylene conduit and conduit fittings shall be suitably marked and identified by the Manufacturer. Conduits used throughout shall be of one manufacturer and marking on the conduit shall include the nominal size. All markings shall be indelible and easily legible.

5 The inside and outside surfaces of conduits shall be smooth and free from burrs, flash and other similar defects.

6 The interior and ends of conduit fittings shall have no sharp edges and surfaces and corners over which the cables are likely to be drawn shall be smooth and well rounded.

7 The conduit entries of fittings shall be so designed that reliable water tight joint can be made between the conduit and fitting. It shall be constructed in such a way that it will be possible to bend the conduit easily without the aid of any tools.

B Nominal sizes and dimensions

1 Corrugated rigid polyethylene conduits shall be of one of the following nominal sizes. 30, 40, 50, 65, 80, 100, 150 and 200 mm dia. Bellmouth type terminators, which shall be installed on the ends of the conduit in a manhole, shall be of the same nominal diameter as the conduit and shall properly fit on to the conduit.

2 Where size is not indicated, select in accordance with the Regulations and as a function of the number and size of conductors.

Part 3 Execution

3.01 Preparation

Sets and Bends

1 Conduits up to 32 mm diameter: form on site with an approved bending machine using proper formers, guides, springs, etc., taking care not to deform conduit.

2 Conduits over 32 mm diameter: use coupling fittings.

3.02 Installation of Conduit

A General
1 Run conduit in square, symmetrical lines, parallel to or at right angles to walls and in accordance with the accepted practice.
2 Conduit system shall be mechanically continuous and watertight after installation. All conduit system shall be arranged wherever possible to be self-draining.
3 Installation shall permit easy drawing in of cables.
4 Keep conduits at least 100 mm from pipes and other non-electrical services.
5 Where conduit runs are to be concealed in the structure or are to pass through floor slabs, the Contractor shall be responsible for marking the accurate positions of all chases and holes on site. The Contractor shall arrange the conduit routing to make maximum use of any preformed conduit holes and slots provided in structural beams. Conduit installation on shear walls shall be kept to a minimum. All routings necessary on shear walls shall be agreed with the Engineer before work is put in hand.
6 Install conduits so as not to interfere with ceiling inserts, lights or ventilation outlets.

B Runs in Reinforced Concrete.
1 Obtain approval for placing PVC before pouring concrete.
2 Run conduits in concrete slabs parallel to main reinforcing steel.
3 Additional openings in finished slabs, where approved, shall be made by drilling, not by breaking.

C Horizontal or cross runs are to be avoided in partitions and side walls.

D Surface Mounted Conduit (including conduit installed above false ceiling) - fix with distance spacing saddles to allow conduits to be taken directly into accessories without bends or sets.

E Concealed Conduit
1 Fix securely to prevent movement before casting of concrete and screeds, application of plaster and the like.
2 Spacing of clips shall be not greater than as follows:

Conduit Size	Spacing
Upto 25 mm	600 mm
32-38 mm	900 mm
50 mm	1000 mm

3 Supports for exposed conduit shall be fixed at each side of bends.

F Expansion fittings shall be fixed in conduit wherever it crosses expansion joints in the structure to which it is fixed.

G Terminations shall be made with a flanged coupling, lead washer and hexagonal male brass bush, where conduit runs terminate in cable trunking, distribution boards or any sheet metal structure.

H Conduit Boxes shall be fixed at all outlet points.

3.03 Installation of Flexible Conduit

A All conduits must be secured to outlet boxes, junction boxes or cabinets by placing locknuts on outside of box and locknuts and bushings on the inside of box.

B Conduits connecting recessed fixtures and their adjacent junction boxes must be flexible metallic conduit 20mm minimum size and shall be of sufficient length to permit dropping of and shall be of the fixture below the ceiling to gain access to the junction box.

C Conduit to motors shall be terminated in the conduit fittings on the motors, the final connection being made with liquid tight flexible conduit and suitable liquid tight connectors.

D A green insulated 4 sq.mm (minimum) tinned copper earth connection shall be made between the solid conduit or cable sheath and the equipment, the copper cable being run inside the flexible conduit. Couplings fitted to removable covers or non-metallic equipment etc., shall be bonded to the earthing terminal of the equipment etc. Where changes to flexible conduits occur, a watertight outlet box with threaded entries shall be inserted and the earth connection made to an internal terminal. The cover screws shall not be used for earthing connections.

3.04 Cleaning

The conduit outlets when installed and before wiring shall be temporarily closed by means of well-fitting wooden plugs, and immediately before cables are drawn in, conduit systems shall be thoroughly swabbed out until they are dry and clean

END OF SECTION 16112

Section 16114

Trunking/Ducting

Part 1 General

1.01 Description

Provide all labour, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in the Contract Documents and as specified herein.

1.02 Reference Standards

Applicable Standards referred to in this Section:

BS 729:	Hot dip galvanized coatings on iron and steel articles.
BS 2989:	Hot dip zinc coated sheet steel and coil
BS 3382: Part 2	Zinc or steel components
BS 4678: Part 1	Steel surface trunking

1.03 Submittals

A Submit samples of trunking and accessories.

B At the time of submitting samples submit manufacturer's details, catalogues etc.

C Submit drawings showing route of trunking system and obtain approval before commencing work.

Part 2 Products

2.01 Trunking

A General

1 Trunking, associated parts and accessories shall be fabricated from hot dipped galvanized sheet steel not less than 16 SWG.

2 Trunking shall be supplied in 3 m lengths, each length complete with lid, coupler and coupler screws and shall provide adequate earth continuity throughout the whole trunking run.

3 Shall be complete with necessary fittings and accessories. All fixing materials shall also be of galvanized sheet steel of 1 mm thickness.

4 Trunking shall not be smaller than the minimum size stated on the Drawings or specified later and shall be so sized that a space factor of 35 percent is not exceeded. The Contractor shall check the minimum size of trunking specified is large enough for his requirements without exceeding this space factor.

B Trunking and Connectors

1 Shall be to BS 4678 : Part 1, but thicknesses of metal for body and cover material may exceed those in Table 1.

2 Metal thickness for trunking and connectors exceeding 150 x 150 mm external dimensions shall be to approval and shall not be less than that specified in BS 4678: Part 1 for the largest trunking detailed.
3 Finish
  a For internal use : Clause 3 heavy protection internally and externally (e.g.) galvanized steel to BS 2989 Class 2A or 2B protection to BS 4678: Part 1).
  b For external use : Class 3 protection
4 Lids shall be lipped and fixed at regular intervals not exceeding 2m on straight runs, by quick release cam type fasteners.
5 Metal partitions shall be at least 1 mm thick, finished to same standard as trunking. The means of fixing partitions shall prevent them being misplaced and shall not cause corrosion or electrolytic action.
6 Connectors shall span the complete internal surface of the trunking. Trunking sections shall have butt joints.

C Bonding links and fastenings
1 Shall satisfy continuity conditions of BS 4678.
2 Shall not cause corrosion.

D Braided Copper Tape shall be 15 x 2mm minimum having a resistance from fixing to fixing equal to or less than the links used in standard trunking joints.

E Steel Screws and Fasteners
1 Shall have a zinc coating finish to BS 729 or BS 3382: Part 2, or equivalent.
2 Fixings used for securing or fitting shall not cause corrosion or electrolytic action. Black screws are not acceptable.
3 Brackets: mild steel angle or channel finished to same standard as trunking.

F Vertical Trunking shall have cable support units with insulated pins at not exceeding 3m centres.

G Horizontal Trunking - sizes exceeding 100 x 50 mm shall have cable separators with insulated pins at not exceeding 2m centres.

Part 3 Execution

3.01 Installation

A Trunking shall be properly aligned, and securely fixed at not exceeding 2m centres on straight runs. At bends, angles and offsets fix with additional fixings at not exceeding 150 mm centres on each side of the fitting.

B Settlement and Expansion Joints
1 Make a trunking joint where trunking crosses such joints.
2 Make connection through slotted holes allowing a 10mm movement horizontally and vertically
3 Earth continuity link across joints shall be braided copper tape which is long enough to allow for the maximum movement of trunking. Fold braid ends.

C Fire Barriers - install non-combustible, non-metallic fire barriers:
1 Where trunking passes through walls, floors and ceilings.
2 At each floor level when trunking is installed in riser ducts.

D Connections - make connections to conduits, multiple boxes, switchgear, switchboards, motor control centres and distribution boards with flanged units.

E Cable Retaining Straps - fix at not exceeding 1 m centres.

3.02 Cleaning and Adjustment

Make good cutting and damages, remove burrs and rough edges and corrosion and treat with a rust proofing agent, followed by an application of zinc epoxy. Class 2 finishes shall receive a coat of paint to match adjacent surface following the zinc epoxy.

END OF SECTION 16114

Section 16120

Wires and Cables

Part 1 General

1.01 Description

This Section to include the supply, installation and commissioning of all wires and cable systems in accordance with the Specifications and Drawings.

1.02 Reference Standards

Applicable standards referred to in this Section:

BS 6004 IEC 227: PVC insulated cables (non-armoured) for Electrical Power.
BS 6346: PVC insulated cables for Electrical Supply.
BS 6749: PVC Insulation and Sheaths.
BS 5467 IEC 502: Armoured Cables with XLPE and HEPR thermosetting Insulation, 600/1000V and 1900/3000V
BS 6622 IEC 502: Extruded cross linked polyethylene Insulation, 3800/6000V upto 19000/30000V.
BS 6500 IEC 227: Insulated Flexible Cords.
BS 6207 IEC 245: Part 1 - Mineral Insulated Cables.
BS 6360: Copper Conductors for Cables.
BS 6234: Polythene Insulation and Sheath for Cables.
BS 2897: Aluminium Strip Armour for Cables.
BS 1442: Galvanized Mild Steel Wire for Armouring Cables.
BS 5308: Instrumentation Cables.
BS 4121: Mechanical Cable Glands.
BS 4579: Performance of Mechanical and Compression Joints for Cables.
BS 6081: Termination of MICC Cables.
BS 6121: Mechanical Cable Glands for Elastomer and Plastic Insulated Cables.
JIS C 3605 XLPE Cross-linked Polyethylene Insulated and Vinyl Sheathed Cable 600 V

1.03 Quality Assurance

A If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on current rating, voltage drop and short circuit current, as relevant, after taking into consideration:
1 type of cable and wire
2 ambient conditions
3 method of installation
4 the disposition of each cable relative to other cables.

B Calculate voltage drop and current ratings based on information given in supply authority's regulations or IEE Regulations, whichever are more stringent.

C All cables and wires shall be suitable for installation and continuous service in the ambient conditions described in Section 16010.

1.04 Products Delivery, Storage and Handling

A Each drum length of cable shall be allotted a distinct and separate reference number. This number shall appear on the test certificates covering the respective length of cable and shall also be clearly marked on the cable drum.

B The Contractor shall advise the Engineer upon delivery to site of each drum length, quoting the reference number, the test certificates shall be handed to the Engineer for examination and approval.

C All cables shall be delivered to site with the manufacturer's seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Engineer.

D The Contractor shall be responsible for the off-loading and handling of the cables on site, and shall ensure that cables are delivered to site on drums and properly protected against mechanical damage. Where lengths are cut from cables, the open cable ends shall be sealed.

Part 2 Products

2.01 Performance Requirements for Environmental Conditions

A The Contractor shall be aware of the need to supply and install all wire and cables for this Contract which are most suitable for the environmental conditions prevailing.

B All conductors shall have good fatigue resistance and not subject to breaks due to nicks or cuts when terminating.

2.02 Cables

A Unless otherwise specified, cables and wires of the following specified voltage ratings shall be used as indicated.

1	27000/36000 V rated cables	:	33000 V equipment circuits
2	8700/15000V rated cables	:	11000V equipment circuits
3	600/1000V rated cables	:	Main and sub-main distribution panels, motor control centres, circuits serving process equipment
4	450/750V rated cables	:	Final sub-circuit supplies for lighting, socket outlets, etc.
5	250V rated cables	:	Extra low voltage wiring, communication circuits where the maximum voltage is 50V.
6	All multicore cables shall be 600/1000V rated.		
7	450/750V rated cables	:	Clock system cables.
8	Special screened and	:	Music/paging system and C.A.T.V. system twisted pair conductors cables.

B General

1 Conductors shall be high conductivity copper, to BS 6360/IEC 228 unless otherwise indicated.
2 Copper conductors shall be stranded for 2.5 mm^2 and over.
3 Signal control cables shall have solid conductors.

4 Flexible cords shall have fine stranded conductors.
5 Conductor sizes shall be metric. Conductors with cross sectional areas smaller than those specified will not be accepted.
6 Insulation for each conductor shall be colour coded or otherwise identified as required by the Regulations. Colour coding shall be maintained throughout the installation.
7 The current carrying capacity of conductors has been determined in accordance with the specified regulations, the specified type of insulation and the expected conditions of installation.
8 All cables shall be as far as practicable, of one manufacturer only. All cables shall comply with the relevant IEC/BS.

C PVC insulated steel wire armoured and PVC over sheathed (PVC/SWA/PVC) cable.
1 Multicore PVC/SWA/PVC cable, 600/1000V grade, to BS 6346
2 Conductor: Annealed high conductivity copper, stranded, shaped and laid in an approved manner.
3 Armour: single layer of galvanized steel wires for multicore cables and aluminium wire or tape for single core cables.
4 Insulation: colour coded to BS 6746C.
5 PVC for sheath and insulation to BS 6746/ IEC 227.

D PVC Insulated PVC Sheathed (PVC/PVC) Cable.
1 To BS 6346, 600/1000V Grade.
2 Conductor annealed high conductivity copper, stranded, shaped and laid in an approved manner.
3 Insulation colour coded to BS 6746C.
4 PVC for sheath and insulation to BS 6746.

E PVC Insulated Wires
1 Single code cables shall be to BS 6004, rated 450/750V, with high conductivity copper conductors and PVC compound insulation. Colour coding shall be:

Red	:	Phase 1
Yellow	:	Phase 2
Blue	:	Phase 3
Black	:	Neutral
Green/Yellow or Green	:	Earth

2 Wires shall be continuous from outlet to outlet and no splice shall be made except within outlet and junction boxes. A separate neutral wire shall be provided for each circuit. Wires shall be left sufficiently long enough to permit making final connections.

F Mineral Insulated Cable
1 To BS 6207: Part 1, rated 600/1000V.
2 Cable shall comprise a pressure packed magnesium oxide insulation contained within a continuous soft ductile copper sheath and copper conductors embedded in the dielectric in standard formation.
3 Conductor insulation: neoprene sleeving retained by cone shaped beads beneath a fibre sealing disc. Each conductor shall be identified with regard to phase etc., by means of sleeving placed over the neoprene insulation.
4 Cable seals: seal cable with screw-in-pot type seals, with brass ring glands designed to accommodate the pot seal.
5 Terminals
a For cable up to 6 sq.mm: two screw pinching type.
b For cable over 6 sq. mm: grip lug type cable sockets.
c Saddles: brass, purpose made, two fixing screw type.

G Heat Resistant Cable
Tinned copper conductors insulated with silicone base rubber compound.

H Flexible Cable
1 To BS 6004, rated in accordance with manufacturer's tables.
2 Flexible cables subject to excessive heat shall be insulated with silicone base rubber compound with an overall varnished glass fibre braiding.

I 600/1000V rated XLPE Cable
1 To BS 5467, 600/1000V grade, designated XLPE/SWA/PVC and XLPE/AWA/PVC on the Drawings.
2 Conductors: Plain annealed copper to BS 6360
3 Cables shall comprise plain copper, stranded circular conductors insulated with an adequate thickness of extruded cross linked polyethylene (XLPE).
4 Conductors shall be laid up together and warmed circular with suitable performed fillers and warnings, bound with polythene terephthalate (PTP) tape and covered with an extruded PVC sheath minimum 1.4mm thick.
5 Multicore cables shall have steel wire armouring and extruded sheath of black PVC.
6 Single core cable shall have aluminium wire armouring.
7 Outer sheath of single and multicore cables shall be at least 2.5mm thick.
8 Design electrical stress at any point in the insulation shall not exceed 3 KV per mm.
9 Conductor screen: non-metallic comprising either semi-conducting tape or a layer of extruded semi-conducting material.
10 The electro-static screen over insulation shall comprise a non-metallic layer of semi-conducting material applied over the insulation and in direct contract with it, followed by a layer of copper tape applied helically over the semi-conducting layer to ensure close contact throughout.
11 Prevent void formation in insulation by careful control of its passage through the temperature graded water baths.

J Instrumentation Cables
1 To BS 5308 part 2, 300/500 V grade.
2 All instrument cables shall include a single wire armour with overall PVC sheath and shall include an overall screen of copper braid or aluminium foil.
3 Shielded Twisted Pair. Cables shall be colour coded individually screened twisted pair, multicore, 0.9 mm^2 copper conductor, PVC insulated, galvanized steel wire armoured with overall PVC outer sheath.
4 Unshielded Twisted Pair. Cable shall be colour coded twisted pair, multicore, 0.9 mm^2 copper conductor, PVC insulated, galvanized steel wire armoured with overall PVC outer sheath.
5 Coaxial Cable. Shall be suitable for local area network conforming to IEEE 802.3 10 Base 2. Thinnet coaxial trunk cable, 20 AWG (19 x 32). 50 ohm characteristic impedance, capacitance 83 pF/m.
6 Unshielded Twisted Pair (LAN). Cable shall be suitable for all local area network and structured cabling systems that require 100 ohm impedance, UTP cabling.

2.03 Sundries

A Joints
1 For conductors up to 16 mm^2 barrel type connectors with pinching screws, the whole shielded in porcelain or hard resistant materials are not permitted.
2 For conductors exceeding 16 mm^2 to be made with bakelite shrouds.

B Jointing Boxes

1 For use where intermediate joints are necessary on MICC mains cable and shall be suitably sized galvanized malleable iron adaptable box with glands and fixed base mechanical clamping connectors of approved design. For external use the jointing box shall be enclosed in a second galvanized box with glands.

2 For use on plastics and elastomer insulated cables of a type recommended by cable manufacturers having an inner box with provision for making a watertight seal into inner sheaths of cables, and an outer cast iron box with provision for making a watertight seal to cable outer sheaths, clamping cable armour and bending the armour across the joint. Where applicable suitable connections shall be provided to ensure electrical continuity of the cable screen is maintained.

C Compression Glands

For terminating plastic or synthetic cables to switchgear, switchboards, motor control centres and other equipment to BS 6121 and to approval.

D Cable Terminations

1 For plastics or synthetic rubber insulated cable with suitable brass compression glands, unless otherwise recommended by cable manufacturer. Glands for armoured or screened cables shall have suitable clamps therefore.

2 External compression glands shall have close fitting PVC shrouds.

3 Earthing for armouring and metallic sheaths shall have suitable brass or copper clamps, and copper strip conductor of selection not less than MEW Regulations or requirements and not less than 2.5 sq.mm.

4 Cables forming part of a LAN or structured cable system shall be terminated to floor plates or wall sockets compatible with the media interface connector specified for the particular network being used.

E Cable Sockets

1 Shall be correct size for type of cable.

2 Shall be sweating type, or an approved crimping type used with an approved crimping tool.

3 Sweating sockets for conductors 70 sq.mm and over : machined cast brass.

F Fire Barriers

1 Shall be purpose made, comprising a rigid fixed frame with adjustable seals and a suitable clamping device.

2 In fire compartment separation walls and floors they shall be same standard of fire resistance as wall or floor.

G Cable covers shall be to BS 2484. Concrete covers exceeding 300mm wide shall be reinforced.

H Pipe ducts shall be PVC or as indicated

I Solder shall be an alloy of lead and tin to BS 219 grade F or H, unless otherwise recommended by cable manufacturer.

J Cable sealing compounds shall be to BS 1858 and be approved by cable manufacturer; shall be tropical grade and shall be an oil-resisting compound where the difference in level between cable ends exceeds 6m.

K Cleats shall be cast aluminium, gunmetal or brass of approved type.

Part 3 Execution

3.01 Installation Generally

A Installation Cables Generally

1 Pull cable into position by hand, where possible using an adequate number of operative roller guides suitably positioned along cable length.
2 Obtain approval of pulling cables by winch or similar appliance.
3 When pulling by winch or the like, fit a suitable tension gauge into the haulage line between winch and cable. Pulling tension shall not exceed the limit recommended by the cable manufacturer.
4 Do not allow cable to twist or rotate about its longitudinal axis.
5 Lay 3-phase groups of single core cables in trefoil formation. If this is not possible obtain instructions.
6 Install cables to allow any one cable to be subsequently removed without disturbing the remainder.

B Bending r shall be as large as possible and not allow cable to bend to a radius less than that specified in IEE Regulations, relevant British Standard, or manufacturer's recommendation, whichever is largest.

C Underground Cables

1 Lay in concrete encased pipe ducts.
2 Cable duct size shall be as specified in the Drawings.
3 Run cables at least 300mm clear of other services, whether the latter run parallel or transversely to cable trench.
4 Run cables below intersecting piped services, unless the cable would be at a depth exceeding 2m, in which case seek instructions.

D Above Ground Cables

1 Protect exposed cables where they are likely to be damaged.
2 Run cables at least 50 mm from each other.
3 Run cables at least 150 mm from piped services.

