No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NATIONAL WATER SUPPLY AND DRAINAGE BOARD
MINISTRY OF HOUSING AND PLANTATION INFRASTRUCTURE
DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

THE DETAILED DESIGN STUDY ON GREATER KANDY WATER SUPPLY AUGMENTATION PROJECT IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FINAL REPORT

(DRAFT) TENDER DOCUMENTS

VOLUME 2C
(STANDARD SPECIFICATIONS)

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NJS CONSULTANTS CO., LTD.
NIHON SUIDO CONSULTANTS CO., LTD.

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Contract GK/JBIC/04
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General Provisions: Equipment

Part 1 General

1.01 Description

The Contractor shall provide all the required labor, project equipment and materials, tools, construction equipment, safety equipment, transportation, and test equipment (unless otherwise specified) for furnishing, installation, adjustment, and full test loading of all the mechanical work shown on the Drawings and included in these Specifications.

1.02 Quality Assurance

A Published specifications, standards, tests, or recommended methods of trade, industry, or governmental organizations apply to work of these Specifications where cited by abbreviations on the plans and below. In every situation, the latest specifications, standards, tests, etc., shall apply unless otherwise noted. In instances, where two codes are at variance, the more restrictive requirements shall apply.

B The Contractor shall provide, for the approval of the Engineer, the equipment/material country of origin, together with clear evidence to demonstrate that it has been successfully manufactured at that facility and has been installed and operating successfully, in a number of similar projects in type and size, under similar conditions to those pertaining to its specified application. The manufacturer must have installed, and had in satisfactory use, for a period of not less than five years a minimum of five installations of similar size and type comparable to the units specified. The Contractor shall provide data on installations of the manufacturer which shall include, but not be limited to, the following:

1 name and location of installation,
2 name of person in direct responsible charge for the equipment,
3 address and phone number of person in direct responsible charge,
4 month and year the equipment was placed in operation,
5 brief description of equipment.

C The equipment to be furnished hereunder shall be new and shall be a standard product of a manufacturer experienced in the design, fabrication and construction of of the specific equipment. Equipment which is a "standard product" with the manufacturer shall be modified, redesigned from the standard mode, and shall be furnished with special features, accessories, materials of construction or finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of the specification. The manufacturer shall demonstrate to the Engineer from operating installations of equal or larger capacity utilizing equipment specified, that all the mechanical features and appurtenances of the equipment will operate satisfactorily for the purposes intended. All the equipment furnished under these Sections shall be demonstrated to the satisfaction of the Engineer that the quality is equal to equipment made by the manufacturers specifically named therein.

1.03 Drawings

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 the installations as described in Section 3.01. 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, blowers and other equipment required by the Engineer and furnished under this Contract. The Contractor shall notify the Engineer three 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.

1.04 Adaption of Equipment

Should any alternate equipment selected require any revision to the structure, piping, electrical, or other work shown on the Drawings, the Contractor shall include the cost of such revisions in his bid for the equipment and no extra payment shall be made for such revision. All such revisions shall be subject to the approval of the Engineer.

1.05 Utility Service and Process Interruption

All utility service and/or process interruptions initiated by the Contractor in the prosecution of his work shall be scheduled in advance and approved by the Employer.

1.06 Operation and Maintenance Manuals

The Contractor shall submit to the Engineer operation and maintenance manuals on all equipment in accordance with the requirements of Section 01300 and the Particular Specifications. The draft manuals shall be submitted for approval not later than the date of shipment of the equipment. The final approved copies shall be available to the Employer's personnel at least two weeks prior to training and start-up for each piece of equipment.

1.07 Installation Manuals

In addition to operation and maintenance manuals, the Contractor shall submit to the Engineer twelve copies of all installation manuals for each piece of equipment. These manuals shall be submitted at the same time as the draft operation and maintenance manuals. Installation of equipment shall not be performed until installation manuals are received.