E Jointing

1 Joints in wires and cables shall be avoided wherever possible. Joints in flexible cables and cords are not permitted. Where joints are unavoidable they shall be permanently accessible and made only in junction boxes.
2 Leave at least 150mm of free conductor at each outlet, switch point and pull box for the making up of joints or the connecting of fixtures and devices, except where conductors are intended to loop without joints through lamp holders, socket outlets and the like.
3 Complete joints and termination in the shortest time without interruption.
4 Do not commence jointing and terminations without approval, except where the work is in a dry, weather-proof place.
5 Do not make joints in wet or dirty conditions.
6 Make outdoor joints under a suitable tent or shelter.
7 Fill joints with compound filling in stages to allow the material to flow. Do not allow compound to cool to the point where re-heating is necessary.
8 Ensure sealing compounds are pouring at the correct temperature. Check compound

level and top up if necessary, after cooling.

9 Make intermediate joints on plastic and elastomer insulated cables in a joint box. Arrange to have each joint inspected by the Engineer before closing and filling.

10 On external joints on MICC cable fill outer box with jointing compound.

11 Joint cables in straight through joints and main cables in tees and other branching joints core to core.

F Terminations

1 Take cable cores through the termination box directly to equipment terminals, without crosses, unless impracticable and make off with sweated cast brass or hydraulically crimped sockets.

2 Sweat cable core solid 25 mm on each side of compound level and over-tape the exposed core insulation with two layers of PVC or other approved tape in appropriate phase colour, half-lapping the tape.

3 Plumb the cable sheath to the brass wiping gland, neatly lay back the armour wires over the gland and fix with an amour clamp effectively bonded to earth.

4 Cut back tape of tape armoured cables neatly below the wiped gland, thoroughly clean, secure with a suitable armour clamp and bond to the body of the terminating box with two soft copper tapes at least 70 mm^2 aggregate cross section.

5 Equipment to which cables are connected shall have blank, undrilled gland plates. Drill holes necessary for fitting glands.

G Cable Support

1 Run single core cables used to make up 3 phase circuits in trefoil formation, unless otherwise indicated, and support in cleats.

2 Adjust spacing of cable supports and fixing devices below the specified maximum as necessary to prevent cables sagging and where cables must deviate to pass obstructions.

3 XLPE/SWA/PVC and PVC/SWA/PVC cables run on cable trays, in trunking, in conduit, in duct or direct buried, as indicated.

4 PVC/PVC cables run on cable trays, in trunking, in conduit or in duct, as indicated.

H Heat Resistant Cables

1 In areas where a constant ambient temperature exceeding 55°C will occur, run all final sub-circuits and distribution circuits in heat resistant cable.

2 Make conversation from PVC cable to heat resistant cable with a fixed block connector housed and fixed into a conduit box or equal, except where the conversion of cable types emanate from a switch, ceiling rose or similar fixed connector accessory.

I Flexible Cables

1 Keep flexible cable to a minimum

2 Install out of sight.

3 Mechanical retainment shall not depend on electrical connections.

J Sealing Cables

1 Seal both ends of cables immediately after tests.

2 Seal MICC cables immediately after cutting to prevent hygroscopic action by the dielectric.

3 Seal aluminium sheathed cables with a metal cap plumbed to the sheath.

4 Seal plastic sheathed cables with a plastic cap embracing the wires and outer sheath.

5 Mark cable ends in accordance with the relevant BS.

3.02 Installing Cable in Cable Trays

A Generally

1 Install cables on trays in a single layer, unless otherwise specified.

2 Use purpose made straps or saddles to maintain cables in a neat regular disposition.

3 Secure cables with load bearing cleats securely fixed to the tray, where trays do not directly support the cables.

4 Space cleats saddles and straps at maximum centres recommended in supply authorities regulations.

END OF SECTION 16120

Section 16140

Wiring Devices

Part 1 General

1.01 Description of Work

This Section shall include all labour, materials, equipment, appliances and accessories necessary for the complete performance of all switches, socket outlets etc., in accordance with the Specifications and Drawings.

1.02 Applicable Standards Referred In This Section

Applicable standards referred to in this section:

BS 88:	HRC Fuses
BS 546:	Specification Two pole and earthing-pin plugs, socket-outlets and socket-outlet adaptors.
BS 800:	Specification for radio interference limits and measurements for household appliances, portable tools and other electrical equipment causing similar types of interference.
BS 1363:	13A Plugs, Switched and Unswitched Socket Outlets and Boxes.
BS 3456:	Specifications for safety of Household and similar electrical appliances
BS 3676:	Switches for Domestic and Similar Purposes (for fixed or portable mounting).
BS 4177:	Cooker Control Units Rated 30 A and 45 A, 250 V Single Phase supply.
BS 4343:	Industrial Plugs, Sockets Outlets and Couplers for ac and dc Supplies.
BS 4662:	Boxes for Enclosure of Electrical Accessories.
BS 5419:	Fuse Switches and Switch Fuses.
BS 5733:	General Requirements for Electrical Accessories.

Part 2 Products

2.01 General

All individual items of materials shall be of the same make throughout the project unless specifically approved by the Engineer.

2.02 Outlet Boxes

A Outlet Boxes

1 Galvanized or sheradized one piece pressed steel, sizes and designs shall suit devices to be fitted.

2 In fuel tank room and battery room: explosion proof.

B Exterior Mounted Boxes

Totally sealed to ensure water tightness.

2.03 Switches

A Lighting Switches shall be to BS 3676 and:

1 Grid fixing type rated 10 A unless specified otherwise. The grid shall be provided with suitable earthing terminal.
2 Recessed with concealed conduit surface pattern elsewhere.
3 Quick make slow break type.
4 Single pole, double pole, one way or two way, as indicated.
5 Matt chrome finish in all areas unless noted otherwise.

B Waterproof Switches
1 To be operated by means of a brass disc.
2 To be watertight and metal clad.

C Switch Plates
1 Where two or more switches are grouped together and connected to the same phase, multi-gang devices and common plates shall be used.
2 Rectangular, chrome finished switch plates shall be used in all areas unless specified otherwise. The rocker shall be insulated with ivory finish.

D Double Pole Switches
1 The double pole switches shall be with indication neon lamps and shall be rated 20 A as specified.
2 The face plate shall be of matt chrome and shall be engraved 'WATER HEATER', 'WATER COOLER' etc. as specified.

2.04 Socket Outlets

A General purpose Socket Outlets
1 To BS 1363.
2 3 rectangular pin (2P+E) shuttered, with combined switch, rated 13A, 250V.

B 15A Socket Outlet
1 To BS 546.
2 3 round pin (2P+E) shuttered switched pattern complete with plug.

C Weather-proof Sockets
1 13A Sockets: to BS 1363, 3 rectangular pins, unswitched type.
2 15A Socket: to BS 546, 3 round pins, unswitched type.
3 To be complete with weather-proof plugs.
4 Plugs for 5 A and 13 A sockets fused type with single pole cartridge fuse link of same rating as plug.
5 Plugs for 15A sockets unfused.
6 Sockets and Plugs:
a To have minimum IP44 grade protection;
b Housing parts: brass or pressure die-cast finished in grey hammered stove enamel;
c Plugs shall have cable grips with rubber compression rings and there shall be rubber gasket between plug and socket to ensure weather tightness.
d Sockets shall have screw on caps that close tight on socket when plugs is not inserted.

D Socket outlet plates shall be matt chrome finish in all areas unless specified otherwise readily identifiable.

2.05 Pushbuttons

A ON/OFF PATTERN PUSHBUTTONS for lighting control to have shrouded buttons coloured green for "ON", red for "OFF".

B Operating Mechanism
1 To be contained in the device box.
2 Operating voltage shall be 230 V.

C Multiple Pushbuttons - where two of more buttons occur in one position they shall be contained in one case and each shall be appropriately labelled to indicate its function.

2.06 Shaver Socket Outlets

A All shaver socket outlet units shall comply with BS 3456 and IEC 335.

B Shaver units shall be flush pattern with white moulded insert in matt chrome plate engraved 'Shaver Only' and be suitable for installation in bathrooms, incorporating a double wound isolating transformer to provide an earth free supply.

C Units shall incorporate primary winding circuit protection in the form of a self-resetting thermal overload device.

D Units shall incorporate on 'ON/OFF' switch with red neon indicator together with a selector switch for 20 VA load capacity at 230 V and 115 V.

E Units shall incorporate two pin shuttered outlet configuration and have terminals to accept 2.5 mm^2 conductors.

F Unit outlet boxes shall be a minimum of 45 mm deep, rust-proofed by galvanizing of equal finish and complete with a brass earthing stud secured to the back of the box.

2.07 Cooker Control Units

A Cooker control units incorporating a 30 A double pole switch and 13A, 3 pin switched socket outlet and neon indicator lights for both cooker and socket.

B The cooker control unit shall be flush mounted.

2.08 Dimmer Switches

A Dimmer switches shall be 230 V, rated as indicated on the drawings, suitable for dimming of incandescent and fluorescent lamps.

B Switch control knobs shall be matt chrome finish or special finish.

C All switches shall incorporate in design features, all necessary screening and circuitry to suppress radio interference in accordance with BS 800.

D All switch module sizes provided shall be suitable for, and installed within, 35mm deep standard BS boxes with internal metal dividers to segregate different circuits as necessary.

2.09 Disconnect Switches ND Switch Fuses

A Generally
1 To be metal clad with front operated handles interlocked with switch fuse case to prevent opening switch in the "ON" position.
2 Switch shall have "ON/OFF" indication and means of locking in "OFF" position.

B Fuse Switch and Switch Fuses
1 To BS 5419.
2 Fuses to BS 88 bolted type, class Q1, certified for 415V and AC 80 Duty, rated as indicated.
3 Fused switch carriages withdrawable type.
4 Fuse switches ASTA certified to 50 KA.

C Disconnect Switches of Isolators
1 Same design as switch fuses, with solid copper links in place of fuses.
2 Single pole and neutral, or triple pole and neutral.
3 Ratings, as indicated.

2.10 Junction, Pull and Terminal Boxes

A The Junction Box shall be completed with a terminal block suitable for connecting up to 10 mm^2 copper conductor (phase, neutral and earth) and an all insulated moulded white cover plate with removal covers.

B The cover plate shall be raised for connecting outgoing cable.

Part 3 Execution

3.01 Installation of Outlet Boxes

A Location of Boxes
1 Determine exact location of boxes on site and obtain the Engineer's approval before commencing installation.
2 Make allowance for overhead pipes, ducts, variations in arrangement, thickness of finish, window trim, panelling and other construction when locating boxes.

B Mounting Heights
1 Where mounting height is not shown or specified, obtain instructions.
2 Boxes for similar equipment mount at uniform heights within same or similar areas.

C Fixing
1 Fix outlet boxes securely.
2 Fix exposed outlet boxes to permanent inserts or lead anchors with machine screws.

3.02 Installation of Switches

Lighting Switches near Door:
1 Located at the strike side of the door.
2 Plates shall be installed with all four edges in continuous contact with finished wall.
3 Plates shall be installed with an alignment tolerance of 1.5 mm.
4 All switch assembly louvered plates shall have their earthing terminal connected to the earth terminal attached to the switch box by an insulated 2.5 mm^2 protective conductor.

3.03 Installation of Junction, Pull and Terminal Boxes

A Generally:
1 Fix junction, pull and terminal boxes where indicated and where required to facilities pulling of wires and cables and connection of future appliances.
2 Locate boxes as inconspicuously as possible, but accessible after work is completed.

B Pull Boxes
Fix at maximum 10 m spacing and to limit the number of bends in conduit to not more than two 90° bends.

3.04 Testing

A Test all switches, socket outlets etc. for correct polarity and continuity of conductors in the presence of and to the entire satisfaction of the Engineer.

B Carry out live phase to earth loop impedance tests at all switches and socket outlets with an approved earth loop impedance tester to the entire satisfaction of the Engineer. Ensure that all device plate have satisfactory earth continuity to the protective conductor system.

C Test all 13 A socket outlets for instantaneous tripping of associated distribution board current operated earth leakage circuit breaker using testing equipment, approved by the Engineer.

END OF SECTION 16140

Section 16150

Induction Motors

Part 1 General

1.01 Description

This Section outlines the electrical requirements for squirrel-cage induction motors.

1.02 Submittals

A In addition to information to be included in the shop drawings as specified in Section 01300, shop drawings shall include the following:
1 Motor locked rotor and full load currents.
2 Power factors and efficiencies at full load, three quarters load and half load.
3 Motor housing material, winding material, NEMA Design letter, NEMA Code Letter, ambient temperatures and maximum elevations in which motor is designed to operate continuously, service factor, NEMA insulation Class, temperature rise, type of enclosure, voltage, bearing life and dynamic balance; all of which shall comply to the requirements of the specifications.
4 Nameplate data.
5 Dimensions, weights and mounting details of motors
6 Motor construction details
7 Speed torque/current at 100 percent volts
8 Wiring diagrams, internal and typical external connections.

B Current Data. Submit eight copies of field recorded current data which shall indicate the full load current for each motor, and current rating for the overload relay in each motor starter and controller.

Part 2 Products

2.01 General

Motors shall be supplied by the manufacturer of the driven equipment as specified in this section, and specifically outlined in the driven equipment specifications. The motors shall be completely fabricated, assembled, checked and tested at the factory in accordance with NEMA MG-1/IEC 60034, 00072, 60085/ JIS B 8103, 8301 - 8306, 8310 – 2827/ JIS A 8604/ JIS B 8313, 8314, 8318, 8319, 8322, 8323, 8324, 8325/ JIS B 8330, 8340, 8341, 8345, 8346/ JIS B 8331, 8342/ JIS C 9603/ JIS M 7613.

A Motor Ratings.
1 Torque and slip characteristics shall be as recommended by the manufacturer of the driven equipment and as specified. Motor manufacturer shall confirm motor capability to the specifications.
2 Motors shall operate continuously and satisfactorily in ambient temperatures from minus 10 degrees C to plus 55 degrees C at a maximum elevation of 1000 m without exceeding nameplate power rating.

3 Motors shall have high power factor. Motors with the following minimum power factors, at full load, shall be provided:
   a Minimum power factor of 0.82 shall be provided for motors up to 11 kW.
   b Minimum power factor of 0.83 shall be provided for motors from 11 kW through 37 kW.
   c Minimum power factor of 0.85 shall be provided for motors from 37 kW through 75 kW.
   d Minimum power factor of 0.87 shall be provided for motors from 75 kW through 150 kW.
   e Minimum power factor of 0.88 shall be provided for motors from 150 kW through 300 kW.
   f Minimum power factor of 0.89 shall be provided for motors larger than 300 kW.

4 Motors shall have high efficiency. Motors with the following minimum efficiencies, at full load, shall be provided:
   a 84 percent minimum efficiency shall be provided for motors through 4 kW.
   b 87.5 percent minimum efficiency shall be provided for motors from 4 kW through 11 kW.
   c 91 percent minimum efficiency shall be provided for motors from 11 kW through 30 kW.
   d 93 percent minimum efficiency shall be provided for motors from 30 kW through 93 kW.
   e 94.1 percent minimum efficiency shall be provided for motors larger than 93 kW.

5 The motors shall be sized so that the brake power does not exceed 90 percent of the full load nameplate power unless otherwise indicated in the driven equipment specifications.

6 The motor must be able to accelerate the driven machine from zero to full speed at 90 percent of rated voltage without overheating.

7 The maximum locked rotor kVA code letter for motors smaller than 11 kW shall not exceed the requirements for NEMA Design B motors. The maximum locked rotor kVA code letter shall be Code G for motors 11 kW through 187 kW unless otherwise indicated. The maximum locked rotor kVA code letter shall be Code F for motors 224 kW and higher.

8 All motors shall be insulated and braced for full voltage across the line starting regardless of the starting method used.

9 Motors 0.37 kW and larger shall be NEMA MG1-1.16 Design B and shall have NEMA MG1-1.65 Class F insulation.

10 The maximum temperature by resistance for each of the various parts of the motor shall not exceed the values of the NEMA MG1-1.65 Class B insulation system as indicated in NEMA MG 1-12.42.

11 All open and TEFC motors 187 kW and less and all vertical motors shall have a 1.15 service factor. All horizontal motors larger than 187 kW shall have a 1.0 service factor.

B Motor Construction.

1 Enclosures for induction motors shall be approved for the installation and as indicated. The enclosure types shall be one of the following as outlined in the driven equipment specifications unless otherwise indicated.
   a Totally-enclosed explosion-proof.
   b Totally-enclosed fan cooled.
   c Totally-enclosed non-ventilated.
   d Weather-protected, Type I.
   e Weather-protected, Type II.

f Drip-proof fully guarded.
g Drip-proof.
h Splash-proof.
i Open.

2 All motors mounted outdoors shall be fitted with appropriate sunshade to maintain motor environment at ambient temperature.

3 Enclosures for motors larger than 187 kW installed outdoors shall be NEMA weather protected Type II enclosures with top air intake, and removable galvanized steel air filters. Motors larger than 187 kW installed indoors shall be equipped with open drip-proof guarded enclosures unless otherwise indicated.

4 Provide epoxy vacuum pressure impregnated (VPI) motors when indicated in the driven equipment specifications. The windings in squirrel cage induction motors shall be completely filled with an insulating resin epoxy which also forms a protective coating. The stator windings on all motors, except 56 and 140 frame sizes, shall be vacuum pressure impregnated with an epoxy or shall be epoxy encapsulated. 56 and 140 frame size motors shall have extra dips and bakes of Class F varnish.

5 Housing, end brackets and all outside components shall be cast iron except WP II or open drip-proof enclosures which may be fabricated steel.

6 A condensate drain hole shall be provided on all non-explosion-proof enclosed motors. The drain hole shall be provided in each end bracket on horizontal motors. A single drain hole shall be provided in the lower bracket of vertical motors. Open motors shall be self draining. A U.L. approved breather/ drain shall be provided on all explosion-proof motors.

7 The motors shall be equipped with terminal boxes for all conduit and wire connections as required.
   a The terminal boxes shall be properly sized, diagonally split, cast iron, and rotatable in 90 degree steps. Provide a gasket between the box and motor frame and between the box and the cover. Terminal boxes shall be attached to the motor frame with grade 5 zinc plated and chromated steel bolts or cap screws. All terminal boxes shall have threaded holes for conduit entrance or cable glands.
   b Terminal boxes on motors larger than 187 kW may be fabricated steel and do not have to be rotable or diagonally split. If the terminal boxes are not rotatable, it shall be so indicated on the shop drawings.

8 The castings shall be coated with a red-oxide zinc-chromate primer, and finished with a corrosion resistant epoxy coating. All fabricated steel enclosures shall be coated on all inside and outside surfaces except shafts and register fits.

9 Provide stainless steel fasteners and nameplates of ample size with clear numerals and letters.
   a Nameplates shall indicate the manufacturer, serial number, model number, type, power, phase, hertz, volts, design, full load amperes, locked rotor code letter, service factor, speed, insulation, class, temperature rating, information required by NEMA MG 1-10.38 and other essential data.
   b Nameplate data shall be in the English language and units.
   c Nameplates shall be secured to the motor frame with corrosion resisting pins in accessible locations.

10 Earth lugs shall be provided in all main motor terminal boxes for earthing.

11 All motors shall have copper windings.

12 Anti-friction bearings shall be grease lubricated except for vertical, high thrust motors which may require oil lubrication.
   a Grease lubricated bearings shall include accessible fittings for in-service, periodic re-lubrication.
   b Oil lubricated bearings shall be a reservoir type with a sump for settling foreign matter, accessible and exterior fill and drain plugs and a visual oil level indicator

with maximum and minimum indicator levels.

c Horizontal, direct connected motor bearings shall be designed for 1 year minimum B-10 bearing life at NEMA minimum V-belt criteria for the rating.

d Horizontal, V-belt connected motor bearings shall be designed for 3 year minimum B-10 bearing life for the application V-belt drive or 1 year minimum B-10 bearing life at NEMA minimum V-belt criteria whichever is more restrictive.

e Vertical motor bearings shall be designed for 2 year minimum B-10 bearing life at design operating thrust. At maximum operating thrust, B-10 life shall not exceed 30 percent of the static deformation limit. Motor shall be designed for 30 percent momentary upthrust capacity except 3000 RPM units which must have 30 percent continuous upthrust capacity. Any system which exceeds 30 percent upthrust must be designed for continuous upthrust at one year B-10 bearing life.

f Pre-lubricated, double shield bearings are acceptable only on single phase and 56 frame motors.

g Sleeve bearings for motors larger than 187 kW shall be ring-lubricated, split-sleeve spherically seated bearing of a design permitting easy removal for repair or replacement. Reservoirs shall be equipped with "Trico Opto-nmatic" or approved equal, constant-level oilers. All oil reservoirs shall drain completely. Sleeve bearing motors shall have a permanent indicator on a main structural member of the motor showing the magnetic center.

13 The dynamic balance of motors built in frame size 143 and larger shall be 0.001 inches total amplitude or peak to peak displacement.

14 Accessories shall include the following:

a Space heaters when required in the driven equipment specifications. The space heaters shall be 240 volt, 1 phase, and adequately sized to raise the temperature inside the motor to a minimum of 6 degrees above ambient.

15 All three phase motors, rated 11 kW and higher, shall have six winding leads brought out into the terminal box to allow connection for star-delta type reduced voltage starting.

16 Accessories for motors 75 kW and larger shall include the following in addition to the above accessories:

a Two sets of non-linear, resistance temperature detectors, "PTC thermistors" or equal, shall be embedded in the windings. The detector relays shall have one normally open and one normally closed contacts, and shall be mounted in box with cover on the motor frame. One relay shall have a normally open contact to actuate an alarm when the temperature rise reaches 15 degrees centigrade below the motor insulation temperature rating when operating in an ambient temperature of 55°C. One relay shall have the a normally closed contact to de-energize the motor controller holding coil when the temperature reaches the motor insulation temperature rating when operating in an ambient temperature of 55°C. The detectors shall protect the motor against overheating caused by overloads, loss of cooling medium and single phasing.

b Space heaters, 2440 volt, 1 phase, and adequately sized to raise the temperature inside the motor to a minimum of 6 degrees above ambient.

c All of the above accessories shall have wires brought out to a terminal box or boxes other than the main motor power terminal box.

17 Accessories for motors larger than 187 kW shall include the following in addition to the above accessories:

a For motors with oil sump lubrication systems, a cold starting oil immersion heater shall be provided with an auxiliary temperature switch preset for a temperature which will allow safe starting.

b A full thermostatically controlled immersion heater shall be provided if the motor is not capable of maintaining proper oil viscosity while running at the minimum

specified operation ambient temperature.

c Immersion heaters may be eliminated entirely if the motor is suitable for start and run at temperature extremes specified. A summer/winter oil change is allowed.

d As required, motors shall be provided with surge capacitors. Surge capacitors shall be mounted in the main motor terminal boxes and connected to the motor leads by the motor manufacturer. Adequate space shall be provided in the terminal boxes for stress cone termination.

e High thrust vertical motors shall have a motor mounted dial temperature indicator with a dual normally open/normally closed temperature switch for the thrust bearings. All 3000 rpm motors shall have this device for both thrust and guide bearings. Temperature switch shall be either adjustable or factory sized for the maximum allowable lubricant operating temperature. The sensing probe of the device shall be in contact with the bearing outer race or bearing mount.

f All of the above accessories, except the surge capacitors, shall have wires brought out in a terminal box or boxes other than the main motor power terminal box.

18 Motors shall have a guaranteed maximum noise level in accordance with NEMA MG1-12.49 for integral horsepower motors and NEMA MG1-20.50 for large motors, except where more restrictive requirements are outlined in other Sections of the Specifications.

Part 3 Execution

3.01 General

For the motors:

1 Provide power, control, alarm and earthing installations for all motors as indicated and required.

2 Check the connections and provide correct rotation for all motors.

3 Record the full load current to each motor, and the overload relay rating in each motor starter for the certified data submittal.

4 Provide the wiring for heaters in the motor frames and the required controls to de-energize the heater when the motor operates.

5 Provide the required wiring for all control equipment that shall be furnished and installed by other Sections of the Specifications.

6 Install the control stations on steel stanchions and building structures near motors as shown on the Drawings.

7 Field damaged factory finish on equipment shall be touched-up with paint that is equal in quality and color to the original factory finish.

3.02 Factory Tests

A All Motors shall be given a standard commercial test as defined by NEMA MG 1-12.51 and IEEE 112a and b.

B All motors 75 kW and larger shall be given complete tests as defined by IEEE 112 A and B. Report of test shall include data on IEEE 112 Form A2, as applicable to the motor tested. Test shall confirm the following:

1 Service factory temperature

2 Efficiency

3 Torque

4 No load, full voltage noise level for all 3000 rpm motors and all others 373 kW and up.

5 No load, full voltage vibration level.

C Noise tests shall be determined by measurement in accordance with the latest revision of IEEE-85, Test Procedure for Air Borne Noise Measurements and Rotating Electrical Machinery. The motor shall be operating during test on rubber at no load with rated voltage and frequency.

D Vibration Tests shall be per NEMA MG 1-12 0.6 and MG 1-20.53 except 3000 RPM motors greater than 187 kW and with sleeve bearings shall be tested at full nameplate horsepower load and temperature.

E All testing, other than lock conditions, shall be at full voltage ±5 percent.

3.03 Field Checks

A Motor installations shall be complete and correct.

B Operation tests shall be performed to observe that motors start, run and stop satisfactorily under design load.

END OF SECTION 16150

Section 16320

Power Transformers

Part 1 General

1.01 Description

A. Transformers shall be oil-immersed, oil naturally cooled, double wound, core type or epoxy-resin mould type, suitable for indoor outdoor installation.

B. The transformers shall be mounted on a steel structure fixed to the concrete slab.

1.02 Standards

A. Transformers shall be manufactured and tested to comply with BS 171.

B. Transformer shall be complied with the following standards.

IEC 60060	High-Voltage Test Techniques
IEC 60071	Insulation Co-ordination
IEC 60076	Power transformer
IEC 60137	Insulating Bushings for Alternative Voltage above 1000 V
IEC 60214	On-load tap-changers
IEC 60354	Loading guide for oil-immersed power transformer
IEC 60542	Application guide for on-load tap-changers
IEC 60551	Determination of transformer and reactor sound levels
IEC 60616	Terminal and tapping markings for power transformer
JIS C 2320	Electrical insulating oils
JIS C 4304	6kV Oil-immersed distribution transformer
JEC 204	Power transformer

C. Transformer shall be tested to comply with IEC 60060-1, IEC 60076-2, IEC 60076-3 and IEC 60270.

1.03 Quality Assurance

The manufacturer shall have quality control conforming to the relevant parts of ISO 9000. Proof of compliance verified by an independent inspection agency shall be submitted with the offer.

Part 2 Products

2.01 Ratings

A. Transformers shall be rated as described in the Particular Specifications.

B. Ventilation pattern shall be oil natural, air natural, ONAN for the oil immersed type.

C. Transformer short-circuit impedance shall be 5.0 percent.

2.02 Transformer Duty

The transformers shall be capable of supplying predominantly motorized loads with ratings up to 400 kW. The Contractor shall furnish the transformer manufacturer with the single line diagrams indicating the types and sizes of the loads connected to the transformers

2.03 Voltage Ratio

A. The voltage ratio shall be referred to the particular specification and the drawings.

2.04 Winding Connections

A. The windings shall be connected HV delta, LV star in accordance with vector group reference Dyn 11 of IEC 60076.

B. The star point of the secondary windings shall be brought out through the tank and suitably terminated in a separate housing for solid earthing in addition to the neutral connection.

C. Provision shall be made for current transformers for fault protection to be mounted on both neutral and earth connections.

2.05 Tappings

A. Adjustable taps shall be provided on the primary windings for variation from +7.5% to -7.5% in 2.5% steps.

B. Tapping control shall be by means of a manual, externally operated, off-circuit tapping switch complete with tap mechanical tap position indicator.

C. Locking facilities shall be provided for the switch such that the lock can be inserted only when the switch is in a definite tap position.

D. The tap changing selector shall be located below the oil level inside the tank and the selector operating rod shall be external outside the tank.

2.06 Construction

A. The core shall be constructed from cold rolled steel laminations manufactured to BS 6404. The laminations shall be insulated from each other by means of a suitable temperature resistant oil proof coating.

B. The windings design and construction shall provide adequately designed and located coolant flow ducts so that possible hot spots are eliminated. Windings shall be braced to withstand dynamic stress due to short circuit conditions. Full details shall be provided of arrangements for taking up or eliminating coil shrinkage during service.

C. The core and winding shall be designed so that the iron loss is at a minimum but the ratio of copper loss to iron loss shall be in accordance with an economic design and the manufacturer shall state the ratio used.

D. The arrangement of internal connections shall be such that the transformer core and windings may be lifted bodily from the tank without disturbing the cable boxes or insulators.

E. The transformer tanks shall be constructed from high grade steel with electrically welded seams. The structure of the tank shall enable it to be handled whilst filled with oil and shall be pressure tested to 70 kN/m^2.

F. Tank shall be mounted on a steel structure fixed to the concrete slab.

G. The tank shall incorporate lifting eyes suitable for the mass of the transformer and oil.

H. The tanks shall be provided with external cooling tubes or fins to provide natural cooling under the climatic conditions.

I. All terminals shall pass through oil tight insulating glands into respective disconnecting terminal chambers to facilitate cable testing.

J The tanks shall be non-breathing hermetically sealed type.

K. The tank covers shall be of such construction as will prevent the accumulation of moisture and shall be bolted to a flange on the tank top to form a weather-proof seal. All gaskets shall be of synthetic rubber and cork compositions. The tank tubes and all steelworks shall be shot blasted internally and externally before painting and a rust inhibiting paint shall be applied to both external and internal surfaces before applying a final finish. The exterior shall be given an additional coat on site of a durable oil and weather resisting paint. The manufacturers paint system shall be submitted to the Engineer for approval.

L. The design and construction of the transformer core winding and tank shall ensure that the noise level at full load is kept to the minimum consistent with economic design. The tank shall be reinforced or braced where necessary to reduce the noise level.

M. The complete transformer arranged for service shall be capable of withstanding the specified impulse voltage on the HV windings.

N. All windings winding terminals and connections shall be fully immersed in oil under all operating conditions and materials shall be suitable for this duty and not be subject to deterioration from contact with oil.

O. The windings shall be thoroughly dried out under vacuum at the manufacturer's works and shall be delivered to Site filled with oil to the normal level and ready for service.

2.07 HV And LV Terminations

A. The HV cable box shall be designed for air insulated dry type termination suitable for 3 core XLPE, double steel tape armour, PVC served, 70 mm^2 copper cables.

B. The HV cable box shall be mounted on the top of the transformer tank and bushings arranged for cables approaching horizontally, similar to the existing transformers.

C. The bushings shall be replaceable without having opened the tank cover.

D. The LV cable terminations shall consist of 3 phase and 1 neutral bushings mounted in an air insulated cable box suitable for receiving 16 x 500 mm^2 one core XLPE AWA PVC cables.

E. The LV cable entry box shall also be mounted on the top of the transformer and bushings arranged for cables approaching horizontally similar to the existing transformers.

F. The cable boxes on the transformer shall be suitable for the above HV and LV cable arrangements and shall be complete with all necessary fittings, grip type cable lugs of specified size, compression glands, armour clamps, bonding straps, tapes etc.

2.08 Fittings

In addition to the standard fittings as per BS 171, the transformer shall be fitted with the following:

1. Thermometer pocket for oil temperature.
2. 200 mm diameter dial type oil thermometer with maximum reading pointer and fitted with 2 No. sets of adjustable contacts for alarm and trip functions.
3. Rating and diagram plate (to comply with BS 171) of a durable and non-corrodible material.
4. Oil level gauge clearly visible from ground levels.
5. Pressure relief valve with alarm contacts.
6. Tank filling and drain valves.
7. Separate neutral earthing terminal with independent access cover enclosed with weather-proof housing for the restricted earth fault current transformer.
8. Earthing terminal for tank.
9. Marshalling box for over temperature and pressure alarm and trip contracts.
10. Large identification labels shall be affixed to each transformer identifying their primary circuit breaker.
11. Lifting and jacking lugs.

Part 3 Execution

3.01 Earthing

A. The transformers shall be connected to the earth bars installed inside the substation.

B. All metallic enclosures, tanks, fittings and accessories must be bonded together and connected to the earth bar.

C. The transformer secondary winding star point/neutral shall be connected to earth.

3.02 Transformer Installation

A. The transformer tank shall be mounted as previously stated.

B. The rollers shall run on existing rails embedded in the concrete floor of the transformer bay. The Contractor shall note the dimensions of the existing rails, spacing and rollers and coordinate same with the transformer supplier.

C. As an alternative, the existing rails may be removed and new rails fitted. Should this option be adopted, the Contractor shall include for all associated building works and repairs to concrete floor finishes.

D. HV and LV cables to the transformers shall be supported on galvanized, heavy duty cable ladders.

3.03 Testing

A. Type and routine tests shall be carried out in accordance with BS 171/IEC 76.

B. Routine tests shall be carried out in accordance with BS 171, including:

1. Measurement of winding resistance
2. Voltage ratio measurement
3. Check of voltage vector relationship
4. Measurement of impedance voltage and load losses
5. Measurement of no-load loss and current
6. Insulation resistance measurement
7. Separate-source voltage withstand test
8. Short-time current test
9. Short circuit current test
10. Power frequency voltage withstand test
11. Lightning impulse withstand test
12. Induced over voltage withstand test
13. Acoustic sound level test
14. External construction inspection
15. Check of oil leakage.

C All the above tests shall be carried out at the transformer manufacturer's factory. Only tests 6, 9 and 10 need to be repeated on site.

D. Type Tests
1. Temperature rise test on the transformer.
2. Impulse withstand test on the transformer shall be applied on the HV winding leg only and shall be in accordance with BS 923 and BS 171.

E. Short circuit test need not be performed if already performed on a transformer of the same rating and similar construction. Type test result shall be made available.

END OF SECTION 16320

Section 16410

Power Factor Correction Equipment

Part 1 General

1.01 Description

Provide all labour, materials, equipment, services and accessories necessary to furnish and install power factor correction equipment operating on electrical power systems up to 600 V ac 50 Hz, complete and functional, as indicated in the Contract Documents and as specified herein and to coordinate the work with all other services affecting the work of this section.

1.02 Reference Standards

Applicable standards referred to in this section:

BS 88	:	Cartridge fuses for voltage up to 1000 V ac
BS 1650	:	Capacitors for connection to power frequency systems
BS 5424	:	Control gear for voltage up to 1000 V ac
IEC 70	:	

1.03 Quality Assurance

The suppliers manufacturing facility shall be certified to the ISO-9000 series of standards from the International Standards Organization.

Part 2 - Products

2.01 General

A. Power factor improvement equipment shall be provided in LV feeder panels. Correction shall be automatic and be capable of correcting the power factor to within the range 0.9 lagging to unity as required by the design.

B. Individual power factor capacitors shall be provided for the larger motorized drives, as indicated on the single line diagrams.

C. All capacitors must be arranged so that they are connected to the LV feeder panels in stages. These stages shall be sized to prevent system over-voltage during light loads conditions.

2.02 Capacitors

A. Capacitors shall comply with BS 1650 and shall be of a dry metalized film construction, containing no liquid and must have low losses (typically 0.5 W/kVAr).

B. Each capacitor shall be housed in a sealed container and be fitted with a fail-safe, pressure sensitive disconnect device.

C. Each capacitor shall be equipped with suitable discharge resistors to reduce the voltage to

less than 50 V in one minute, or less, after supply disconnection.

D The capacitors shall be housed in a metal enclosure, forming part of the LV feeder panels. The enclosure size should allow enough space and cabling etc., for at least one additional capacitor unit to be fitted at a later date.

E. Provision shall be made to ensure that a connection point is available for a series connected, de-tuning reactor in case of problems with harmonics.

F. The equipment must comply with BS 800 with respect to electrical interference.

G. The capacitors shall be protected by a fused switch-disconnector or circuit breaker on the LV feeder panels.

H. The capacitor manufacturer must recommend the maximum fuse or circuit breaker that will ensure the protection of each capacitor bank.

I. All power and control cables used within the capacitor bank enclosure must be in accordance with BS 6231 Type BK.

2.03 Control and Protection

A. The switching of capacitor units on each section of switchgear must be controlled by a single relay.

B. The relay shall:
1. have stage indication;
2. be fitted with hand/off/auto controls for each capacitor unit;
3. have a time delay between the switching of stages;
4. be capable of switching all fitted capacitor units and have provision for switching at least one additional capacitor unit;
5. be fitted within the capacitor bank enclosure;
6. have provision to switch all capacitors out of circuit when the essential alternator is operating, by operation of a remote relay contact.

C. Switching contactors must have a minimum duty category AC4 to BS 5424 and a minimum current rating of 1.3 x the current consumed by the capacitor bank. (See BS 1650).

D. Due account must be taken of system harmonics when selecting capacitors.

Part 3 Execution

3.01 Documentation

Documentation shall be provided detailing:
1. Type test certificate
2. Routine test certificate
3. Maintenance requirements
4. Fault diagnosis
5. Parts list with part numbers and recommended spares
6. Commissioning instructions

END OF SECTION 16410

Section 16425

Switchboards and Motor Control

Part 1 General

1.01 Description of Work

This Section shall include all labour, materials and accessories for the complete performance of all Main Low Tension Switchboards, Main Switchboards, Submain Switchboards, Motor Control Centres and Motor Control in accordance with the Specifications and Drawings.

1.02 Reference Standards

Applicable standards referred to in this section

BS 88, IEC 269	Cartridge Fuses.
BS 142, IEC60255-6	Electrical Protective Relays.
BS 159, IEC 60439-1	Busbar & Connection.
BS 162, IEC 60947-2	Electrical Power Switchgear.
BS 3938, IEC 60185	Current Transformers.
BS 4794, Pt.2 IEC 60947-4-1	Control Devices.
BS 37 Pt.1	Electricity Meters General.
BS 89, IEC 60051	Direct Acting Indicating Elect. Measuring Instruments.
BS 5685, IEC 51	Electric Meters.
BS 5420, IEC 529	Degree of Protection of Enclosures.
BS 4752, IEC 60947-2	Switchgear and control-gear.
BS 5419 IEC 60947-2	Air Break Switches.
BS 5424, Pt.1 IEC 60947-4-1	Contactors.
BS 5472, IEC 60947-2	Low Voltage Switchgear and Control-gear.
BS 6231	PVC Insulated Cables for Switchgear.
BS 5486, IEC 60439	Factory Built Assemblies LV
IEC 60947-3	Low Voltage Motor Starters

1.03 Submittals

A Shop Drawings: All submittals in accordance with 01300.

1 Submit dimensional drawings of all the switchgears, switchboards and motor control centres, including sections and elevations, showing the following:

a) Arrangement of all components, instruments, indication and dimensions of all busbars.
b) Positions and method of fixing cables and boxes.
c) Location of Terminal blocks.
d) Single line diagram of the circuits showing the rating of all components, the type and size of the incoming and outgoing feeders.
e) Schematic and elementary wiring diagrams, for each control unit, showing numbered terminal points, numbered wires and numbered interconnections to other equipment's and remote devices.
f) Connection wiring diagrams, for each control unit, showing numbered terminal points, numbered wires and numbered interconnections to other equipment's and remote devices.
g) Complete catalogue information for all components.

h) A complete list of parts, with prices, that would be necessary to maintain and/or modify the equipment.
I) Other relevant data.

B Product Data.
1 Full specifications of the enclosures and the components of the switchgear, switchboards and motor control centres, with relevant sheets of manufacturer's catalogues.
2 Test certificates of all components and whole assembled MLTB's from an internationally recognized testing authority or from independent testing lab in accordance with IEC 439. All expenses of this work shall be part of Electrical Contractor's scope of work.
3 Confirmation that the switchgears, switchboards and motor control centres comply with the relevant specification as mentioned in this Section.

C Overcurrent Protective Device Coordination.
1 Properly coordinated automatically operated overcurrent protective devices shall be provided for this project. The overcurrent protective devices shown on the Drawings shall be coordinated for adequate continuous current and interrupting capacity to assure proper overcurrent protective devices operation under normal and fault conditions in the system.
2 All overcurrent protective devices on this project and the first upstream device of the existing electrical system shall be coordinated so that they will perform as follows. When two or more overcurrent protective devices (including the first upstream protective device of the existing system) in series with each other experience current flow greater than their rated current, the device with the lowest rated current shall trip and/or open the circuit first and thereby prevent the higher rated devices from operating.
3 The Supplier of the overcurrent protective devices shall prepare a coordination study to verify the above stated performance requirements. The study shall be documented by the Supplier and the documents shall include but not be limited to the following:
a) A composite drawing or drawings (on full size, reproducible, log-log paper) showing the entire new electrical system (including the first upstream protective device of the existing system) showing all protective device curves (including motor overloads), short circuit duties, motor starting curves and damage curves for motors, equipment and conductors. This drawing or drawings shall show that all protective devices are properly coordinated to perform as stated above.
b) Manufacturer's overcurrent operating curves (on full size, reproducible, log-log paper) for each overcurrent device. In the case of fuses, both minimum melt and maximum clearing time curves shall be included.
c) Reproducible copies of all project single line diagrams so marked to show short circuit duties at all switchboards and motor control centres, and which operating curve applies to each overcurrent device on the diagram (the operating curves shall also be correspondingly marked);
d) A tabulation of the short circuit duties at all switchboards and motor control centres, sizes and ratings of all overcurrent protective devices and the required settings of all of the adjustable overcurrent protective devices so that the performance requirements are met. Protective devices which have earth fault protection features are specifically required to meet this performance requirement.
4 This documented coordination study shall be submitted for review before the overcurrent devices are supplied for the project.

1.04 Quality Assurance

A The switchgear manufacturer must have a previous record of satisfactory service for at least 3 years.

B All main low tension panels, main switchboards and motor control centres shall be submitted to testing by an approved laboratory, testing agency witnessed by the Engineer's nominated representative, and test certificate issued accordingly prior to delivery to site. The cost of such tests shall be included in the tender price. The tests shall be done in accordance with IEC 439 and shall include mechanical test, voltage test, short circuit test, degree of protection test, creepage distances and clearances in air test and other required tests as approved by the Engineer.

Part 2 Products

2.01 Main Low Tension Switchboard (M.L.T.B.)

A General

1 The Main Low Tension Switchboard shall be of Indoor construction, purpose made, floor standing, dead front, totally enclosed, cellular cubicle type, dust protected, vermin-proof and of clean and modern appearance containing the main components shown on the Drawings and/or specified.

2 The switchboards shall be fabricated, assembled, wired, checked, tested and coordinated at the factory by one manufacturer using the same make for all internal switchgear components and shall be constructed in accordance with BS 5486; Part 1 or IEC 60439.

3 The switchboard shall be equipped with Air Circuit Breakers, moulded case circuit breakers, relays, instruments, transformers, ancillary devices necessary for operation protection or measurement purposes and Auto Transfer Switch with Manual by pass arrangement as indicated on the Drawings.

4 The Normal Components, Fittings and Accessories required for safe and proper operation of switchgear shall be provided, whether specifically mentioned herein or not.