1.08 Warranty

A Each piece of equipment shall be warranted to be free from defects in materials and workmanship when properly installed, maintained and operated under normal operating conditions for a period of one year from date of Taking Over Certificate.

B 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 Contractor shall furnish and install, a replacement part without cost to the Employer. In addition to performance guarantees, all processes or systems shall comply with the requirements of applicable portions of the Sections of these Specifications describing those systems.

C The Contractor shall furnish the Employer with manufacturer's guarantee and warranty certificates for all equipment, duly registered with the manufacturer.

Part 2 Products

2.01 Materials and Workmanship

A All equipment furnished under this Division shall be new and guaranteed free from defects in materials, design, and workmanship. These Specifications, to the extent possible, identify service conditions and requirements for all equipment; however, it shall be the manufacturer's responsibility to ascertain, to his satisfaction, the conditions and service under which the equipment will operate and to warrant that operation under those conditions will be successful. All parts of the equipment shall be amply proportioned for all stresses that may occur during fabrications, erection, and intermittent or continuous operation.

B All equipment shall be designed, fabricated, and assembled in accordance with the best modern engineering and shop practice. Individual parts shall be manufactured to standard metric sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests. Materials shall be suitable for service conditions.

C Except where otherwise specified, structural and miscellaneous fabricated steel used in items of equipment shall conform to the Standards of the American Institute of Steel Construction, Japanese Industrial Standards and British Standards. All structural members shall be considered as subject to shock or vibratory loads. Unless otherwise specified, all steelwork shall have a minimum nominal thickness of 6mm. The location of the fabricator and his shop schedule shall be furnished to the Engineer prior to the beginning of fabrication so that the Engineer can schedule shop inspection if so desired.

2.02 Safety Guards

All belt or chain drives, fan blades, couplings, exposed shafts and other moving or rotating parts shall be covered on all sides by safety guards which shall be free of all sharp edges and corners. Safety guards shall conform to the of the requirements of the local safety regulations and appropriate safety agencies, such as OSHA. Safety guards shall be fabricated from 1.6 mm, or heavier, galvanized or painted, aluminum-clad sheet steel, stainless steel or 12mm mesh, galvanized expanded metal. Each guard shall be designed for easy installation and

removal. All necessary supports and accessories shall be provided for each guard. Supports and accessories, including bolts, shall be hot-dip galvanized or stainless steel. All safety guards in outdoor locations shall be designed to prevent the entrance of rain and dripping water.

2.03 Nameplates

A Unless otherwise specified, all equipment furnished shall have a data plate fabricated of stainless steel with a minimum thickness of 2 mm and embossed or preprinted lettering, and fastened to the frame with corrosion-resisting pins. Nameplates shall have stamped on them the manufacturer, serial number, model number, type, operating and performance data, and other pertinent data. Letters and numerals shall not be smaller than 5 mm high.

B Where the size of the equipment prevents the fastening of data plates, name tags shall be provided and attached to the equipment and device item to identify it. The name tags shall have a rectangular configuration with square corners and shall be approximately 40 mm by 75 mm in size. They shall be made from brass or stainless steel sheet metal and have a minimum thickness of 2 mm. Letters and numerals shall be engraved or etched in the name tags by a professional engraver and shall not be smaller 3 mm high in size. The name and number for each item of equipment, as designated on the Drawings, shall appear on the name tag for the item. Valve tag information shall conform to the Plans and Specifications. A 5 mm diameter hole shall be provided in the upper left-hand corner of each name tag and shall be used to attached the name tags to the equipment and device items with 3 mm stainless steel cable.