5 To withstand thermal and mechanical stresses set up by short circuit conditions in accordance with the fault through current of the feeding transformer. In general minimum fault breaking capacity shall be as follows unless otherwise specifically indicated on the drawings. Higher breaking capacities may be required at no extra cost to satisfy calculation/analysis.

a) 50 KA R.M.S. for MLTB and MCC if fed directly from transformer "2000 KVA Transformer".
b) 30KA R.M.S. for MSB, MCC and SMSB if fed from MLTB.
c) 22KA R.M.S. for SMSB and MCC if fed from MSB.
d) 14KA R.M.S. for Individual MSB if mentioned specifically. For higher rating Transformers the breaking capacity shall be as per M.E.W. Requirements.

6 Spare ways indicated on the Single Line Diagram shall be fully equipped.

B Construction.

1 Switchboard shall be factory built, totally enclosed, and rear accessible. Size, rating arrangements shall be as indicated on the Drawings.

2 The switchboard shall consist of standard cubicles assembled together on continuous base channels to form a rigid in line flush fronted free standing continuous switchboard assembly. Frames are constructed from 2.0mm thick folded sheet steel strengthened wherever necessary. The cubicle shall be sufficiently rigid to withstand all operating forces without deformation or damage.

3 Each cubicle shall be divided into segregated busbar section and circuit section. The circuit section shall be further divided into segregated compartments for housing main and emergency circuit breakers and other devices. Access to internal components of any compartment must be feasible by isolating its particular switch. The hinged door shall be mechanically interlocked with the switch in such a manner that the door can be opened only in the 'OFF' position.
4 The switchboards shall be totally enclosed, all hinged doors, covers shall be gasketed to provide protection against dust.
5 Cabinet shall have adequate means of lifting and shall be capable of being rolled or moved into the installation position and bolted directly to the floor.
6 The switchboards shall be provided with suitable cable glands to suit the type, size and number of cables as indicated on the Drawings. The cable glands or bracket where required shall be adequately mounted inside the switchboard. The switchboards shall be provided with the proper cable fixing clamps and terminal lugs for incoming and outgoing cables as well as earth bonding connections.
7 After fabrication, steel work shall be cleaned, zinc sprayed and stove enamelled with one prime coat, two under-coats and one finishing coat, the surface being rubbed down after each coat.
8 Finished colour : light grey or as approved by the Engineer.

C Labels.
1 All the components in the switchboards shall be identified by means of white labels of an approved design engraved with 5mm black lettering adequately describing the function of the unit to which it is attached and shall be secured by screws to the outside of each item. Special outlets and equipment shall be fitted with labels in a similar manner. Labels secured by adhesive are not acceptable.
2 All labels shall be engraved in English and shall be approved by the Engineer.

D Switchboard Wiring.
1 Switchboards shall be furnished completely wired including all cleats and terminal blocks.
2 Control and instrument wiring shall be made with a standard switchboard colour coded cable with fire resistant braid. No cable sizes smaller than 2.5 sq.mm shall be used.
3 The wiring on instrument panels shall have flexible connections to the terminal blocks.
4 The end of every wire shall be numbered with the number as stated in the control circuit wiring diagram of the manufacturer, also number the terminal blocks.
5 A sufficient number of terminal connections including 15% spare terminals shall be provided for all control and instrument wiring.

E Safety Measures.

Circuit breakers shall be provided with suitable means to prevent unauthorised and accidental operations. Interlocks to prevent dangerous operations shall be provided wherever necessary. High voltage parts shall be protected to prevent accidental human contact. Warning signs of durable type fixed on visible place shall be provided on high voltage parts. Earthing of metal parts shall be provided.

F Panel Lighting.

Each cubicle, where a door is required to be opened for access, shall be provided with fluorescent lighting which shall be automatically switched on when the panel door is opened.

G Annunciation.

Audible and visual annunciation for each panel shall be provided. The audible annunciation for minor fault and major fault shall be differentiated by separate tones.

H Lamp Test and Re-setting.

Each panel shall be provided with lamp testing switch and re-setting facility.

I Lamp Indication.

A pilot lamp for each panel shall be provided. The lamp shall light up when the input cable is live irrespective of the position of the circuit breaker in the panel.

J Busbars.

1 The busbars shall be electro-tinned hard drawn, high conductivity 99.9 percent purity, suitably sleeved for phase identification to BS 158.
2 All busbars shall extend through the length of the board with same cross section throughout unless indicated otherwise.
3 A Copper Earth Busbar sized at least 50 percent of the phase busbars shall be provided along the full length of the board.
4 Busbars shall be adequately supported by porcelain or moulded insulators spaced on suitable centres so that the complete assembly can withstand the maximum mechanical stresses to which it may be subjected to under fault conditions.
5 Busbars shall be housed in separate adequately ventilated compartment which shall not contain any wiring or apparatus other than that required for connections for busbars.
6 Rating : As indicated on the drawings.

K Main Air Circuit Breakers

1 To IEC 60947-3 or BS 4752 : Part 2, suitable for triple pole service and shall have breaking capacity of 50 KA symmetrical for 1 second at 415 Volts.
2 The Air Circuit Breakers (the conventional type and not moulded case circuit breaker) shall be 500 V, 50Hz, triple pole with neutral link on ratings as shown on the Drawings. They shall be air break, trip free, drawable type with mechanical and electrical ON/OFF indicators.
3 All air circuit breakers shall be electrically operated by automatic motor wound spring mechanism. A standby manual operating handle shall be provided for operating the circuit breaker in case of power or motor failure.
4 The air circuit breaker shall be provided with over current, short circuit and earth fault protection having the following characteristics:
   a) Adjustable long time delay current setting (50 percent - 150 percent) with varied tripping time.
   b) Adjustable short time delay current setting (400 percent - 1000 percent) with variable tripping time.
   c) Instantaneous tripping for heavier over current adjustable from 400 percent - 1600 percent of base current.
   d) Adjustable earth fault trip current setting (20 percent - 60 percent) with variable tripping time.
5 The circuit breaker shall have three positions on the drawout mechanism, namely service position where all main and auxiliary contacts are made, test position where main contacts are open but auxiliary contacts are closed and isolated position where all contacts are open. An indicator shall clearly show these positions and provisions shall

be made for locking the breakers in any position. ON/OFF indicator shall be provided.

6 Mechanical Interlocks shall be provided to prevent withdrawing or inserting of the breaker when it is 'ON'. Any attempt to do so shall trip the breaker automatically.

7 The withdrawable part of the circuit breaker shall be effectively connected to earth through scraping contacts that shall make before and break after the main and auxiliary contacts.

8 The moving contacts comprising the main and arcing contacts shall be of the spring loaded, self-aligning type. The arc contacts shall be arranged to make before and break after the main contacts.

9 Each ACB shall be included but not limited with following components and accessories:
   a) Auxiliary Contacts
   b) Arc Chutes
   c) Folding Extension Rail
   d) Charging Handle
   e) Open and Close Pushbuttons
   f) Over Current Trip Indicator
   g) Keylock on Trip Button
   h) Spring Charge Condition Indicator
   i) Breaker Position Indicator
   j) Making Current Release
   k) Automatic Shutters for the B/B Terminal
   l) Carriage for every size of ACB exceeding 25 kg in Weight
   m) Operation Counter.

10 The main incoming circuit breakers shall be provided with cable boxes to suit the incoming cables from the transformers.

11 Circuit breakers shall be tropicalized to operate continuously in the specified ambient temperature and high relative humidity.

12 Type test certificate for each size of circuit breakers and MCCB's from an internationally recognized testing authority acceptable to the Engineer shall be provided.

L Moulded Case Circuit Breakers.

1 Shall have a combination of thermal and magnetic tripping giving an inverse time delay protection against sustained overloads and instantaneous tripping under heavy overloads and short circuits.

2 Breakers shall have a quick make, quick break over-centre switching mechanism that is mechanically trip free from the handle so that contacts cannot be held closed against short circuits and abnormal current.

3 Tripping due to overload or short circuits shall be clearly indicated by the handle assuming a position mid-way between the manual ON and OFF position.

4 Latch surfaces shall be polished.

5 Poles shall be constructed to open, close and trip simultaneously.

6 Ampere ratings shall be clearly visible.

7 Breakers shall be completely enclosed in a moulded case to IEC No. 60947-2, suitable for installation inside switchboards.

8 Non-interchangeable trip breakers shall have the trip unit sealed.

9 Breakers with earth leakage relay protection shall be provided with shunt trips.

10 Frame sizes shall be as per manufacturer's standard size and as approved by the Engineer.

11 The magnetic trip shall be adjustable type for rating 200 Amp. and above.

M Earth Leakage Relay.

1 The relay shall comprise a core balance transformer, tripping mechanism and reset

testing buttons.

2 The relay shall operate within 0.2 sec, when the fault current exceeds specified sensitivity as detailed on the Drawings.

3 The relay shall be connected to the load side and the testing device shall be connected to the supply side.

4 The relay shall withstand available short circuit. In case of using with the MCCB's integrated E/L Relay in MCCB can be accepted.

5 Audible and visual alarm earth leakage relay shall be provided where specified on the Drawings.

a) Similar in construction to Earth Leakage Relay except it operates an audible and visual alarm located in the board and remotely positioned in lieu of shunt trip of the breakers.

b) Audible Alarm shall be of sufficient level and may be cancelled by suitable reset button but visual indicator shall remain ON until fault is cleared.

N Instruments.

The Measuring Instruments shall include ammeters, voltmeters, kWh meters, selector switches and associated accessories as indicated on the Drawings and described herein as follows:

1 Ammeter, Voltmeter and Power Factor Meter.

a) The measuring instruments shall be moving iron vane type, flush pattern with dust and moisture-proof enclosure. Anti-glare glass front, anti-parallax scales and white faces with black numerals and marking shall be used. All instruments shall be of long scale 240 Degree with full load indicating approximately at 180°.

b) The dial size shall be 10 x 10 sq.cm.

c) Accuracy shall be one percent of full scale values.

d) Moving elements shall be provided with zero adjustments located at face of dial.

e) The Ammeter shall be capable of withstanding twice of rated current for 10 minutes and overload sustained under fault conditions without damage or loss of accuracy.

f) Voltmeter shall have a measuring range from 0 to 500 V and shall withstand twice the rated full scale voltage for 1.0 minute without damage.

g) Three Ammeters or a single ammeter with selector switch shall be provided to read the current of each phase, as indicated on the Drawings.

h) The voltmeter selector switch shall be of the rotary type with cam operated contactor and shall have (7) positions off, R-Y, Y-B, R-N, Y-N, B-N.

i) Single and poly phase power factor meters with associated current and potential transformers shall be provided as required and specified herein.

2 Current Transformers.

a) Current transformers shall be of the bar primary type, air cooled and suitably insulated. The current transformers shall be of Class C accuracy for indication and Class CM accuracy for metering purposes.

b) Current transformers shall be rated not less than 5 VA and shall have thermal and mechanical rating at least equal to those of the main circuit breakers.

3 kWh Meters.

a) The kWh meters shall be suitable for operation on 415/240 Volt, 3 phase, 4 wire, 50 Hz supply and shall conform to BS 37 Part 1 and BS 5685.

b) The meters shall be dust-proof and vermin-proof, protected from corrosion due to high humidity and compensated against the effect of temperature up to 55°C.

c) The meters shall maintain their accuracy over many years service under the project site climatic conditions. The counter shall be of the cycle meter type with six figures, the lowest figure being unit. Pointer type counters are not

acceptable.

d) The meter cover and cases shall be of metal.

e) Meters shall not have less than 5mm diameter terminal holes and shall be operated through three 3000/5A current transformers and the counter of the meter should be calibrated to read the primary kWh.

f) All meters shall be handled over to the supply authority for calibration prior to final installation and connection.

O Automatic Transfer Switch (A.T.S.)

1 The A.T.S. shall consist of 4 pole, 3 phase, rated as shown on the Drawings.

2 With the A.T.S. provide manual change-over switches to by-pass the A.T.S. in case of emergency, maintenance or repair.

3 The arrangement, wiring and components shall satisfy the requirements of the Diesel Generator Manufacturer. His written approval shall be submitted.

4 Control voltage of A.T.S. shall be normally fed from the main supply, in case of failure of the main supply it shall be fed automatically from the emergency supply.

5 In addition to transfer switches the A.T.S. arrangement shall be equipped with the following:

a) A selector switch to control the operation of A.T.S. on normal, emergency, automatic and OFF.

b) Adjustable - 3 phase voltage sensing relays sense failure in a phase/phases and voltage drop below 70 percent of the normal voltage (pick-up and drop-out voltages and adjustable within the range 70 - 100 percent of the normal voltage).

c) Visual Mechanical Indicator for transfer switch position.

d) Indicator lamps to show transfer switch position normal, emergency and OFF.

e) An adjustable time delay relay of 1 - 3 seconds for starting signal to the Generator set after cutting of main supply.

f) An adjustable time delay relay of 0 - 3 minutes which allows A.T.S. from Normal to Emergency after the voltage build up relay of the generator has sensed 90 percent rated voltage when frequency within 90 percent rated of rated frequency.

g) An adjustable time delay relay of 1 - 10 minutes to allow A.T.S. from Emergency to Normal.

h) An adjustable time delay relay of 0.5 - 5 seconds to prevent instantaneous transition from EMERGENCY to NORMAL i.e. the delay allows time sufficient for the residual motor voltage to decay to a safe switching level.

2.02 Main And Sub-Main Switchboards

A The main and sub-main switchboards shall be totally enclosed, dust protected and factory fabricated suitable for operation on 400/230V, 3 Phase, 4 wire, 50 Hz supply unless shown otherwise.

B The main and sub-main switchboards shall comprise main incoming MCCB, busbars, outgoing MCCB, earth leakage relays, earth bus, etc. with ratings and arrangements as shown on the Drawings and all housed in a sheet steel panel fully rustproofed and stove enamelled equipped with a hinged door with approved locking device.

C The moulded case circuit breakers, earth leakage relays and busbars shall be as specified above in this section.

D The earth bus shall have adequate ratings and length for connecting the incoming and outgoing earth wires or tapes.

E The switchboards shall be complete with all necessary internal wiring and connections.

F The arrangement of the boards shall be such that the main MCCB and outgoing MCCB can be operated when opening the door but to gain access to the MCCB's cabling and terminations a second cover shall be removed. There shall be ample clearance and ample space available inside the boards for cabling and terminations. Adequate clearance shall be maintained between phases and non-current carrying metal and terminals shall be so located that in the final connected positions there shall be no crowding of wires in close proximity of metals.

G The boards shall be complete with cable glands for convenient terminations of incoming and outgoing cables. The cable glands shall be so fixed inside the board that ample clearance exists between various feeders.

2.03 Motor Control Centres

A Provide the metal enclosed motor control centres as indicated, specified and required. The motor control centres shall be switchboard type construction as described in Paragraph 2.01 except as modified herein. The motor control centres shall be front access only. Shipment shall be made in sections to facilitate field handling, and the shipped sections shall be joined together to form a complete back-to-wall or back-to-back unit assembly as indicated.

B Vertical sections shall contain adequate space for connecting the incoming power supply circuits, outgoing branch circuits, motor circuits and control circuits to terminals, horizontal and vertical power bus bars, horizontal earth bus, circuit breakers, magnetic starters, contactors, control stations, pilot lights, timers, terminals, transformers, panels, relays, ammeters, voltmeters, meter switches, earth leakage protection, thermostatically controlled space heaters, thermostats, fans, vents, screens, filters and switches. The vertical sections shall be fabricated from heavy gauge steel, with uniform surfaces. The standard section shall be 600mm wide by 600mm deep. Holes shall be provided in the structural base of each section for anchor bolts. Sections shall contain wireways, brackets, supports, plates, trims, barriers, gaskets, doors, base channels, lifting angles and hardware. Horizontal wireways (top and bottom) shall extend through the width of each section. Wireway openings shall be provided between sections with closing plates on the end sections. Each vertical section shall contain its own individual full height vertical wireway separated from the vertical bus by a metal barrier, and also separated from the individual control units by the side pan of the control unit. Wire ties shall be furnished in the vertical wireways to group and securely hold the conductors in place. A separate cover shall be provided on the vertically wireway. Control units shall be isolated from one another by horizontal steel barriers. Front to rear bracing shall not interfere with the cable entrance areas. Hinged doors shall be equipped with screwdriver operated quarter-turn latches that catch automatically when the door is pushed closed. Large doors shall be equipped with additional latches. Provision shall be included to add a vertical section on either end of the line up in the future.

C The power supply compartment shall be sized to accommodate the incoming power conductors. The compartment shall be located at the top or bottom of the vertical section as shown on the Drawings. The power compartment shall be covered by a hinged door and shall be held closed with quarter-turn pawl type latches.

D Bus Bars shall be provided for the power and earth systems. When shown on the Drawings, provide full length full capacity and insulated neutral bus and cable connectors. Bus joints shall be connected with bolts, nuts and spring washers. The main horizontal power bus

shall be located in the centre or near the top of each section, joined together to form a continuous bus for the full length of the motor control centre. The horizontal power bus shall be copper and the current rating shall be as shown on the Drawings. The vertical power buses shall be copper full height and rated for the section total load. The minimum current rating for the vertical power buses shall be 300 amperes. Small openings in the vertical barriers shall permit the plug-on control unit contacts to pass through and engage with the vertical bus bars. Unused plug-on openings in the vertical barriers shall be equipped with plastic snap-in closing plugs.

E Control Units shall be plug-on type, metal enclosed, with a single door, and contain the equipment indicated and required. The plug-on contacts shall be a high quality two point connection for each phase. The contacts shall be self-aligning, copper, silver plated and backed by steel clips to provide high pressure connections. An interlock shall be provided to prevent insertion or removal of the control unit unless the circuit is in the "OFF" position. There shall be a copper earth plug-on contact, in each control unit, that engages the vertical earth bus prior to the phase plug-on contacts engaging the vertical power bus. The unit door shall be equipped with the required control stations, pilot lights, reset pushbutton, hardware and other indicated devices. An operator handle, with positive handle position indication, shall be provided on the control unit door for each circuit breaker. The handle shall have an up-down motion or equal, and the down position shall be "OFF". It shall be possible to lock the operator handle in the "OFF" position with a padlock. The handle shall be interlocked with the control unit door so that the circuit breaker cannot be placed in the "ON" position when the door is open, nor can the door be opened when the circuit breaker is in the "ON" position without by-passing the interlock by using a small screwdriver. The highest position of the circuit breaker operator handle shall not exceed 1980mm above the floor with the motor control centre installed on a concrete housekeeping pad as shown on the Drawings. The control units shall accommodate the circuit breakers, magnetic starters, reset buttons, contactors, meters, switches, transformers, control circuit fuses, control stations, relays, timers, pilot lights, earth leakage protection equipment, wiring, terminals and nameplates as indicated. Each control unit shall be sized to accommodate the required relays and other equipment as shown on the Drawings. There shall be a provision to disconnect external control circuits inside the control unit when the circuit breaker is opened.

F Circuit Breakers shall be as described in Paragraph 2.01, and shall have the ampere trip ratings as shown on the Drawings. Each circuit breaker shall have a single operating handle, positive handle indication and proper wire connectors. As indicated, non-automatic circuit breakers shall be provided for manual opening and closing circuits and shall have no overload protection. Circuit breakers shall be equipped with lugs properly sized to terminate all required conductors as shown on the Drawings.

G Motor Starters shall be magnetic, single speed, variable speed, full voltage, reduced voltage or reversing as indicated and specified. Reduced voltage starters shall be the star-delta type or auto-transformer type unless indicated otherwise.

2.04 Motor Control

A Control Stations shall be heavy duty, oil-tight and shall consist of operators, contact blocks and legend plates. Control stations shall be included in equipment and in cast metal-boxes with threaded hubs and gasketed covers as indicated. Control stations in cast metal boxes shall form a IP65 assembly. The pushbutton, selector switch, cylinder lock and pilot light operators shall include the number of units as indicated and required. Operators shall be

non-illuminating and black, except the "STOP" button shall be red. Provisions shall be included for locking the "STOP" button in the depressed position, and locking the selector switch in the "OFF" position. Cylinder lock operators shall be provided as indicated. Locks shall be keyed alike and provide two keys. Pushbutton operators shall have full guards, momentary or maintained contacts as indicated and required. Legend plates shall indicate the operator functions. Selector switch operators shall have standard knobs with manual return and the indicated positions. Indicating lights shall be transformer type, push-to-test, 50 hertz with 6 volt lamps and colour caps as shown on the Drawings.

B Control relays shall be provided for the control and alarm circuits as required. The relays shall be electrically held, 50 hertz, continuous duty, multipole, connected to 240 volt ac control circuits and mounted inside motor control centres or separate metal enclosures as indicated. Control relays shall have convertible contacts with a continuous rating of 10 amperes at 75 percent power factor. The relay base assembly shall accept from 1 through 8 convertible poles. Magnetic coil inrush power for relays 2-8 poles shall be approximately 155 volt-amperes, and the operating time shall average 10 milliseconds. Relays shall be attached to pre-spaced mounting channels with captive screws.

C Timing relays shall be provided for the control and alarm circuits as required. The relays shall be as described for the control relays with a solid state timer module attachment. The timing module shall be capable of operating up to 8 convertible timed contacts when mounted on and wired to the control relays, and can be panel and channel mounted. The "Off-Delay" operation with the timing module shall incorporate an auxiliary relay with a normally closed output contact in the load circuit. An alternative to the control relay with a timer module would be a solid state timing relay.

1 The solid state timing relays shall be electrically held, 50 hertz, continuous duty, multi-pole, connected to 240 volt AC control circuits and mounted inside motor control centres or separate metal enclosures as indicated. Timing relays shall have up to two timed and two instantaneous contacts with a continuous rating of 5 amperes. Timing relays shall be solid state, encapsulated, and shall provide "On-Delay" (delay-on-pull-in) and "Off-Delay" (delay-on-drop-out) operations as required. The repeat accuracy of the timing cycle shall be approximately plus or minus 1 percent at constant voltage, ambient temperature and reset time.

2 "On-Delay" loads shall be energized upon the completion of the timing cycle. Closing the control contact shall initiate the timing cycle. Opening the control contact shall de-energize the loads. The "On-Delay" timing relay shall be reset after completing the timing cycle, or during the timing cycle by opening the control circuit contact for at least 15 milliseconds. "Off-Delay" loads shall be energized upon closing the control circuit contact. Opening the control circuit contact shall initiate the timing cycle. The loads shall be de-energized upon the completion of the timing cycle. The "Off-Delay" timing relay shall be reset after completing the timing cycle, or during the timing cycle by closing the control circuit contact for at least 15 milliseconds. The relays shall have a timing range of 0.3 to 30 seconds unless otherwise indicated.

D Magnetic Contactors shall be electrically held unless otherwise indicated, 415 V, 50 Hz, industrial duty, and connected to 230 volts AC circuit with remote control device. The Drawings shall indicate the number of poles and ampere ratings for the contactors and the locations, which shall be mounted inside motor control centres, panel boards or separate metal enclosures as indicated. Contactors shall be IEC type and rated. The power contacts shall be load break within the rating of the contactor without assistance from additional arcing contacts. The magnetic coil shall be continuous duty, encapsulated, easily removable and provide rapid action on pickup or dropout with satisfactory operation without hum.

E Magnetic Starters shall consist of a magnetic contactor equipped with an overload relay in each phase and an external manual reset button. The overload relays shall be thermal bi-metallic types. All relays shall be of the same type. Motor starters shall be IEC type, The moulded magnetic coil shall be connected to the 240 volt, 50 hertz control circuit and shall operate satisfactorily through a range of plus and minus 10 percent of the control circuit voltage. Each motor starter shall be equipped with minimum two normally open and two normally closed auxiliary contacts. Provide one set of spare contacts for each motor starter provided.

F Solid-state, reduced voltage motor starters shall be closed transition, shunt duty type with shorting contactor, for full speed operation. When the motor and load reach full speed, the shorting contactor by-passes the SCR power section. The solid-state power section shall consist of six silicon controlled rectifiers (two per phase connected back-to-back, in reverse parallel configuration) to provide a soft start for the indicated pump motors. The starters shall conform to the latest IEC Standards.

G The starters shall use the current limit method of starting with the current adjustable between 150 percent and 425 percent of full load current of the motor. At turn-on, the control ramps up to the current limit in approximately 1 second and maintains that current until the motor comes up to full speed. If a problem exists and the motor fails to reach rated speed within a predetermined period of time, the control will shut-down. The starter shall provide a smooth, stepless acceleration and deceleration of the load from start to full speed and from full speed to stop. The starter shall be equipped with metal oxide varistor type surge suppressors across the SCR's to protect against voltage transients and resistor/capacitor snubber networks to protect against false firing of the SCR's. Each SCR heat sink shall have a temperature sensor that shall shut the starter down in the event of an over temperature condition. When a starter failure occurs, the actual problem shall be indicated by an LED on the control panel front.

H There shall be an over current protective device, which shall provide over current protection and main disconnect function for the control unit. The position of the operating handle shall indicate "ON" or "OFF" position of the protective device and include provision for padlocking in the "OFF" position. This protective device shall be equipped with a shunt trip and shall trip when there is a SCR or plant power failure. Motor space heaters shall be energized when the motor is not running.

I The reduced voltage starters shall be equipped with micro-processor controlled motor protection relays to control, monitor and protect the motors. The relay shall monitor three phase current and voltage and make trip and alarm decisions based on pre-programmed motor current and voltage conditions. Control functions shall include start detection, starter transition, incomplete sequence and number of starts per hour. The relay shall monitor and display load current and percent of full load current of each phase and running time. The relay shall protect the motor against time overcurrent, instantaneous overcurrent, underload, phase unbalance, earth fault, phase loss and phase reversal.

J The manufacturer shall supply certified test results to confirm that the controller has been tested to substantiate designs according to applicable standards. The tests shall verify not only the performance of the unit and integrated assembly, but also the suitability of the enclosure venting, rigidity and bus bracing. In addition, the unit shall be factory tested in accordance with applicable standards.

K Manufacturer shall be prepared to show proper evidence of having tested for noise immunity on both input and output power connections.

Part 3 Execution

3.01 General

A The Main Low Tension Boards (M.L.T.B.) shall be supplied and installed in the electrical substation as indicated on the Drawings.

B The Contractor shall submit details of proposed equipment and method of installation to the Engineer for approval prior to commencement of installation work.

C Provide all the motor control equipment installations, wiring installations and tests, including connections and interconnections for the electrical controls as indicated, specified and required. Assure proper fits for all equipment and materials in the spaces shown on the Drawings.

D Equipment shall be installed level and securely attached to the concrete foundations and walls with expansion anchors. The sections shall be joined together with bolts, nuts and washers to form a complete unit assembly. Floor standing equipment shall be installed on concrete housekeeping pads as shown on the Drawings.

3.02 Earth Bonding

A Each panel section shall be individually bonded to main earth bar located in the electrical rooms.

B Each panel section shall be cross bonded to adjacent panel section earthing terminal.

3.03 Motor Control

A Install all the wiring and control equipment as indicated, specified and required.

B Motors shall be provided with the driven mechanical equipment.

C The wiring installation shall be complete. Include all the required wiring interconnections between the motor magnetic starters, and between the starters and the instrument control panels. Provide motor frame cable connection boxes as required. Be certain that all wiring connections provide the proper motor rotation.

D Provide the control stations near motors as shown on the Drawings.

E The magnetic starters shall be provided in the motor control centres unless otherwise indicated.

END OF SECTION 16425

Section 16450

Earthing System

Part 1 General

1.01 Description

This Section shall include all labour, materials and accessories for the complete performance of the earthing systems in accordance with the Specifications and Drawings.

1.02 Quality Assurance

The earthing system shall be in accordance with the supply authority's rules and regulations and to BS 7671.

1.03 Submittals

Shop Drawings

1 Submit full technical details and conductor size calculations of each type of cable or wire proposed.
2 Submit exact route of each cable or wire proposed.

Part 2 Products

2.01 Materials

A Products used in the earthing system shall be copper or an approved copper alloy, unless otherwise specified, and specifically manufactured for the purpose.

B Earth Continuity Conductors
1 Sizes shall be not less than half that of the associated phase conductors.
2 Insulation shall be of the same material as insulation in associated sub-circuits.

C Main Earth Loops - 25 x 3 mm tinned copper tape, unless otherwise indicated.

D Rod Electrodes
1 Shall be the earth rod electrode type, unless impracticable to drive deep into the particular soil.
2 Earth rod electrodes: 16mm diameter steel core copper jacketed type, comprising a high strength steel alloy core with a molten welded copper covering.
3 To be 3.6m long, in 1.2m sections coupled by strong bronze couplers.

E Plant Electrodes - to be either
1 Copper; or
2 Cast iron where artificial treatment of soil is necessary because of high soil resistivity.

F Earth Connectors shall connection of rod electrodes: bolted type.

G Removable Earth Links - to comprise a bolted copper link fixed on porcelain insulators and

complete with studs, nuts and washers to take the earth tape and a bolted lug adequately sized for the final connection of the earth electrode.

H Bolts, Washers and Nuts in Bolted Connections:
High copper alloy or silicone bronze. Ferrous hardware is not acceptable.

I Earth Pit Cover
1 Shall be of heavy duty cast iron cover.
2 Shall have a recessed lifting hook.
3 Shall have a brass plate, engraved "Electrical Earth Below".

Part 3 Execution

3.01 Installation

A Circuit Wiring
Shall have a green and yellow coloured insulated earth continuity cable connecting the earth bus or earth terminal in switchboards, switchgears, motor control centres and panel boards to the motor, equipment, outlet and device earthing lugs.

B Main Earth Loops
1 Fix in mechanical equipment rooms and other areas indicated on the drawings, in convenient locations, allowing two return paths to earth.
2 Fix copper tape to structure with copper or brass saddles and/or screws. Make tees and straight joints by riveting and seating, welding or brazing.
3 Make branch connections between main loop and major equipment, such as switchboards, switchgears, motor control centres and large motors, with copper tape of same size as main loop tape.
4 Make other branch connections to equipment with copper conductors of size not less than half that of the relative phase conductor.

C Removable Earth Links
1 Fix in every main earth lead to enable the electrode system to be disconnected for testing.
2 Install in an accessible position, above ground as close as possible to the earth electrode.

D Exposed Earth Cables
Install and locate to provide maximum mechanical protection, utilizing ceiling corners, suspended ceiling and webs of beams as much as possible.

E Bolted Connections
1 Multiple bolt type.
2 Where bare copper is bolted in connections contact surfaces shall be silver electroplated.

F Brazed Connections
Where earthing terminal connections are to be brazed to equipment, thoroughly clean metal prior to brazing and repaint impaired surfaces to prevent corrosion.

G Connections between Dissimilar Metals
Protect by

1 Painting with a moisture resistant bituminous paint or compound, or
2 Wrapping with protective tape to exclude moisture.

H Equipment Earthing
1 Connect all non-current carrying metallic parts of the electrical/mechanical installation to the earthing system.
2 Non-current carrying metallic parts of the electrical installation include:
a Metal conduit cable armour (steel and aluminium) raceways, outlet boxes, cabinets, and the like.
b Exposed metal parts of apparatus.
c Enclosures, doors, grilles, barriers and the like protecting or shielding electrical equipment from direct access.
3 Series earthing of one piece of equipment to another is not acceptable.

I Fire fighting equipment shall be earthed on a separate ring system.

J Motors Earthing
1 Connect the motor terminal box to the relative earth loop. The terminal must be mechanically connected to the frame or, where this is not feasible.
2 Extend the earthing conductor through an insulated bushed opening in the connection box and connect to the frame.

K Main Switchboards, Switchgears And Motor Control Centres Earthing
1 Connect the special earthing lug or busbars inside the cabinet to the main earth copper tape.
2 Connect all parts of the switchboards, switchgears and motor control centres other than "live" parts, to the earth bar in the board in an approved manner.

L Connect an earthing conductor from the main distribution earth busbar to an earth connector welded to the cabinet and earthing bushings on the incoming and outgoing feeder conduits.

M Bus-Duct Feeders Earthing
Connect the green coded earth busbar directly to the earth bus-bar in main switchboard with earth copper tape.

N Connect steel and aluminium armour to the earthing system.

O Earth Rod Electrodes
1 Drive extensible rods of the same diameter into the ground, either manually or by power driven hammer, to a suitable depth to obtain low resistivity in the particular soil.
2 Weld earth connectors to the top of the rods, in sufficient number to make connection with all incoming cables.

P Earth plate electrodes shall be used where ground resistivity is low but increases with depth or it is not possible to go deep into soil. Terminations shall be protected against corrosion.

Q Construct a small concrete pit 1130 x 30 cm, complete with removable heavy gauge cast iron cover with recessed lifting hook, at the head of the earth rod, to protect the rod and allow access to connections for testing.

R Telephone earth shall be either by means of steel cored rods or G.I. pipes but shall be isolated from the general earth. The earthing lead shall be bonded to the MDF. The earth resistance shall be one ohm or less. The size of the earthing lead shall be not less than 10 mm^2. All the earthing for the positive pole of any PABX and other low voltage equipment shall be taken from the telephone earth. This earth shall be kept isolated from the electrical earth.

S Lightning Protection

1 Lightning air terminals and down conductors for lightning air terminals shall be provided and shall be min of 15 mm diameter tinned copper (air termination rod) 0.8 metre long with top spike. Roof conductors and down conductors shall be of PVC sheath 3 x 20 mm copper tape or copper conductor size 50 mm^2 PVC colour to be approved by the Engineer. However copper tape may be used.

2 Air termination rods shall be securely anchored and welded. Down conductors shall be run along the outer surface of the wall or column of the building. Down conductors shall be as short as possible protected and directly connected to earth pit. Anchoring bolts shall be used to hold roof conductors and down conductors in firm position. Lightning conductor connectors shall be provided for conductor splice connections and conductor terminal connections. The connectors shall be heavy duty, cast metal and shall have hex-head screws in the bodies and holes in the tongues for bolts. Handrail and structures in the vicinity of the lightning protection system, if any, shall be bonded to the system by 50 mm^2 PVC sheath copper.

3 Suitable concrete earth pit and cover supplied by the same lightning protection system manufacture shall be provided.

T Testing

1 Testing earth electrode resistance by earth resistance tester.

2 The resistance of the earth electrode shall not exceed 10 ohm.

3 Install additional earth electrodes if these figures are not met.

END OF SECTION 16450

Section 16470

Distribution Boards

Part 1 General

1.01 Description

This Section shall include all labour, materials and accessories for the complete performance of all distribution boards in accordance with the Specifications and Drawings.

1.02 Reference Standards

Applicable standards referred to in this Section

BS 5486 PT. 11, PT. 12	Particular Requirements for HRC Fuses, Miniature Circuit Breaker Boards.
BS 3871 PT. 1, IEC 157-1A	Miniature Circuit Breakers.
BS 4293	Current Operated Earth Leakage Circuit Breaker.
BS 6231	PVC Insulated Cable for Switchgear and Control Gear Wiring.
BS 5420, IEC 144	Degree of Protection for Enclosures.

1.03 Submittals

A Submit fully detailed specifications for the enclosures and components of distribution boards with relevant sheets of manufacturer's catalogues.

B Submit confirmation that boards offered comply with relevant Specifications, Drawings and Schedule of Points.

Part 2 Products

2.01 General

A Distribution boards shall be provided to serve lighting, fans, socket outlets, instrumentation, controls, small loads and other appliances. Board shall be arranged in banks of ways as indicated on the schedule of points.

B Distribution boards shall be flush mounted type, surface mounted type or mounted in motor control centres, as indicated. The boards shall be totally enclosed, dust protected, vermin-proof type. Enclosure shall be fabricated from robust galvanized sheet fully rust-proofed, stove enamelled, of minimum thickness of 1.5mm. The enclosure shall be protected to IP31 for internal use with neoprene gaskets for the doors.

C The distribution boards shall be provided with fixed cover and a hinged door with padlock which can be opened without any obstruction about 120 degree and conduit knockouts from the top and bottom. The hinged door with a lock and key shall be integral part of the fixed cover.

D The cabinet shall be constructed so that it is necessary to open the door to operate Miniature Circuit Breakers or E/L.C.B. Access to interior components and internal wiring

shall be gained by removing a separate barrier within the enclosure.

E All distribution boards shall be controlled by an adequately rated ON load isolator to interrupt the supply to the entire distribution board. All electrical distribution boards shall be provided with H.R.C fuses as back-up protection with the same rating of the isolator.

F A circuit label shall be provided to indicate the area served by M.C.B.

2.02 Busbars

A Shall be of appropriate current carrying capacity at least equal to the rating of the main incoming isolator.

B Shall be of high electrical conductivity copper.

2.03 Moulded Circuit Neutral Connector Block

Shall be of ample size to ensure a separate way is available on the connector block for the neutral conductor of each circuit.

2.04 Miniature Circuit Breakers (MCB)

The M.C.B. shall comply with BS 3871 Part 1 and amendments and shall be of category M6 Type 3. The M.C.B. shall be of the trip free pattern to prevent closing the breaker on a faulty circuit and shall be engraved to indicate "ON/OFF" position and rated current. The MCB shall have:

1 frame size : 50 A.
2 trip settings : As indicated on schedule of points.
3 a minimum symmetrical RMS interrupting capacity of 6 kA.
4 the thermal overload trips to operate at 125 percent rated current and instantaneous magnetic trip to operate at:
5 500 percent rated current for single pole breakers.
6 800 percent rated current for triple pole breakers.
7 arrangement so that it is possible to replace three single phase units with one three phase unit.
8 triple pole miniature circuit breakers shall have inherent characteristics to prevent single phasing and shall be fully suitable for motor duty.

2.05 Current Operated Earth Leakage Circuit Breakers (C.O.E/L.C.B.)

A Current operated earth leakage circuit breakers shall provide accident protection by interrupting dangerous contact with voltage which may be present in faulty electrical equipment as a result of frame faults, insufficient insulation or misuse.

B The E/L.C.B. shall also provide a high degree of protection against earth leakage, fires and electric shock and can withstand at least 6kA. The breakers shall generally comply with BS 4293, 1983 and the recommended specification CEE 227 of the IEC on Rules for the approval of electrical equipment.

C The breaker shall consist of a core balance transformer, a tripping coil with contact assembly, main supply contacts, ON/OFF switch, a test button and a trip free mechanism all enclosed in a robust body of all insulated material.

D Degree of protection against earth leakage throughout the electrical installation shall be as indicated and as follows:

10mA trip rating	-	for under water lighting.
30mA trip rating	-	for all socket outlets and domestic apparatus.
300mA trip rating	-	lighting circuits and all other apparatus and equipment

E The breaker protecting lightning and power circuits shall be mounted in the panel board enclosure.

2.06 Contactors

Lighting Contactors

1 The lighting contactors shall have minimum making and breaking capacity in accordance with utilization category AC3 and shall be suitable for intermittent duty class I.
2 The mechanical rated life of the contactor shall not be less than 3 million operations.
3 The contactors shall be single coil, electrically operated, mechanically held (latch type) and shall be rated for tungsten, fluorescent or discharge lighting load.
4 Contactors rating and number of poles as indicated.
5 Operating coil suitable for 240 V, 50 Hz. supply.
6 Main Contacts: double break silver to silver type protected by arcing contacts.
7 Contacts: self-aligning, renewable from the front panel.
8 Solenoids: shaded pole pattern of such construction that lamination noise is eliminated.
9 Control of contactor: by local and remote pushbuttons as indicated. A manual operating lever shall also be included.
10 Lighting contactor's controlling lighting circuits of distribution boards shall be mounted in the board enclosure.

2.07 Distribution Boards Controlled by Contactor and Pushbutton

A These distribution boards shall be the same as specified above except that the contactors shall also be installed within the enclosure of the boards.

B Where there exists multi-contactor, number of bus sections shall be referred from schedule of points. Adequate space shall be provided to accommodate all the contactors and other contents of distribution boards. The construction of contactor shall be such that it is not possible to come into contact with live parts. The operating coil of contactor shall be suitable for operation at 240 Volts, 50 Hz, single phase.

C These distribution boards shall be of special design and shall consist of all components including E/L.C.B., as shown on the schedule of points. The details shall be submitted and approved by the Engineer, before placing the order.

2.08 Feeder Pillars

Feeder pillars shall be fabricated from hot dipped galvanized sheet steel in accordance with relevant IEC Specifications and shall be fully suitable for outdoor installation, contents as shown on schedule of points and as approved by the Engineer.

Part 3 Execution

3.01 Installation

A Distribution boards shall be supplied and installed as indicated on the Drawings as approved by the Engineer.

B Distribution boards shall be installed in electrical rooms, electrical closets or motor control centres as indicated on the Drawings. The top end of the distribution board shall not be higher than 1800 mm above finished floor level.

C Drawings showing the proposed distribution boards construction and layout, including a diagram of all internal connections on which the proposed identification markings for all cables and terminals are shown, shall be submitted to the Engineer for approval before construction commences.

END OF SECTION 16470

Section 16475

Overcurrent Protective Device

Part 1 General

1.01 Ratings

The ratings of the various overcurrent protective devices shall be as indicated on the Contract Drawing or in the Particular Specifications.

1.02 Standards

Applicable standards referred to in this section are:

BS 88	Cartridge Fuses
BS EN 60947-2, IEC 947-2	Circuit Breakers
BS EN 60898-2, IEC 947-2	Miniature Air Break Circuit Breakers

1.03 Overcurrent Protective Device Coordination

A. The contractor shall carry out and provide an overcurrent protective device coordinator study as part of his material submission, as outline below.

B. Properly coordinated automatically operated overcurrent protective devices shall be provided for this project. The overcurrent protective devices shown on the Drawings shall be coordinated for adequate continuous current and interrupting capacity to assure proper overcurrent protective devices operation under normal and fault conditions in the system.

C. All overcurrent protective devices on this project and the first upstream device of the existing electrical system shall be coordinated so that they will perform as follows. When two or more overcurrent protective devices (including the first upstream protective device of the existing system) in series with each other experience current flow greater than their rated current, the device with the lowest rated current shall trip and/or open the circuit first and thereby prevent the higher rated devices from operating.

D. The supplier of the overcurrent protective devices shall prepare a coordination study to verify the above stated performance requirements. The study shall be documented by the supplier and the documents shall include but not be limited to the following:
   1. A composite drawing or drawings (on full size, reproducible, log-log paper) showing the entire new electrical system (including the first upstream protective device of the existing system) showing all protective device curves (including motor overloads), short circuit duties, motor starting curves and damage curves for motors, equipment and conductors. This drawing or drawings shall show that all protective devices are properly coordinated to perform as stated above.
   2. Manufacturer's overcurrent operating curves (on full size, reproducible, log-log paper) for each overcurrent device. In the case of fuses, both minimum melt and maximum clearing time curves shall be included.
   3. Reproducible copies of all project single line diagrams so marked to show short circuit duties at all switchboards and motor control centres, and which operating curve applies to each overcurrent device on the diagram (the operating curves shall also be correspondingly marked).
   4. A tabulation of the short circuit duties at all switchboards and motor control centres,

sizes and ratings of all overcurrent protective devices and the required settings of all of the adjustable overcurrent protective devices so that the performance requirements are met. Protective devices, which have earth fault protection features, are specifically required to meet this performance requirement.

E. This documented coordination study shall be submitted for review before the overcurrent devices are supplied for the project.

1.04 Quality Assurance

The suppliers' manufacturing facility shall be certified to the ISO - 9001 series of standards from the International Standards Organization.