2.04 Equipment Bases and Bedplates

A heavy cast-iron or welded steel base shall be provided for each item of equipment which is to be installed on a concrete foundation. Equipment assemblies, unless otherwise specified, or shown on the Drawings, shall be mounted on a single, heavy, cast-iron or welded steel bedplate. Bases and bedplates shall be provided with machined support pads, tapered dowels for alignment of mating, or adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. All seams and contact edges between steel plates and shapes shall be continuously welded and ground smooth. All pump bedplates must include a drip lip and provision for directing accumulated gland leakage to a single disposal drain point. Pipe all accumulated gland and seal water leakage and spent cooling water to a floor drain provided adjacent to each piece of equipment. Floor drain may be provided for more than one piece of equipment provided the equipment drain line does not create a safety or tripping hazard.

2.05 Jacking Screws and Anchor Bolts

Jacking screws shall be provided in the equipment bases and bedplates to aid in leveling prior to grouting. 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. Sleeves shall be a minimum of 1-1/2 times the diameter of the anchor bolts. Unless otherwise shown or specified, anchor bolts for items of equipment mounted on baseplates shall be long enough to permit 25mm of grout beneath the baseplate and to provide a minimum of adequate anchorage into structural concrete. 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 shall be 304 stainless steel which conforms to ASTM A-276 or JIS 4303.

2.06 Drives

A All drive units shall have an AGMA or equivalent rating and service factor suitable for 24 hours per day operation under the specified maximum, or "worse case" operating load. Drive unit housings shall be constructed of high-grade cast iron, welded steel, or other suitable material. Thermal rating of each unit shall exceed the design load or proper cooling devices shall be provided. All drives shall be designed especially for the service for which they are to operate.

B All electric motors supplied under this Contract shall conform to all requirements specified in Division 16. Additional or superseding requisites for certain motors may be found in various Sections of Division 11, and to a lesser extent, in other Divisions wherein electric motor driven equipment is specified. The Contractor must coordinate the work of all trades, and the functional, safety and Code requirements for each installation, in order to comply with these Specifications.

C Where motors are mounted above the driven machine on a pedestal, the belt tensioning shall be accomplished by four studs which are double nutted to the motor plate to raise and lower the motor plate. Hinges with a jacking screw to tension the belts shall not be used. Where motors are mounted horizontally adjacent to the driven equipment, belt tensioning shall be accomplished by utilization of sliding rail type motor mount, with manual adjustment of motor location, and thereby, belt tension, through a manual, permanently mounted hand crank mechanism. All V-belt tensioning devices shall be such that under no circumstances will it be possible for any device, once set to the desired adjustment, to go out of the adjustment due to the load being imposed upon the drive at that setting. This requirement shall not be construed to mean that a set belt tension may not go out of adjustment due to gradual stretching of belts, but shall mean that no portion of any device or devices used to accomplish belt tensioning may slip, become loose, or otherwise move from the desired set point, once selected, except when manually reset by operating personnel by use of the adjustment device or devices.

2.07 Lubrication

Lubrication of equipment shall ensure constant presence of lubricant on all wearing surfaces. Lubricant fill and drain openings shall be readily accessible. Easy means for checking the lubricant level shall be provided. Prior to testing and/or operation, the equipment shall receive the prescribed amount and type of lubricant as required by the equipment manufacturer. The Contractor shall provide to the Employer a two year supply of lubricants for each piece of equipment installed. All lubricants shall be properly packaged, labelled, and delivered to the Employer concurrent with equipment installation. An inventory listing of lubricant types by equipment and quantities shall be provided.

2.08 Gears

A Oil-lubricated totally-enclosed gear reducers and increasers shall be provided.

B Each gear shall have a nameplate service power rating equal to the nameplate rating of the driving motor. Each gear shall have mechanical and thermal capacity equal to, or greater than, an equivalent power determined by multiplying the service power rating by the specified service factor recommended by AGMA, or equivalent for heavy duty service, except each set of worm gears shall have a minimum service factor of 1.20 and all other gears shall have a minimum service factor of 1.50.

C Thermal rating for the equivalent power shall be obtained without auxiliary cooling

equipment such as heat exchangers. Units shall be designed to operate continuously for the conditions specified in a location where ambient temperatures vary from (0º C to 55º C). If a cooling coil is required, it shall be minimum 25mm diameter tubing with a 25mm solenoid supply water valve with the gear.