1.05 Manufacturers

Preference will be given to one manufacturer of ACBs, MCCBs and MCBs to ensure proper coordination in accordance with Clause 1.04 above.

Part 2 Products

2.01 Air Circuit Breakers

A. To IEC 947-2 or BS EN 60947-2, suitable for triple pole service and shall have breaking capacity of 50 kA symmetrical for 1 second at 415 Volts.

B. The Air Circuit Breakers (the conventional type and not moulded case circuit breaker) shall be 500 V, 50Hz, triple pole with neutral link on ratings as shown on the Drawings. They shall be air break, trip free, draw-out type with mechanical and electrical ON/OFF indicators.

C. All air circuit breakers shall be electrically operated by automatic motor wound spring mechanism. A standby manual operating handle shall be provided for operating the circuit breaker in case of power or motor failure. The supply to the motor shall be 60 V DC.

D. The air circuit breaker shall be provided with over current, short circuit and earth fault protection having the following characteristics:
   1. adjustable long time delay current setting (50 to 150 percent) with varied tripping time;
   2. adjustable short time delay current setting (400 to 1000 percent) with variable tripping time;
   3. instantaneous tripping for heavier over current adjustable from 400 to 1600 percent of base current;
   4. adjustable earth fault trip current setting (20 to 60 percent) with variable tripping time.

E. The circuit breaker shall have three positions on the draw-out mechanism, namely service position where all main and auxiliary contacts are made, test position where main contacts are open but auxiliary contacts are closed and isolated position where all contacts are open. An indicator shall clearly show these positions and provisions shall be made for locking the breakers in any position. ON/OFF indicator shall be provided.

F. Mechanical interlocks shall be provided to prevent withdrawing or inserting of the breaker when it is 'ON'. Any attempt to do so shall trip the breaker automatically.

G. The withdrawable part of the circuit breaker shall be effectively connected to earth through

scraping contacts that shall make before and break after the main and auxiliary contacts.

H. The moving contacts comprising the main and arcing contacts shall be of the spring loaded, self-aligning type. The arc contacts shall be arranged to make before and break after the main contacts.

I. Each ACB shall be included but not limited with following components and accessories:
1. auxiliary contacts;
2. arc chutes;
3. folding extension rail;
4. charging handle;
5. open and close pushbuttons;
6. over current trip indicator;
7. keylock on trip button;
8. spring charge condition indicator;
9. breaker position indicator;
10. making current release;
11. automatic shutters for the b/b terminal;
12. carriage for every size of ACB exceeding 25 kg in weight;
13. operation counter.

J. The main incoming circuit breakers shall be provided with cable boxes to suit the incoming cables from the transformers.

K. Circuit breakers shall be tropicalized to operate continuously in the specified ambient temperature and high relative humidity.

L. Type test certificate for each size of circuit breakers and MCCB's from an internationally recognized testing authority acceptable to the Engineer shall be provided.

2.02 Moulded Case Circuit Breakers

A. MCCBs shall have a combination of thermal and magnetic tripping giving an inverse time delay protection against sustained overloads and instantaneous tripping under heavy overloads and short circuits.

B. Breakers shall have a quick make, quick break over-centre switching mechanism that is mechanically trip free from the handle so that contacts cannot be held closed against short circuits and abnormal current.

C. Tripping due to overload or short circuits shall be clearly indicated by the handle assuming a position mid-way between the manual ON and OFF position.

D. Latch surfaces shall be polished.

E. Poles shall be constructed to open, close and trip simultaneously.

F. Ampere ratings shall be clearly visible.

G. Breakers shall be completely enclosed in a moulded case to IEC No. 157 - 1A, suitable for installation inside switchboards.

H. Non-interchangeable trip breakers shall have the trip unit sealed.

I. Breakers with earth leakage relay protection shall be provided with shunt trips.

J. Frame sizes shall be as per manufacturer's standard size and as approved by the Engineer.

K. The magnetic trip shall be adjustable type for rating 200 A and above.

2.03 Miniature Circuit Breakers

These shall be suitable for the type of load they feed. They shall be fault rated so that fuse backup protection is not required. They shall be rated in accordance with BS EN 60898. They shall include the following minimum features:

1. magnetic and thermal trip elements;
2. trip-free mechanisms;
3. locking of facilities with detachable proprietary brackets and clearly marked ratings;
4. trip healthy pushbuttons to test the trip circuit.

2.04 Fuses

A. Fuses shall be the high breaking capacity (HBC) type to BS 88.

B. The fuse shall either include a suitable fuse carrier or it shall be capable of isolation. If the fuse carrier is included it shall be such that when it is being withdrawn normally or when it is completely withdrawn the operator is completely protected from accidental contact with any live metal of its fuse link fuse contacts and fixed contacts.

C. If the fuse is capable of isolation it shall be so interlocked with the switch that isolation is complete before the fuse enclosure can be opened further. The switch shall be prevented from closing while the fuse-cover is open.

Part 3 - Execution

3.01 Testing

A. All overcurrent protective devices shall be tested both at the manufacturer's works and on site in accordance with Section 16425.

B. Test certificates or type test certificates shall be provided for all devices.

END OF SECTION 16475

Section 16481

Variable Speed Drives

Part 1 General

1.01 Description

A. Variable speed drives shall be of the electronic, pulse width modulating (PWM) variable frequency type with an output suitable for controlling standard industrial squirrel cage motors, with a synchronous speed of 750 rpm, unless otherwise specified.

B. Unless otherwise specified, the invertors and associate control equipment shall be housed within a cubicle forming part of the relevant motor control centre. The inverter cubicle shall be considered as a starter and generally comply with the requirements for motor starter cubicles.

C. Unless otherwise specified, the load characteristic should be taken to be "pump-type" with variable torque.

1.02 Standards

A. The drive shall conform to the requirements of IEC 600146, IEC 61800-1, IEC 61800-4.-.

B. The drive shall comply with EMC requirements such as EC directive 89/336/EEC.

C. The drive shall conform to the guidelines outlined in the Electricity Association, London, Engineering Recommendation G.5/3, IEEE 519, IEC 61000-2-4 regarding harmonic distortion. The level of total harmonic distortion shall not exceed 5 percent and or be subject to these standards.

1.03 Quality Assurance

The supplier's manufacturing facility shall be certified to ISO - 9001 series of standards.

Part 2 Products

2.01 Ratings

A. Rated input voltage = 11kV, 6.6kV, 3.3kV or 400 V ± 10 percent, 3 phase, 50 Hz ±5 percent.

B. The incoming line power factor shall range between 1.0 and 0.95, lagging, over the entire operating speed range.

C. The drive shall be capable of being stored at a temperature between -40°C and 70°C.

D. The drive shall be capable of operating in ambient temperature between 0°C and 50°C with a relative humidity of up to 95 percent (non-condensing).

E. The drive shall be capable of operating at altitudes up to 200 m above sea level.

F. The drive shall be capable of operating at a minimum efficiency of 95 percent at full load and full speed.

G. The rating of the drive unit must be sufficient for the continuous maximum rating of the motor and not its running load.

2.02 Design Characteristics

A. The VSD shall have a fixed and alternatively variable V/f curve characteristic for centrifugal applications such as pumps and fans.

B. The VSD shall be capable of varying the motor speed from a maximum speed at full load and at any intermediate speed down to 10 percent full load speed.

C. The drive shall be designed to be selectable for variable or constant torque. When selected for constant torque, the drive shall supply 150 percent of rated current for up to one minute. When selected for variable torque the drive shall supply 115 percent of rated current for up to one minute.

D. The VSD shall employ a pulse width modulated (PWM) inverter system with IGBT, IGCT, SGCT –or other type transistors to minimize audible motor noise and increase overall performance.

E. The drive shall be designed to have an adjustable PWM carrier frequency with a minimum range from 2k Hz to 8k Hz to minimize audible motor noise.

F. The drive shall be optimized for 4 kHz switching frequency at 44 kW or less and 2 kHz at 55 kW and larger.

G. The drive must be capable of switching on to a motor already rotating in either direction.

H. The starting arrangement must include a ramp speed control, to achieve starting currents not exceeding normal full load current.

2.03 Control System

A. The drive shall be arranged for either manual or automatic speed control.

B. Manual speed control shall be by means of a hand adjusted potentiometer.

C. In the automatic mode, the drive shall have an integrated PID control system as standard to accept 4 to 20 mA external signals coming from sensors and transducers in pumping applications.

2.04 Controller Keypad

A. The drive controller shall incorporate a user friendly programmer keypad having LCD "Plan Language Text Display" with "Help" feature to enable easy drive diagnostics and setting up of various parameters without reference to an instruction manual. Complete configuration of the drive shall be possible through the keypad.

B. All parameters shall be password protected to prevent tampering and unauthorized changes.

2.05 Communications Interface

The drive shall incorporate a~~n~~ Profi-bus/MOD-bus fibre optic communications interface to allow full drive control, programming, monitoring and diagnostics, including access to history record.

2.06 Fault Detection

The drive shall keep a record of the last ten trips, plus a 100 sample history record of up to ten pre-defined parameters to enable fast diagnosis and minimum down time. Automatic printout of history record to a serial printer shall be an available feature.

2.07 Protection Features

A. The drive shall incorporate the following protective functions:
   1. active limiting of fundamental current by frequency fold back on acceleration loads and frequency hold on decelerating loads;
   2. overcurrent protection;
   3. short circuit protection;
   4. fast acting supply fuses;
   5. dc intermediate bus under voltage;
   6. dc intermediate bus over voltage;
   7. power section over temperature;
   8. earth fault protection without damage;
   9. power section faults.

B. The drive shall be protected against supply-phase loss and mains discontinuity.

C. The drive shall have a selectable auto-restart after trip.

D. The drive shall be designed to shut down with no component failure in the event of any of the above fault conditions arising.

2.08 Emergency Stop Control

A. The drive shall incorporate facilities to allow the connection of an Emergency Stop Push-button to ensure effective direct stopping of the drive if dangerous situations arise. The means provided should include direct connection to an air-break device e.g. a contactor, arranged such that its opening on-load:
   1. Does not inhibit any in-built deceleration provided by the variable speed controller.
   2. Does not produce additional safety hazards.
   3. Does not cause damage to the controller.

B. Such contactors shall be to BS EN 60947-4-1 with utilization category AC-3.

2.09 Drive Enclosures

A. Drive enclosures shall generally be fabricated in accordance with the requirements for motor control centres specified in Section 16425.

B. The drive enclosure shall have a protection rating of IP 31 minimum to BS EN 60947-1.

C. Where necessary, forced cooling and shall be provided incorporating a visual indication on the front of the cubicle door in the event of a cooling system failure.

D. Anti-condensation heaters shall be provided with a thermostat and have OFF/AUTO control on the cubicle front door. The heater shall not be in operation when the inverteer is functioning.

Part 3 Execution

3.01 Documentation

A. The following documentation shall be provided:
1. load de-rating;
2. harmonic distortion;
3. circuit diagrams;
4. maintenance instructions;
5. fault diagnosis;
6. parts list with part numbers;
7. commissioning instructions.

B. A recommended spares list for two years continuous operation on completion of the defects liability period shall be submitted at the time of tender. Where multiple, identical units are being supplied a rationalized list, i.e. not a summation of individual drives, requirements, should be produced.

3.02 Commissioning

A. The manufacturer of the drive system shall have a factory trained service representative residing in the country for commissioning, programming and to provide training and after sales service.

B. The representative to be trained in the installation, maintenance and trouble-shooting of the equipment specified and to assist the contractor to set-up the variable speed motor drives and controls.

3.03 Training

A. The AC drive manufacturer to provide for an on site training program for building operating personnel. This program to provide operating and instruction manuals, training in equipment operation and troubleshooting of the AC drive. The training program to include, but not be limited to:
1 instruction on the basic theory of pulse width modulation control;
2 instruction on the layout of the variable frequency controller indicating the location and purpose of each component;
3 instruction on troubleshooting problems related to controller;
4 installation and removal of printed circuit boards;
5 actions to take under failure of controller;
6 necessary cleaning of component parts.

END OF SECTION 16481

Section 16500

Lighting

Part 1 General

1.01 General

This section includes the supply and installation of lighting fittings as shown on the Drawings and described in the Particular Specifications.

1.02 Reference Standards

Applicable standards referred to in this section:
BS 800; Radio Interference
BS 1853 Tubular Fluorescent Lamps for General Lighting Service.
BS 2818; Part 2 Fluorescent Chokes
BS 3677 Mercury Vapour Bulbs
BS 3772 Fluorescent Starters
BS 4017 Capacitor
BS 4533 Lamp Fittings
BS 4782 Mercury Vapour Chokes
BS 6702 Tube and Starter Bases

1.03 Quality Assurance

Design Criteria:

1 Lighting fittings shall be of first class quality, made by approved manufacturers and shall be suitable for trouble free operation on the system voltage at the site.
2 Lighting fittings shall be complete with internal wiring between lamp holder and termination point. Wiring shall be in silicone rubber insulated flexible cables of appropriate sizes.
3 The Contractor shall be responsible for coordinating the work of this Section with the components of ceiling systems specified under Division (9) of this Specification.
4 All lighting fittings shall be complete with accessories and fixing hardware necessary for installation whether so detailed under fixture description or not.
5 Outdoor lighting fittings shall be installed at mounting heights as specified or instructed on site by the Engineer.
6 All outdoor lighting fittings shall be suitably constructed and protected to withstand the corrosive atmosphere and high ambient temperature of the site, whether indicated under the fittings description or not.
7 Lighting fittings shall have power factor not less than 0.9.
8 All light fittings shall be earthed.

1.04 Submittals

A Products Data

1 Fluorescent fittings and other electrical discharge lamp fittings, submit:
a full technical details of the fittings, including the control gear, indicating the type and size of materials used in construction;
b relevant sheets of manufacturer's catalogues and dimensional drawings of the fittings, clearly showing the location of the component;

c wiring diagram of international connections indicating colour, size and type of wiring;
d confirmation that control gear is suitable for prolonged and continuous service in the ambient conditions described in Section 16010;
e the power factor under operating conditions and illumination data sheets;
f type and quality of any plastic materials used in the fittings.

2 Other lighting fittings, submit:
a full technical details of the fittings, with relevant manufacturer's catalogues and illumination data sheets;
b type and quality of all metal finishes;
c size and quality of all glassware.

3 At least one piece of each of the lighting fixtures originally specified shall be submitted and displayed at the project office for comparison in the event an alternate make is offered unless otherwise specified.

Part 2 Products

2.01 Lamps

A Lamps shall be furnished and installed in all lighting fixtures covered under the Contract.

B Lamps used for temporary lighting services shall not be used in the final lamping of fixture units.

C Lamps for permanent installation shall not be placed in the fixtures until so directed by the Engineer, and this shall be directly before the building areas are handed over.

2.02 Fluorescent Lamps

A Tubular fluorescent lamps: to BS 3677, sizes as indicated.

B Tube colour: cool white, unless otherwise indicated.

C Fittings shall comply with BS 800: 1983 for suppressing radio frequency interference.

2.03 High Pressure Mercury Vapour Lamps

A Wattage as indicated.

B Colour: Deluxe white

C Lumen output of lamp after 100 burning hours shall not be less than:

50W	:	2000 lumen
80W	:	3850 lumen
125W	:	6500 lumen
250W	:	14000 lumen

D Burning position: Universal

2.04 Control Gear for Fluorescent Lamps

High frequency electronic ballasts not less than 25 kHz to IEC 928

2.05 Lamp Holders

A According to BS 5042 and BS 6702.

B SBC, BC GES, Bi-pin, etc. as necessitated by the lamp cap.

C Edison screw lamp holders: to be designed so that the lamp cap only makes electrical contact when fully screwed home and to have means to prevent the unscrewing of the lamp due to vibration or similar cause.

D Lamp holders for fluorescent lamps shall be the spring loaded rotor type for use with bi-pin lamps

2.06 Outdoor Lighting

A Compound lighting shall involve the supply and installation of lamp posts, 3 phase underground distribution, high pressure sodium vapour lamps and the relevant control and distribution boards as shown on the Drawings.

B Lamp posts shall be as detailed in the Particular Specifications or as shown on the Drawings.

C The general layout for the conduits and the approximate positions of the handholes and or related manholes shall be clearly shown on the Contractor's submittal. Conduits shall be either galvanized steel or PVC and shall be laid straight between handholes at 600 mm depth and on the centre line on the handholes.

D The distribution and control boards for the faculty lighting shall have 3 phase supplies, with lamp circuit controlled by timer and photo cell switches at the location shown on drawing. All control switches for the lighting circuits shall be permanently and legibly labelled. Override switch shall be provided to enable manual switching for individual circuits.

2.07 Lighting Fittings

All lighting fittings shall conform to BS 4533 and shall be supplied complete with appropriate control gear where necessary, lamps, mounting and fixing accessories etc. whether explicitly mentioned in the description of each light fitting or not. All the fittings shall have the same appearance, material, technical details and approximate dimensions.

Part 3 Execution

3.01 Lighting Installation

Terminations:

1 General fluorescent fittings mounted direct to conduit outlet boxes shall have the circuit wiring run direct to the fittings terminal position. Provide flexible conduit pigtail for all fixtures to J-box.
2 Terminations for recessed or semi-recessed pattern fittings fitted in false ceilings shall have the circuit wiring terminal above the ceiling in a ceiling rose outlets mounted adjacent to the fitting.

3.02 Installation of Lamps

A Install lamps in all lighting fixtures at substantial completion.

B Do not use lamps used for temporary lighting in the permanent installation.

END OF SECTION 16500

Section 16610

UPS System

Part 1 General

1.01 Description

This specification sets out the requirement of the UPS system. The work comprises the supply and installation of all services, equipment, components, accessories and fittings required for the operation of the UPS system.

1.02 Quality Assurance

A The equipment to be furnished shall be new and shall be a standard product of a manufacturer experienced in the design, fabrication and construction of UPS systems. The manufacturer shall demonstrate to the Engineer from operating installations of equal or larger capacity utilizing equipment such as herein, that all the features and appurtenances of the equipment will operated satisfactorily for the purposes intended. All equipment furnished under this Section shall be demonstrated to the satisfaction of the Engineer that the quality is acceptable.

B The Tenderer shall submit a list of customers to whom this equipment has been supplied, with dates and value of contract.

Part 2 Products

2.01 Battery Power Supplies

A Battery power supplies shall be suitable for operation with the battery system and voltage specified. The battery charger assembly shall be solid state constant potential incorporating a self-protecting current limiting feature for protection against low battery voltage short circuit or reverse polarity connection to the batteries.

B The charger shall have controls for:
1 on/off
2 float/boost charge
and indication of:
3 automatic high rate charge
4 rectifier failure
5 high dc voltage
6 low dc voltage
7 battery voltage
8 output current.

C Volt-free contacts shall be provided for remote signalling of common alarm.

D The charger shall incorporate an automatic high rate charge circuit to be initiated manually or by operation of the rectifier current limit for a period of time. This shall automatically bring the battery system, over a site adjustable time period, to float charge level.

E Batteries shall be cathode absorption seal type or nickel cadmium type designed, constructed and tested in accordance with IEC 623.

F Batteries shall be contained within translucent impact resistant flame retardant polypropylene cases. They shall be designed for low maintenance and shall have a life in service of at least 20 years.

G The batteries shall be suitable for use on switchgear and circuit protection applications.

H Batteries shall be housed within the battery charger enclosure or within a separate battery enclosure. The cells shall be arranged in tiers to enable a rapid visual check of electrolyte level and access for maintenance. Terminals shall be shrouded to prevent accidental contact. The battery enclosure shall be corrosion resistant and ventilated to prevent the build-up of gases.

I The battery installation shall be supplied complete with all tools etc. necessary for the safe and efficient maintenance of the batteries.

J Warning notices shall be provided for wall mounting to warn of the presence of charge gases.

2.02 Un-interruptible Power Supply (UPS)

A The UPS shall be floor mounted, self-contained and metal clad and shall be suitable for supplying a non-linear load. It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.

B The UPS shall be an on-line type incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply. The UPS shall incorporate a dc under-voltage trip circuit to electronically trip the UPS output in order to protect the batteries.

C The noise level of the unit shall not exceed 60 dB (A) at 1 m from the UPS cabinet.

D The output of the inverter shall be a sine wave having less than 2 percent THD for linear loads and less than 4 percent for 50 percent non-linear load. It shall be suitable for load power factors 0.7 lag to 0.9 load.

E The unit shall have a dynamic response such that a 100 percent step load causes an output voltage transient of less than ± 4 percent with a recovery time of less than 4 ms.

F For three phase output units the output voltage shall not vary by more than ± 1 percent for an unbalance of 10 percent.

G The load crest factor shall not be less than 3:1.

H The efficiency at full load and 0.8 power factor shall be greater than 88 percent.

I The unit shall incorporate a monitoring and diagnostics system to provide an audible alarm to provide warnings and fault indication.

J The following parameters shall be monitored:
1 inverter output voltage
2 battery voltage
3 static bypass voltage
4 output current
5 inverter output frequency
6 available battery bridging time at rated load
7 available battery bridging time depending on actual load.

K Indicators to indicate:
1 UPS status
2 UPS alarm conditions

L It shall be possible for operations and maintenance personnel to determine the cause of UPS failure by viewing a fault annunciation display or by interrogation of a `user friendly' integral key pad and display unit.

M The UPS shall have an emergency power off facility. This shall be operable both locally and remotely. A 24 V dc emergency shutdown relay shall be provided to accept the remote shut down signal.

N The UPS shall be required to be manually reset after operation of the emergency shutdown.

O The UPS shall provide a volt free contact output to indicate:
1 warning, ie low battery capacity
2 fault
3 static bypass in use.

P The UPS shall have an overload capacity of 150 percent for 30 seconds and shall be protected in the event of a short circuit of the output.

Q The radio interference level shall be equal to or better than suppression degree `N' as defined in VDE0875.

R The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable for location adjacent to the UPS.

S The batteries shall be of the maintenance free sealed for life lead acid type.

T Batteries shall be contained within translucent impact resistant flame retardant polypropylene cases. They shall be designed for low maintenance and shall have a life in service of at least 10 years.

U The cells shall be arranged in tiers to enable a rapid visual check of electrolyte levels and access for maintenance. Terminals shall be shrouded to prevent accidental contact. The battery enclosure shall be corrosion resistant and ventilated to prevent the build-up of gases.

V The battery installation shall be supplied complete with all tools etc. necessary for the safe and efficient maintenance of the batteries.

W Warning notices shall be provided for wall mounting to warn of the presence of charge gases.

X The battery supply to the UPS shall be via a fused load break switch disconnecter circuit breaker.

Y The battery recharge time to 90 percent of full charge shall be approximately ten times the discharge time at full load.

2.03 ac Power Supplies

A ac stabilised power supplies shall be based on the ferro-resonant, saturable reactor transformer principle. They shall provide a regulated and filtered voltage power supply.

B They shall be maintenance free and have a short circuit current limit of 2 times rated current.

C Output voltage regulation shall be better than ±1 percent for steady state and ±3 percent for transient input voltage variation of ±15 percent. Harmonic distortion shall not exceed 3 percent.

D A change of supply frequency of one percent shall not produce a voltage change in excess of 1.5 percent.

2.04 dc Power Supplies

A The power supplies will operate from 230 V ac, and produce a 24 V dc output voltage at full load current.

Voltage regulation	0.02 percent for ±10 percent mains voltage variation
Load regulations	0.3 percent from zero to full load conditions
Ripple at full load	<1 mV rms
Noise	<5 mV to 10 MHz.

B The power supply shall incorporate an overvoltage protection circuit, the components of which shall be independent of the voltage regulating circuit.

C The protection circuit shall operate within 50 ms of an overvoltage occurring, and shall cause rupturing of the mains input or output fuses.

D Automatic reset of the overvoltage protection circuit is not permitted.

E For a 24 V power supply, the overvoltage tripping setting shall be 28 V.

Part 3 - Execution

3.01 Testing

A. All equipment shall be tested both at the manufacturer's works and on site.

B. Test certificates or type test certificates shall be provided for all devices.

END OF SECTION 16740

Section 16620

Standby Diesel Generator Set

Part 1 General

1.01 Description

The Contractor shall supply, install, commission, test and handover in good operable manner including two years guarantee and maintenance. Upon mains failure, standby diesel generator set starts automatically as indicated on the drawings. The set shall be complete with diesel engine, generator, control panel, batteries, starting motor, built-in or separate air cooled radiator, daily fuel storage tank and all other accessories as specified.

1.02 Referenced Standards

Applicable standards referred to in this Section

BS 5514, JIS B 8002, 8005, 8014	Engines
BS 4999, JIS C 4004, JEC-114, JEC-2131, JEM-1354	Alternators

1.03 Quality Assurance

A The generator set shall be the product of a single manufacturer regularly engaged as a manufacturer of such equipment. All the diesel generator installation work shall be carried out by a diesel generator sub-contractor. Diesel generator sub-contractor shall be one who is normally an agent representing one or more of the approved makes of diesel/generator sets. Diesel generator installation shall be supervised, checked and tested by a qualified representative of the manufacturer and hand-over the works in perfect running order to the satisfaction of the Engineer.

B Test the combined engine generator set at the factory and submit the certified test copies of all tests to the Engineer for his approval.

C The manufacturer should have a local agent who is well experienced in installation and maintenance of diesel generators of the size specified herein. The agent should have been associated with the manufacturer for a minimum period of five years.

D Design Criteria

1 All materials and equipment shall comply with relevant IEC, JIS and BS specifications as regards quality of materials, performance and proving tests.

2 The emergency power supply system and its components shall be such as may be properly maintained and serviced without the necessity of carrying expensive spare part stocks, or being subjected to interrupted service due to the lack of spare parts.

3 Emergency generator set shall be designed to allow easy replacement of major items subject to wear.

1.04 Submittals

A Shop Drawings

1 Submit a complete wiring diagram for the generator set, drawn on a single standard size sheet, showing the following:

a All components of:

1. engine starting control
2. engine alarm
3. generator control
4. battery
5. battery charger
6. earthing
7. transfer switch control relays

b Interior wiring, terminals and interconnecting wiring.

c Certified dimensions and weights.

2 Submit a composite wiring diagram of the entire emergency transfer system showing all wiring between the engine starting panel, engine generator set and the automatic transfer switches.

3 Wiring diagrams shall clearly show:

a main current conductors, in heavy lines.

b control conductors, with colour and/or number coding.

c location of relays and apparatus.

d description of function, type and catalogue, of all components.

4 Alternator Control Panel

Submit a schematic line diagram showing:

a interlocks

b protection

c instruments

B Product Data

1 Submit curves showing the actual performance of a similar engine (same model, stroke, etc.) to that proposed, superimposed on the standard published performance curves for continuous, and maximum operation.

2 Submit the following information together with manufacturer's catalogues:

Generating set manufacturer

Name and Address

Generating set Model No

a Diesel Engine:

1. Manufacturer’s Name and Address:
2. Type of Engine & Model No.
3. Output:
4. at N.T.P. as specified:
5. Percent derating for engine:
6. Revolutions R.P.M.:
7. Bore x stroke mm x mm:
8. Mean effective pressure kg/sq.cm:
   - full load g/kWh:
   - at 1/2 load g/kWh:
9. Recommended lub. oil capacity-litre:
10. Lub. oil temperature at full rated output under specified conditions:
11. Design working range of cooling jacket water temperature Deg.C.:
12. Turbo charged or not?
13. Max. outlet cooling water temperature from engine at full rate output when air temperature inlet to radiator is Deg. C:
14. Safety control setting of cooling water outlet temperature Deg. C
15. Type of Governor:
16. Starting Motor
17. Number of starting motors:
18. Engine Weight kg.

19. Alternator Weight kg.
20. Complete set weight (Engine plus alternator plus common bed) kg.
21. Overall length of set
22. Overall length of set
23. Overall width of set

b Radiator:
1. Manufacturer's Name & Address:
2. Type of Radiator
3. Tube material:
4. Fin or fin core material

c Fuel System:
1. Fuel injection pump type and manufacturer's name & address
2. Fuel tank (daily service) (height; width; depth; storing capacity; material).

d Alternator:
1. Manufacturer's Name & Address:
2. Model No
3. Rated voltage
4. Rated frequency .
5. Power factor
6. Rated output kW under local conditions
7. Rated current
8. Efficiency %
9. Speed rpm
10. Type (brush or brushless)
11. Alternator field voltage
12. Alternator field current
13. Alternator field power
14. Enclosure
15. Class of insulation
16. Maximum temperature rise ^{o}C
17. Suitability for paralleled operation

e Exciter
1. Manufacturer's Name and Address
2. Type and Model No.
3. Rated current
4. Rated voltage
5. Rated power
6. Type of automatic voltage regulator
7. Maximum temperature rise ^{o}C.
8. Enclosures
9. Class of insulation

f Starting Battery:
1. Manufacturer's Name & Address
2. Type
3. Normal voltage DC
4. Terminal voltage when floating DC
5. No. of cells
6. Normal capacity
7. Normal charging current
8. Normal voltage per cell DC
9. Final discharge voltage per cell volts DC
10. Material:
    a. Positive plate

b. Negative plate
c. Separator material
d. Electrolyte material
e. Specific gravity of electrolyte

g) Control Panel:
1. Manufacturer's Name & Address
2. Type
3. Dimensions (height; width; depth).
4. Other Details

h. Service Facilities
1. Indicate the nearest location from which service facilities and spare parts may be obtained after the guarantee period.

C Operation and Maintenance Data
1 Submit certified copies of data obtained during factory tests of the engine generator test.
a Manuals for generator set.
b Detailed instruction books.
c Operator's manuals.
d Maintenance schedules.
e Parts catalogues.
2 Submit the following:
a Complete instruction covering the operation of the engine generator set and associated equipment.
b A manual covering engine operation and maintenance.
3 Fix one copy of the composite wiring diagram of the emergency transfer system inside the transfer switch compartment door and another in the generator control panel.

Part 2 Products

2.01 Emergency Generator Set

A The set shall be of rugged reliable design and built for long trouble free service under the worst specified climatic conditions and made by an approved reputable manufacturer.

B The rated output shall be as indicated on the drawings, 240/415 V, 3 phase and 50 Hz. The rated output shall mean the net full continuous de-rated output at the specified ambient temperature and at relative humidity of 95 percent. The set shall also be capable of 110 percent load for one hour and 150 percent load for one minute under these conditions at the rated speed without undue heating of the engine or alternator including AVR and the exciter and without mechanical or electrical troubles.

C Diesel Engine
1 The diesel engine shall be of the stationary heavy duty, turbo charged compression/ignition, multi cylinder 4 stroke operation. The steel base frame shall be provided with spring type vibration isolators. The engine shall be able to deliver full load in the shortest possible time after start. The engine speed shall not exceed 1500 rpm. The engine construction shall be in such a way as to allow for dismantling of any engine component for inspection or repair without undue complication i.e. without dismantling of other non-defective parts. The crank-case shall be provided with inspection windows.
2 The diesel engine shall be equipped with starting system detailed hereunder and as per Engineer's approval.

a The engine shall be started by a 24V, DC starting motor automatically engaging with engine flywheel and positively dis-engaging on engine starting.
b The engine starting control equipment shall be arranged to disconnect the battery charger to prevent it from being over-loaded during starting. The starter motor shall be of adequate power of its duty.
c Batteries for starting shall be of the nickel cadmium type, 24V, heavy duty diesel starting type and of sufficient capacity to provide continuous cranking of 1.5 minute duration without recharging. Batteries should have sufficient capacity to provide five successive starts.
c The batteries shall be filled with electrolyte an installed on proper racks with cables and clamp. A hydrometer shall be supplied with the batteries.
d The battery charger shall be static type enclosed in an adequately ventilated sheet steel case and incorporated within the control panel with its associated instruments and controls mounted on front of panel.
e The charger shall be complete with all necessary relays, cutouts, controls, switches and instruments for automatic charging of batteries. The charger shall automatically control the charging rate to suit state of battery thus charging at high rate following a period of use of battery and, when battery nearly fully charged, reverting to trickle charging automatically.
f An ammeter and voltmeter in the control panel shall indicate the state of the battery and its charging rate.

3 Cooling System
a. Radiator: built-in type or separate type with sufficient capacity to dissipate the total joules per hour rejected by the engine cooling system at 110 percent full load.
b. Blower fan: to have sufficient pressure to circulate required quantity of air for engine cooling. The fan shall be provided with a suitable guard. D/G room inside temperature should not exceed 50 ^{o}C.
c. If specified jacket water heaters shall be provided on the engine to facilitate quick starting under low ambient conditions.
d. The cooling system shall be capable of keeping the temperature of cooling water at safe limits at all conditions of load required in the specifications. Maximum temperature of cooling water after 10 hours of continuous running at full load at worst climatic conditions at the project site shall not exceed the maximum temperature limits of the diesel engine.
e. The cooling system shall include an engine shaft driven circulating water pump. The water jacket of the engine cylinder shall be so constructed that the water in the jacket can be drained completely.
f. The radiator finned tubes shall have a common inlet and common outlet headers.
g. A drain valve and a filling valve shall be provided to the radiator for flushing and quick filling.
h. If specified the radiator shall be equipped with suitable rated immersion heater with integral thermostatic controls in order to prevent freezing when standing idle during cold climate. Cooling water piping, complete with all necessary supports; control valves, flanges and fittings, thermometers, pressure gauges, relays etc., shall be supplied and installed to form a complete engine water cooling line. Piping shall be as of B.S. 1387.
i. The pump discharge valve shall preferably be a globe valve, the other valves shall be (sluice) gate valve.

4 Fuel System
a. The engine shall be suitable for running on diesel oil as described below:

Specific gravity at 60F distillation (P.P. 123/40)	0.834
IBM	219 C
10%	250 C

50%	276 C
90%	314 C
F.E.P.	342 C
Flash Point PME	189 C
Sulphur	1.1%
Calorific value B.T.U./lbs gross carbon residue.	19750
0.01/wt diesel index	62
Viscosity redwood seconds at 100F	34

b. Fuel supply to the engine shall be maintained by a separate day tank located in the room. Daily fuel tank shall be sufficient capacity for continuous run of 8 hours at full load, and shall be fitted with strainers (see filters), control cocks, drain cock, piping to the engine and a level indicator with alarm contacts, vents and all other necessary fuel lines and fittings.

c. Duplex Diesel Oil Pumping Set

1. Provide packaged type duplex fuel oil pumping and straining set with a capacity of four times the total fuel consumption of engine at full load. Pump sets shall be factory assembled, piped, wired and tested. Pumps shall be activated by a switch in the day tank automatically. All pumps installed in the diesel generator room shall be flame-proof and fire-resistant.
2. Piping shall be complete to suction, discharge and return line connections. Provide gate valves and unions arranged to permit removal of either pump while the system is in operation. Install check valves and relief valves on pump outlet and gate valves prior to pressure gauges.
3. Suction strainer shall be flanged connection, duplex type, one-piece, cast-iron body, ASTM A48 Class 30, with 1.2 mm perforation brass baskets.
4. Oil pump set shall be factory assembled on a structural steel channel beam base to include pumps, motors, flexible couplings and guards. Pump set shall be suitable for diesel oil.
5. Suitable manually operated pump shall be provided.

d Tank Gauges

Each gauge is to be provided with an aluminium case and calibrated to indicate level of fuel in the tank. Mounted on gauges shall also be a high/low level alarm switch. The switches and gauges shall be designed for a 230 V single phase, 50 Hz system. Locate indicating gauges as shown on the Drawings or required. Tank fittings and pressure fittings shall be made of solid bar stock to prevent leak possibilities.

e Fuel Oil Piping

1. Provide all diesel fuel oil piping from storage tank to day tank fill lines, water tight fill boxes, vents, vent caps, tank foot valves, and accessories.
2. Provide swing check valves and gate valves at pump inlets. Provide approved anti-siphon valves at high points of suction lines. Provide whatever additional valves that may be required by local regulations.
3. All piping shall be provided with ground joint unions at piece of apparatus to facilitate connecting and disconnecting.
4. All piping, unless otherwise specified, shall be schedule 40 standard weight black wrought iron pipe.
5. Steel vent pipelines shall run from the fuel oil storage tanks, carried to the proper height within building construction and terminating with vent fittings. Fittings shall be "Bronze Ventilating Brick" with thickness of 20 mesh bronze wire gauge in front of louvered opening.

5 Lubricating System

a. The lubricating oil system shall be forced fed type. The details of the system shall be included in the offer. The shaft bearing lubricating shall be directly fed from the lubricating oil pump and not through the main bearings. The lubrication system

shall be positive displacement type. By-pass arrangement should be provided in case of filter clogging.

b. The lubricating oil shall be of a type readily available in the project country.

c. A heat-exchanger shall be provided for cooling the lubricating oil and this shall be of long-life type i.e. the system shall not require constant cleaning or other maintenance work. A valve for taking oil sample shall be provided. The coolant for the above shall be jacket water of the engine. That is, the cooling system of the engine and the lube-oil heat-exchanger cooling system shall work in parallel or in series. If the lube-oil pressure reaches low value, the engine shall be shut down automatically and also immediately should give audible alarm together with visual indication. The lube-oil system shall be provided with means to monitor pressure at important points at the engine-monitor panel.

d. Suitable manual-pumping arrangement for easy draining of the whole quantity of lube-oil into a drum shall be provided.

6 Exhaust System

a. Exhaust pipes shall be of Schedule 40 black steel and of adequate size to ensure that back pressure does not exceed the value specified by the manufacturer.

b. The exhaust pipe shall be connected through airtight flexible coupling to the engine.

c. Exhaust pipes shall be adequately lagged with 75mm thick (minimum) rock wool covered with aluminium sheaths so that to take care of exhaust gas temperature in pipes exceeding 500 ^{o}C. When exhaust pipes pass through walls or roof a suitable weather-proof sleeve or thimble shall be provided to isolate exhaust pipe from the building. A silencer of heavy duty residential type shall be provided in the exhaust system and it shall also be lagged. The operation of casting the sleeves in the concrete, if required, will be carried out by civil contractor.

d. Exhaust pipes and silencers shall be supported from the ceiling by special vibration isolating hangers and the pipe shall be slanted away from the engine and a condensate trap fitted at the lowest points. Approved rain caps shall be installed at the discharge end of the exhaust pipes on the roof.

e. Suitable flexible expansion joints shall be provided along the pipe run to take care of expansion requirements.

7. Filters

Cleanable/replaceable elements should be provided.

a The fuel oil system shall have a primary fuel filter of ample capacity to prevent all particles of 10 microns size or smaller and a secondary filter to prevent all particles down to 3 microns size or smaller, fitted before the fuel injection pumps.

b The lubricating oil system shall have full flow filters of sufficient capacity.

c Air is inducted to the engine manifold through a pre-cleaner and large capacity air cleaner. Both filters are required due to severity of dust storms and dust suspensions in the air. The engine exhaust line shall be fitted with flexible fitting efficient silencer to give efficient silencing with minimum back pressure and terminated outside the engine room.

8. Ventilation

Metal louvers with metal cleanable filters shall be provided for outside air intake into the engine room. Filters shall be permanent heavy duty metal cleanable type minimum 100 mm thickness. Filters to be sized to perform their duty with a face velocity are not more than 100 m/min when engine is running. Filters are to be installed in an appropriate arrangement on the room walls. Total filter area shall consider air for engine intakes and radiators cooling. Filters with handles and latches shall be provided.

9. Governing System

a The engine shall run steadily at any load within its rating at its rated speed, and the changes in speed due to change in load shall comply with BSS 5514/77 for Class A1 or with ISO 3067.

b The governor should be of the electronic type to comply with BS 5514/77 Class A1.

10. Coupling and Common Bed
    a The engine and the alternator shall be suitably coupled directly without interposing gear arrangement.
    b The common bed shall be provided with suitable damping devices for fixing to the floor.
    c The engine vibration shall be the minimum possible and shall comply with the relevant BS. The vibratory force induced as the engine passed through resonance revolutions during starting and stopping period shall not cause any damage to the whole system.
11. Engine Monitor Panel
    a Each engine shall be provided with a monitor panel adequately isolated from vibration which shall contain facility to monitor the following:
        1. engine speed
        2. temperature
        3. pressure
        4. engine operation hour counter
        5. other required items
    b) The engine shall be able to operate manually from the monitor panel. Manual speed control facility shall be provided.

D Alternator and Exciter

1 The alternator shall be able to withstand the stresses caused by the sudden application of the loads.

a.	Type	:	Self excited, self-regulated, self-ventilated, air cooled, splash-proof, synchronous alternator.
b.	Output	:	As indicated.
c.	Voltage	:	415 V
d.	Frequency	:	50 Hz.
e.	No. of poles	:	4
f.	No. of phases	:	3, (neutral to be brought out).
g.	Power factor	:	80 percent lagging.

h. Commercial efficiency not less than 90% (including excitation and field losses).
i. Voltage regulation: Automatic and static.

2 Class "F" insulation shall be applied to stator, rotor and exciter windings.

3 The alternator shall be suitable for continuous running duty type S1, BS 2613.

4 Distortion of no-load voltage wave form at alternator terminals shall be within 5 percent from the sinusoidal wave form.

5 Voltage adjustable range of the output voltage by adjusting the exciter shall be not less than 3 percent of rated voltage at rated load and not less than +-5 percent of rated voltage under no-load conditions. This adjustment shall be able to be performed from panel mounted handle or knob.

6 The voltage of the alternator shall be automatically controlled by electronic static circuits.

7 The alternator shall not be switched on the load until terminal voltage has reached at least 90 percent of the nominal value. It is essential that the voltage regulation equipment shall have sufficient fast response time so that the alternator is ready to accept load in the shortest possible time.

8 The voltage regulator shall be designed to maintain the alternator terminal voltage constant within +-1 percent of the nominal value from no load to full load within normal variations of engine speed with change in load.

9 The exciter shall be brushless, self-excited, rotor mounted type. The rectifying elements shall be silicone.

10 The unit shall be suitably protected so that when there is a sudden variation of load, the sudden increase of field current in the rotor shall be curtailed and thus the speed build-up of the engine and the voltage build up of generator shall vary proportionately.

11 Terminals with cable end boxes shall be provided respectively for the alternator and exciter.

12 The cooling air for alternator and exciter shall be drawn through openings at the non-drive end and exhausted sideways at the driving end.

13 The alternator shall be fitted with air-condensation heater to keep the winding in good, dry and safe condition. The air-condensation heater shall be automatically cut-of when the machine is running. Necessary on-off switches shall be provided on the control panel and the operation status of the heater shall be indicated.

14 Temperature Rise

Alternator components shall be sound electrically and mechanically in continuous operation lasting over 24 hours at the rated output.

15 Insulation resistance of the machine at strategic points shall be provided with the offer submitted with the shop drawings.

16 The dielectric strength, the voltage of testing and test procedure at various points of the machine shall be submitted with the shop drawings.

17 Vibration at the fixed components of the alternator under excited no-load operation shall be as per relevant BS.

18 Terminal Symbol.

a) Terminal symbols for the alternator shall be in accordance with BS 822 requirements.

b) The alternator shall be provided with protection against over speed, over voltage, over current, short circuit, reverse power, earth fault and any other found necessary.