D Anti-friction bearings shall be provided throughout, designed to give a minimum 50,000 hours B10 life for the specified power in continuous operation, of proportions, mountings, and adjustment consistent with acceptable modern practices for applied radial and thrust loads at speeds involved. Thrust bearing rates shall be at 1-1/2 times the maximum thrust loadings involved.

2.09 Gauges

Gauges shall be installed in the suction and discharge of each pump and blower. The gauges shall be 100 mm diameter and in accordance with Division 13 and shall include a petcock between the pump/blower and the gauge. For solids bearing or corrosive fluids a diaphragm gauge isolator or tubular isolator shall be provided. Suction gauges shall be of the compound type and shall have a range of 750mm of mercury to 1 bar. Discharge gauge ranges shall be a standard commercially available range with the maximum reading not less than 5 bar greater than the pump rated shut off pressure and shall be equipped with snubbers.

2.10 Stainless Steel

Unless otherwise specified all Stainless steel shall be 304 to ASTM A-276 or JIS G 4303.

2.11 Dissimilar Metals

All dissimilar metals shall be insulated from each other unless the Contractor can show that galvanic corrosion will not occur.

2.12 Spare Parts

Spare parts shall be provided as detailed in the individual specifications. The Contractor shall deliver the spares to the Employer's storage warehouse in accordance with a program to be agreed with the Employer and Engineer. The Contractor shall provide the lists and details of the spares in a format acceptable to the Employer.

2.13 Special Tools and Accessories

All special tools, special tool lists, equipment, or accessories required for the installation and maintenance of equipment specified, as well as three copies each of instruction manuals necessary for the proper use of such tools, equipment, or accessories shall be provided by the equipment manufacturer. Special tools shall be defined as those items manufactured by the equipment supplier specifically for performing maintenance and installation of their respective equipment, or which are not available from local tool suppliers. All non-metric tools required to service and maintain the equipment and all components shall be provided.

Part 3 Execution

3.01 Co-ordination

A The Drawings show, in a diagrammatic form, the arrangements desired for the principal apparatus, piping, and similar appurtenances, and shall be followed as closely as possible. Proper judgment must be exercised in carrying out the work to secure the best possible

headroom and space conditions throughout, to secure neat arrangement of piping, valves, fixtures, hangers, and similar appurtenances, and to overcome local difficulties and interferences of structural conditions wherever encountered.

B The Contractor shall take all measurement for his work at the installation sites, verify all Drawings prior to required submittal and be responsible for the proper installation, within the available space, of the apparatus specified and shown on the Drawings. The Contractor must secure the approval of the Engineer for all variations and/or substitutions before making any changes.

3.02 Protection

A All equipment shall be boxed, crated, or otherwise completely enclosed and protected during shipment, handling and storage. All equipment shall be protected from exposure to the elements and shall be kept thoroughly dry and clean at all times. Pumps, blowers, motors, electrical equipment, and other equipment having anti-friction or sleeve bearings shall be stored in weather-tight storage facilities such as warehouses. All materials and equipment showing evidence of rust, dirt contamination, or other surface or subsurface deterioration shall be cleaned and restored to the Engineer's satisfaction prior to installation.

B Painted surfaces shall be protected against impact, abrasion, discoloration, and other damage. All painted surfaces which are damaged prior to acceptance of equipment shall be repainted in accordance with the requirements of Section 09905 to the satisfaction of the Engineer.

C Electrical equipment, controls, and insulation shall be protected against moisture or water damage.

D The Contractor shall maintain equipment storage facilities in accordance with the provision of Division 1 and all equipment shall be stored in the designated storage facilities from delivery until installation.

E All mechanical equipment, whether in the Contractor's designated storage facility prior to final installation, or whether installed, but not yet placed into service or accepted by the Employer, shall be periodically exercised at intervals, and in accordance with procedures prescribed by each manufacturer, if such a recommendation is included in the manufacturer's installation, operation and maintenance instructions.

3.03 Installation Check

A The Contractor shall have an experienced, competent, and authorized representative of the manufacturer or supplier of each major item of equipment (defined as equipment for which there is an individual Section in these Specifications) visit the site of the work and inspect, check, adjust if necessary, and approve the equipment installation. In each case, the equipment supplier's representative shall be present when the equipment is placed in operation. The Contractor shall have the equipment supplier's representative revisit the job site as often as necessary until all problems are corrected and the equipment installation and operation is satisfactory to the Engineer.

B Each equipment supplier's representative shall furnish to the Employer, through the Contractor, a written report certifying that the equipment: (1) has been properly installed and lubricated; (2) is in accurate alignment; (3) is free from all stress imposed by

connecting piping or anchor bolts; and, (4) has been operated successfully under full load conditions.

C Equipment manufacturers shall furnish the services of competent, factory-trained personnel during the warranty period specified to inspect, service, and repair the equipment where required. Service requests shall be answered and acted upon promptly. This requirement shall not include normal maintenance and service of equipment, which will be the responsibility of the Employer.

3.04 Equipment Installation

All equipment shall be installed in full accordance with the equipment manufacturer's recommendations and good practice. Where specified in other Sections, factory-trained service personnel shall be on-site to supervise the installation. Sufficient notice shall be given to the Engineer prior to equipment installation in order that the Engineer or his representative may be present during installation. In general, the following installation practices shall be followed:

1 examine equipment for damage in shipping and handling. The examination shall include checking for corrosion, poor workmanship, dirt or deleterious substances, and poor fits,
2 level the base plate or bedplate,
3 install equipment,
4 check alignment of couplings,
5 if grout has been used, check alignment and levelness after the grout has set,
6 check direction of rotation and correct, if necessary, to insure proper operation,
7 provide drain lines from all equipment gland leakage housings, seal water openings, spent cooling water outlets, and strainers to nearest floor drain or point of disposal. Blow-down valves shall be provided on all strainers whether or not shown on the drawings,
8 ensure that all submerged, or intermittently submerged, powered equipment does not have power and control cable splices of any kind inside wells or pits.

3.05 Placing in Operation

Prior to being placed in operation, equipment shall be inspected by the manufacturer's factory-trained personnel. All defects discovered during this inspection shall be corrected prior to initial equipment start-up. Internal coatings applied at the factory shall be removed if required. Lubricant shall be applied in the proper places and levels shall conform to the manufacturer's recommendations. In the presence of the Engineer, full-load operational testing shall be performed and the results of such tests shall be recorded. Unsatisfactory performance shall be corrected and tests shall be repeated until the equipment performance meets the Specifications. The Contractor shall furnish all power, materials, services, test equipment and labor required to successfully complete all full load equipment testing specified. The Contractor shall certify in writing to the Engineer, in triplicate, that all tests were conducted in accordance with these Specifications and that all components within each system successfully function as required. The Contractor shall notify the Engineer ten calendar days in advance of the time when the equipment will be placed into operation. During the course of initial operation, the Contractor shall instruct the Employer’s personnel in the proper operation and maintenance of the equipment, as specified herein.

3.06 Instruction

After the equipment specified in Divisions 11, 13, 14, 15 and 16 has been installed, tested, adjusted, and placed in satisfactory operating condition, services of representatives of each equipment manufacturer shall be provided to instruct the operating personnel in the use and maintenance of the equipment. The instruction period shall be scheduled at a time mutually

agreed upon with the Employer. The manufacturer's representatives shall fully instruct the Employer's personnel regarding use and maintenance of the equipment. During this instruction period, it shall be the responsibility of the manufacturer to answer all questions from the Employer's operating personnel. Manufacturer shall also demonstrate lubrication, disassembly, adjusting, routine parts replacement, and other "hands-on" activities related to maintenance of the equipment. Provide a minimum of not less than eight hours for this instruction for each piece of equipment or set of identical pieces of equipment provided unless otherwise specified. More days shall be provided if called for in the individual equipment specification. Each manufacturer shall include the service in the price of his equipment. Training session schedules shall be coordinated with the Employer and Engineer and under no circumstances shall more than two training sessions be scheduled for the same day. The Contractor shall designate an individual through whom manufacturer's training will be coordinated. This individual will coordinate all training sessions through the Employer's designated training coordinator.