The neutral points of alternators shall be solid by connecting to earth.

19 Panel Wiring

a) All wiring of battery charger, exciter and control panel shall be P.V.C tropical grade of adequate current carrying capacity to prevent over-heating under worst climatic conditions.

b) All wiring shall conform to the relevant BS and at least 50 percent de-rated with minimum size of 2.5 mm^2. or its equivalent.

20 Terminal Board

a) Terminal boards shall have pairs of terminals for Incoming and Outgoing wires and not more than two wires shall be connected to any one terminal.

b) Insulating barriers shall be provided between adjacent connectors. Labels for wiring designation marks shall be provided on the fixed portion of the terminal boards as well as wires. No live metal shall be exposed at the back of the terminal boards.

c) Terminal boards having pressure type terminal lusts or equivalent shall be used so that no terminal clamp is necessary. 10 percent spare terminals shall be provided for each terminal board assembly.

21 The alternator and the exciter and any component shall be capable of 110 percent load for one hour and 150 percent load for one minute under local conditions at the rated speed without undue heating and without mechanical or electrical troubles.

2.02 Control Board

A Cabinet

1 Sheet steel construction, totally enclosed, IP55.

2 A hinged, lockable door shall give access to control and instruments.

3 "Live" parts shall be secured to prevent inadvertent contact with them.

4 Controls for diesel engine, alternator, exciter, meters and alarm device shall be positioned to give ample space for removing and installing components.

B Instrument in Control Board

1 Control panel shall include:

a. 4-pole air circuit breaker with over-current, short circuit and earth fault protection as specified in this specification.
b. Busbar system as specified in this specification.
c. Voltmeter (0-500V) with selector switch to read phase to phase and phase to neutral voltages.
d. 3 ammeters of suitable range.
e. Frequency meter of range 45 - 55 Hz.
f. Duty selector switch OFF/TEST/MANUAL/AUTO key operated.
g. Solid state voltage and frequency sensing relays.
h. Starting, cycling and shut-down relays and timers.
i. Exerciser clock.
j. Current transformer for measuring and protection devices.
k. Watt meter for unbalanced phases.
l. Voltage trimmer.
m. Visual and audible alarm for engine starting, engine running overspeed, high water temperature, low oil pressure, failure to start, engine stalling or shut down, low fuel level in tanks, and alternator overload.
n. Relays for remote operation and alarm signalling.
o. Indicator lamps for supply available, battery charger and cooling water heater.
p. Manual starter, stop, emergency OFF and lamp test pushbuttons.
q. Manual and automatic service pushbuttons.
r. Control switch for alternator circuit breaker, ON and OFF.
s. Mimic diagram with moving coil indicator for position of air circuit breaker.
t. Battery charger, automatic type, nominal current 10 A for charging 24 V nickel cadmium starter battery and all required instruments.
u. All other accessories, fuses, terminal boards, small wiring, etc.

2.03 System Operation and Performance

A The normal mode of system operation shall provide for unattended automatic transfer of load for the emergency power system. Emergency power shall be supplied to the system emergency loads within 10 seconds after interruption of the normal service. Upon receiving a signal from the ATS indicating a failure or normal power from transformer, the system control unit will signal engine generator to start. Generator circuit breakers are open at this time and the emergency busbar is dead. The generating set to reach approximately 90 percent of rated frequency and voltage signals to start sensor. The sensor then inhibits the operation of sensors and initiates a closing signal to circuit breaker, connecting this generating set to the emergency busbar. The priority control then initiates operation of the designated transfer switch, applying load up to the total kW rating of the generating set.

B The generating set fails to start after cranking for the suitable cranking period, it shall be locked off the busbar and the overcrank light on its switchboard shall light and the alarm sound. The control prevents critical transfer switch from operating. The generating set may receive troubleshooting after placing its engine control function switch in the "OFF" position. When the generating set is operational, it may again be placed into automatic operation by returning its function switch to the "remote" position.

C If a generating set stalls and shuts down during normal operation, its respective switchboard circuit breaker shall open, removing it from the busbar. The appropriate failure light operates and the alarm sounds. The load shedding contacts in the control close, tripping a breaker in the load circuits, reducing system load to the rating of the remaining available generating capacity. After the generating set is made operable, it can be automatically reconnected to the busbar by resetting the load shed switch and engine control switch.

D After normal power has been restored to transfer switch and after the time delay on retransfer has expired, the transfer switch shall return to normal power. After the time delay on stop has expired, the generator circuit breaker shall open simultaneously and controls automatically return to a reset condition in preparation for the next operation. The set shall then shut down simultaneously.

2.04 Manual Operation

The manual operation of the diesel generator set shall have the following features:

1. The emergency power system shall have the capacity of being manually operated. The generator may be started by engine control switch located on the engine control unit. Once started and stable, the generator may be manually connected to the emergency busbar through generator circuit breaker.
2. The generator control unit shall be equipped with a generator breaker control switch, engine speed adjusting potentiometer and a generator voltage adjust thermostat and facilitate.

2.05 System Responsibility

The generating set, switchboard and automatic transfer switches shall be interconnected according to building load requirements and to manufacturer's recommendations, to prevent the emergency generating system from stalling or faltering due to momentary or temporary overloads beyond system rating, from distribution faults, motor starting loads.

Part 3 Execution

3.01 Installation

A Product Delivery, Storage Handling

1 Lift all generator equipment using eyes, yokes and skids provided by the manufacturer.
2 Do not store equipment assemblies exposed to weather.
3 Physically protected all generator equipment against damage from work of other trades.
4 Cover all generator equipment with suitable material to avoid damage to finish.

B Installation

1 The engine and generator shall be properly aligned and mounted on a common steel base through resilient mountings to prevent vibrations. The whole set shall be fixed on the concrete slabs through suitable number of adjustable spring type vibration isolators. Foundation and other builder's work shall be as recommended by the manufacturer and approved by the Engineer.
2 Except as may be described in this Section or shown on the drawings carry out installation strictly in accordance with the manufacturer's recommendation.

C Run all outgoing cables from the generator to the control boards in the floor trench as indicated.

D Fix record print of each generator set, framed behind non-glare plexiglass, on a wall near the generator control room.

3.02 Site Quality Control

A Testing shall be carried out at full load after completion of installation by the Engine manufacturer's qualified representative in the presence of the Engineer.

B If the above cannot be done then testing shall be done at the manufacturer/supplier's premises at full load in the presence of the Engineer. All arrangements and costs incurred by such a test shall be responsibility of the Contractor.

3.03 Commissioning

A Engine-generator shall be made ready for automatic operation and started by means of the test transfer switch on the automatic transfer switch. Unit shall run for the duration of all time delays and then automatically shut-down. This test shall be made with unit operating, and twice with unit simulated for a starting failure.

B Testing of the Set

1 Engine

a The engine shall be tested at site before and after erection to BS 649 and amendments or equivalent including items which are said to be subject to mutual agreement. The test shall include inspection, after testing the following parts:

b Subsequent running test of eight hours shall be carried out of the set.

c The engine shall be subjected to vigorous performance tests at site under the worst environmental conditions prevailing here to the satisfaction of the Engineer and the main items shall include:

1. Output characteristics.
2. Temperature rise.
3. Checking of valve clearance, fuel pump setting, governor setting, pipeline connections, exhaust piping and flexible connections.
4. Checking the base and set are level in all directions, checking alignment of engine and generator and vibration-isolators location and proper installation.
5. Checking of proper operation of engine safety devices.
6. Checking of fuel pipelines, fuel pumps, tank level gauges and level control switches operation.

2. Alternator and Exciter

a The alternator and exciter shall be tested to BS 5000, P.99 amendments thereof.

b Tests at site before erection and after erection prior to handing over shall be carried out to the satisfaction of the Engineer. The main items of tests deemed necessary by the Engineer shall be carried out at the expense of the Contractor. The performance test shall be for 24 hours under the worst climatic conditions prevailing.

c The Contractor shall be fully responsible to provide all the necessary facilities for the test at his own expense.

3.04 Training of Operation and Maintenance Personnel

The Contractor shall train a number of persons who will be selected by the Engineer for the operation and maintenance of all the works within the contract before these works are handed over to the Engineer. The training has to be carried out by qualified staff of the Contractor for each specified service and shall be maintained for a one month period following on the Certificate of Completion.

END OF SECTION 16620

Section 16740

Private Automatic Branch Exchange System

Part 1 General

1.01 Description

This specification sets out the requirement of Private Automatic Branch Exchange (PABX) equipment. The equipment shall be a model type approved by the local telecommunications authority. The work comprises the supply and installation of all services, equipment, components, accessories and fittings required for the operation of the PABX equipment, internal distribution network and extension telephone instruments.

1.02 Quality Assurance

A The equipment to be furnished shall be new and shall be a standard product of a manufacturer experienced in the design, fabrication and construction of PABX systems. The manufacturer shall demonstrate to the Engineer from operating installations of equal or larger capacity utilizing equipment such as herein, that all the features and appurtenances of the equipment will be operated satisfactorily for the purposes intended. All equipment furnished under this Section shall be demonstrated to the satisfaction of the Engineer that the quality is acceptable.

B The Tenderer shall provide a statement of compliance and description of relevant information in respect of each clause and sub-clause of this document stating the extent of such compliance of the offer with the stipulations prescribed in such clauses.

C The Tenderer shall submit a list of customers to whom this equipment has been supplied, with dates and value of contract.

1.03 Maintenance

A The tenderer shall quote:
1 The recommended life period and the period of guarantee of the equipment inclusive of the installation.
2 The annual maintenance fee inclusive of labour and replacement cost of defective components, which will commence from the date of expiry of the period of guarantee and remain valid till the end of the life period quoted. The tenderer shall state whether such fee is payable at the beginning or at the end of the period of each year after the expiry of the period of guarantee. The maintenance contract should be within the guidelines stipulated in the government regulations.
3 The price escalation formula applicable in the event of the value quoted above being liable to price variations. The price escalation formula shall have provision to account for inflation in respect of local and foreign materials and services and also for variation in parity rates in the case of the foreign component of the cost of maintenance.

B The supplier shall, if the customer so desires, enter into an agreement to maintain the installation at the annual rate quoted subject to price escalation quoted during the life period of the equipment commencing from the expiry of the guarantee period quoted. The supplier shall also agree to pay the residual value of the equipment in the event of default of such agreement. In the alternative customer has the right to select maintenance support

on a piece wise basis, as and when maintenance services are required. The charges for such maintenance support should be mutually agreed upon. The residual value shall be the depreciated value adjusted for inflation and currency variations computed as from the date of default to the date of expiry of the life period of the equipment supplied.

C The supplier shall guarantee the availability of spares during the life period of the equipment after commissioning.

D The Supplier shall state whether the equipment offered needs controlled ambient temperatures & humidity and if so the limits within which the system is designed to work without any damage to the equipment. It is preferable that the equipment is capable of functioning without any air-conditioning under the ambient conditions.

Part 2 Products

2.01 Construction

A The equipment shall be constructed to enable operation in a tropical environment under ambient conditions stipulated in this specification. The equipment supplied shall be fully tropicalized and shall be of design and construction of high quality.

B All electronic components used in the equipment shall meet with the climatic requirements of IEC publication No:68. All metal parts shall be specially protected. In the case of steel parts, they shall have a passive zinc-plate finish to prevent corrosion. All visible and exposed metal parts shall be chromium plated.

C Wiring and layout of components should be such that it provides adequate insulation under ambient conditions specified in this specification. The insulation resistance under these condition should be better than 100 M Ohms, when tested with a 250 volts megger.

D The basic operational and maintenance characteristics shall be guaranteed by the use of reliable components. The design of apparatus shall ensure that the equipment parts are adequate protected from dust.

E The system offered shall be a digitally controlled PABX of modern design & proven quality and digital.

2.02 Basic Facilities and Housing Requirements

A The PABX system shall be equipped to be connoted to electromechanical and electronic type public exchanges with DP and DTMF type signalling without any hardware changes. The exchange shall be capable of meeting all the requirements of the local telecommunication authority requirements in signalling, routing and numbering.

B The equipment shall preferably be housed in corrosion resistant metal cabinets that permit easy handling during transportation and installation. The nature of the mechanical design shall permit modular and cost effective growth.

C The system offered shall have a high degree of flexibility and shall permit the introduction of new facilities and services with simple additions and updates of software. Activation of facilities or updating of office data shall be carried out from input devices provided with the offer.

D Diagnostic programs shall be used to check functional elements and fault recovery software shall reconfigure the system on detection of any faults in sub-systems.

2.03 System Dimensions and Standards

A The system offered shall have the specified capacity.

B The trunks, common control equipment with ancillary parts shall be dimensioned to satisfy the following grade of service and the quantities of such equipment provided shall be mentioned in respect of each incoming, outgoing, both way and other types of common equipment:

1 The probability of a dial tone delay shall not be more than 2.5 sec. For 1.5 percent of the calls;
2 The probability of internal congestion not to exceed 01 percent at normal traffic load and 20 percent at overload;
3 The probability of the number of calls experiencing a switching delay of over 1 sec. Shall not exceed 10 percent.

C A list of all Printed Circuit Board (PCB), common control and other modules, shelves, cabinets etc., required to meet the initial capacity and final capacity stated corresponding to the requirements, of each type and the unit price of each shall be furnished with the offer.

2.04 Transmission Requirements

A Two wire nominal impedance of line circuits shall be 600 ohms balanced. The return loss against any input or output port shall not be less than 12 dB in the range 300 to 600 Hz and 18 dB in the range 600 to 3400 Hz.

B The intelligible crosstalk attenuation between any two connection setup through the exchange measured in the audio frequency band shall be better than 75 dB.

C The busy hour mean psophometric noise power level shall be better than – 67 dB mop.

D The offered equipment shall be capable of working with a loop resistance not exceeding 600 ohms, excluding extension instrument.

E The offered equipment shall contain the forced release facility, the response delay of which shall be adjustable by the customer to confirm to the following.

1 Forced release of dial tone connection without dialling response 5 to 15 secs.
2 Failure to dial successive digit following dialling of the first digit.
Internal - 5 to 15 secs; external - 5 to 10 secs.

2.05 Protection

A The proposal shall include protective devices to safeguard the equipment against over-current and over-voltages on the telephone and exchange lines.

B The details of earthing required by the proposed system shall be provided in the offer.

C The earthing ancillaries shall be included and quoted separately in the offer.

D The maximum allowable earth resistance for satisfactory operation of the system shall be indicated.

E The installation of earth shall be such that the measured value shall never exceed the maximum allowable earth resistance value given above during the life period of the system.

F Subsequent to commissioning, if it is later found that the earth resistance has exceeded the maximum allowable value given above, the successful supplier shall undertake improvements to earth free of charge.

2.06 Ring & Tone Generation

A The tenderer shall indicate the frequencies of the tones of each specific audible signalling application and the ringing current.

B Facility should be provided to prevent damage due to the over loading of the ring and tone generator equipment during normal operation. The tenderer shall indicate the maximum number of connections to which the tone generator can provide necessary rings and tone facilities simultaneously.

2.07 Facilities

A The offer shall contain a detailed list of facilities which are available with the system and those offered as optional.

B It shall be possible to program the PABX to allow only selected extensions to dial outside numbers.

C Barring of outside dialling and removal of barring shall be possible by changing the category of the extensions. The functions of each category offered with the equipment shall be clearly defined.

D It shall be possible to divert all incoming call on trunk lines to pre-selected extensions, when the operator console is unattended or in case of power failure or system failure.

E System shall have tie line facility to interconnect other systems to this PABX in the future.

F Maximum allowable distance between the operator console and the PABX equipment shall be stated by the tenderer.

G On line maintenance facilities available in the proposed system shall be stated by the tenderer.

H It shall be possible to connect and work, DTMF telephones for extensions.

2.08 Features of Extension Lines

a Connection of PABX to extension telephones shall be on two wire basis.

B The offer shall contain a list of available features of extensions and those features offered as optional items and the involved costs.

C Facilities shall be provided for recording of calls originated by extension telephone lines.

2.09 Printer Requirement

A RS232 port shall be provided for the purpose of call logging.

B The format and the data structure of the logging shall be clearly stated.

2.10 Data Communication Facilities

A Provisions shall be available to introduce data communication whenever required in the future.

B Data communication terminals shall use V24/V28 (RS232C) communication interface.

2.11 Wiring

The Tenderer shall submit a copy of the proposed cable distribution plan of multi core cable, with the offer as per requirements stated in the specification.

2.12 Extension Telephone Instruments

The system shall include the specified number of analogue extension telephone instruments of a type approved by the local telecommunications authority.

2.13 Paging System

A If a paging system is specified it shall be operated or decontrolled by the PABX.

B The amplifier shall have enough to deliver to all speakers (15 to 20 numbers). The amplifier shall be switched on by remote relay controlled by the paging access of the PABX.

C The loudspeakers installed in high noise level areas should be adjusted to handle more power. It shall be possible to adjust the power on each loudspeaker and the speakers shall have good quality for the audio bandwidth. The speaker should be 200 to 250 mm in diameter and shall be mounted in suitable cabinet. The cabinets shall be made of good soft wood to prevent standing wave or vibration and shall have a volume of about 0.4 m^3.

Part 3 - Execution

3.01 Testing

A. All equipment shall be tested both at the manufacturer's works and on site.

B. Test certificates or type test certificates shall be provided for all devices.

END OF SECTION 16740

Section 16950

Electrical Testing

Part 1 General

1.01 General Procedures for Testing

A. The Engineer shall be authorized to inspect, examine and test at any reasonable time and in the premises of the manufacturer the quality of the material used for the equipment to be supplied. These work inspections shall include but not be limited to the following equipment: lighting fixtures, emergency power equipment, switchgear, switchboards, motor control centres, drives, main and sub-main distribution boards. He shall also be authorized to verify the qualifications of the staff employed by the manufacturer.

B. Should part of the equipment be subcontracted to another manufacturer, the Contractor shall ensure that the Engineer is authorized to inspect, examine and test the equipment in the premises of the Sub-Contractor.

C. These inspection, examinations and tests shall not relieve the Contractor from any of his obligations under the Contract.

D. The Contractor shall notify the Engineer in writing at least 15 days beforehand of the date and place at which any equipment shall be available for tests to be made according to the provisions of the Contract. Should the Engineer not have appeared at the place indicated within ten days following the date indicated by the Contractor, the latter shall proceed with the tests and it shall be deemed that they had been witnessed by the Engineer. The Contractor shall send the Engineer duly certified copies of the results of the tests.

E. The Engineer shall notify the Contractor of his intentions to attend the test 24 hours beforehand.

F. Should the Contract provide for tests to be made in the premises of the Contractor or any Sub-Contractors or suppliers, the Contractor shall provide free of charge any assistance, labour materials, electricity, fuel supplies, equipment and instrument required and which can be reasonably requested for these tests to be carried out efficiently.

Part 2 Testing

2.01 Tests at the Manufacturer's Works

A. All tests or inspection at the manufacturer's works shall be in accordance with the relevant Japanese/British/USA or such other standards as approved by the Engineer.

B. All tests or inspection at the manufacturer's works shall be accompanied with test or inspection certificates showing all the relevant information and details relating to the test or inspection.

C. Four copies of Test Certificates signed by the Manufacturer's representative shall be submitted to the engineer on or prior to the dispatch of equipment to site.

2.02 Electrical Installation Testing

A. On completion of the entire electrical installation work or any separate or distinct part thereof, the Contractor shall notify the Engineer, in writing, that the complete part of the electrical work is ready for inspection. Before doing so, the Contractor shall perform initial trial tests and test, correct, adjust, balance, regulate, etc., the section concerned as necessary until the required conditions are obtained.

B. The inspection of the Contractors work shall be carried out in the presence of the Engineer and in accordance with the requirements of Section 'E' of the IEE 'Regulations for Electrical Equipment of Buildings' and shall comprise of but not limited to:
   1. Verification of polarity
   2. Earthing system and earth electrode resistance
   3. Insulation resistance test
   4. Test of ring circuit continuity
   5. Phase rotation
   6. Continuity of protective conductors
   7. Earth fault loop impedance
   8. Polarity tests
   9. Operation tests of relays, interlocks and any other protective and control device to ensure correct functioning e.g. residual current devices.

C The results and readings obtained shall be equal or better than the requirements of the IEE and the local electricity supply authority regulations, whichever are more stringent, and these shall be recorded on forms similar to the ones described in the IEE Regulations.

D. The Contractor shall supply all instruments and tools required for carrying out the tests.

E. In case that the above mentioned tests are satisfactory and no errors or faults appear in the installation, the Contractor shall submit the necessary test forms, duly filled out, to the local electricity supply authority and to repeat, if necessary, the tests in the presence of local electricity supply authority's inspector.

F. The Contractor shall follow-up and make all necessary arrangements with the electricity supply authority and the telecommunications authority for the purpose of providing permanent electricity supply and telephone services to the new facilities. The Contractor shall also provide all facilities and attendance to the Employer for any other tests carried out before energizing the installation.

2.03 Electrical Equipment Testing

The testing requirements for the various items of electrical equipment is specified in the other relevant specification sections of Division 16 and the particular Specifications.

2.04 Test Instruments

A. All instruments which are to be used for the purpose of testing (either at manufacturer's works or site at Site) shall be approved by the Engineer and if called for by the Engineer, shall be calibrated by an independent recognized official authority at the Contractor's own expense.

B. Particulars of the calibration shall be given on the test certificates. Re-calibration of any instrument after testing shall be carried out when requested by the Engineer. Should an instrument show any difference in readings between the first and second calibrations, both the test and calibration shall be repeated, if so required by the Engineer.

END OF SECTION 16950