3.07 Shop Painting

A Except as specifically supplemented or superseded by requirements herein, shop painting shall conform to requirements in Section 09870. Electric motors, gears, starters, and other similar self-contained or enclosed components shall be shop primed and finished with a high-grade oil-resistant acrylic enamel. Surfaces which will be inaccessible after assembly shall be painted or otherwise protected before assembly by a method which provides protection for the life of the equipment.

B Surfaces to be painted at the project site shall be shop painted with one or more coats of a primer which will adequately protect the equipment until finishes are applied at the project site. Primers shall be as specified in Section 09870. All equipment shall be primed with primer compatible with the coating system selected by the Contractor, and if not, the Contractor shall re-prime the equipment such that it is compatible and in conformance with Section 09870.

C Machined and polished metallic surfaces which are not to be painted shall be coated with a rust preventive compound as specified in Section 09870.

3.08 Damaged Products

The Contractor shall notify the Engineer in the event that any equipment or material is damaged subsequent to receipt at the job site, and prior to acceptance of the installation by the Employer. Repairs to damaged products in lieu of replacement shall <u>not</u> be made without prior approval by the Engineer.

3.09 Witnessed Shop Testing

A Each major component shall be subjected to a complete witnessed shop test as specified herein. Certified test reports shall be submitted, in triplicate to the Engineer. No equipment shall be shipped until receipt of the Engineer’s written approval. All costs for the shop tests shall be borne by the Contractor.

B Each assembled unit and drive listed herein shall be shop tested to determine the following characteristics at the maximum speed at which the units are to be operated:
1 pressure-capacity curve,
2 brake power curve,
3 efficiency curve,
4 balance,

5 vibration,
6 bearing temperature and alignment,
7 percent slip at motor full-load torque,
8 load test at 115-percent of motor full-load torque and minimum load speed of 96-percent of motor speed with normal field excitation and determination of the motor current; output speed; and drive excitation,
9 all pump tests shall be performed in accordance with the latest Hydraulic Institute Standards,
10 the Contractor shall notify the Engineer not less than one month days prior to the date on which the pump manufacturer will conduct the performance tests of the units,
11 in the event any unit does not meet the specified requirements, it shall be modified by the manufacturer to meet the requirements of the Specifications and shall be retested in accordance with the provisions of the Specifications. All costs of retesting shall be borne by the Contractor,
12 motors shall be tested per requirements of Section 16150.

C Following completion of the installation and satisfactory start-up of the equipment, the Contractor shall provide the services of the equipment manufacturer's representative to operate each unit of all equipment, unless modified in the equipment section, over the entire specified range. The operation, over the entire specified range, shall be free of vibration, noise, or cavitation and shall cover the following aspects as a minimum:

1 vibration shall be checked and recorded and the full speed vibration of all pumps shall be equal to or less than the amplitude limits recommended in the Hydraulic Institute Standards, Japanese Industrial Standards and/or the manufacturer's recommendation, whichever is more stringent,
2 each unit's performance shall be documented by obtaining concurrent readings showing motor voltage and amperage, pressure head and discharge head. Readings shall be documented for at least three conditions to ascertain the actual performance curve. One test shall be at shutoff conditions. Each power lead to the motor shall be checked for proper current balance,
3 bearing temperatures shall be determined by a contact type thermometer. A running time of at least two hours shall be maintained at the maximum specified pressure. Bearing temperature shall not exceed the limits recommended in the HI standard for pumps and/or the manufacturer's recommendation for equipment, whichever is more stringent,
4 in the event equipment fails to meet the above test requirements, it shall be modified and re-tested in accordance with these specifications.

End of Section 11005

Section 11070

Double Suction Centrifugal Pumps

Part 1 General

1.01 Description

The Contractor shall furnish and install the specified horizontal or vertical double suction centrifugal pumps complete with motors and appurtenances as shown on the drawings and as specified herein.

1.02 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation, and installation data together with detailed specifications and performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams, and all other accessories of the equipment furnished. The submittals shall include, but not be limited to the following:

A Manufacturer's product data.

B Shop Drawings.

C Motor data, including:
1 Manufacturer.
2 Minimum guaranteed efficiency.
3 Power factor at full load, 3/4 load, and 1/2 load.
4 Locked rotor current.
5 Motor speed.
6 Mounting details.

D Pump characteristic curves.
1 Plot flow, total dynamic head, brake power, shutoff head, efficiency, and net positive suction head required for full operating range of pump.
2 Plot minimum of four curves for variable speed pumps covering required speed range.
3 Show recommended limits of continuous operation.
4 Reflect operation with the specified fluid (e.g. include the effects of fluid viscosity).

E Certificates of compliance.

F Certified test reports.

G Operation and maintenance manuals.

H Training program.

1.03 Quality

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 pumping equipment. The pumps shall be the product of an experienced manufacturer and:

1. must demonstrate equal or larger capacity installations using similar equipment and

equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified;
4. the pump manufacturer's machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 Products

2.01 General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration. The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as thoughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To insure vibration-free operation, all rotative components of each pumping unit shall be statically and dynamically balance. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standards or Japanese Industrial Standards. At any operating speed, the ratio of rotative speed to the critical speed of a unit. or components thereof, shall be less than 0.8 or more than 1.3. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and oil or water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty. The Contractor shall be responsible for proper operation of the complete pumping system, which includes pump and motor.

2.02 Design Conditions

The design conditions shall be as specified in the Particular Specifications.

2.03 Materials

A Castings, fabrications, machined parts and drives shall conform to the industry standards for strength and durability and shall be rated for continuous duty over the entire operating range. Service factors, where applicable, shall be assumed to be 1.0.

B The impeller shall be of the enclosed double suction type, of one-piece construction made of bronze casting finished smooth and statically balanced.

C Removable casing ring made of bronze casting shall be provided on the pump casing.

D The pump shaft shall be made of carbon steel or chrome molybdenum steel and be ground and polished over the entire length.

E The casing shall be made of gray iron casting conforming to the requirements of ASTM designation A48 or JIS G 5501 FC 200.

F The bearing shall be an anti-friction ball bearing, and suitable lubrication system shall be

provided. For horizontal pumps there shall be a deflector fastened to the shaft at the inner end of each bearing housing. For vertical pumps a water deflector shall be provided at the inner end of the upper bearing housing and a gland drain pan shall be provided at the inner end of the lower bearing assembly.

G Couplings between pump and motor shall be flexible type and shall have sufficient capacity to develop the full strength of the shafting, which they connect. For vertical pumps, intermediate shafting shall be provided for connecting pump and motor.

H All bolts and cap screws shall be of high strength zinc plated and chromated steel. All anchor bolts, nuts, and washers shall be stainless steel.

2.04 Pump Construction

A Fabrications shall conform to ASTM Designation A36 or JIS G 3101 SS400 for fabricated steel.

B The impeller shall be tightly mounted on the pump shaft with a key so that it will not become loose.

C The shaft shall be of ample size and rigidity to ensure low working stress under all conditions of operation. The shaft shall be protected from wear corrosion by removable sleeves made of stainless steel. The sleeves shall extend from the impeller to the outside of the stuffing boxes.

D The casing shall be split horizontally or vertically, for horizontal and vertical pumps, respectively, on the centerline of the shaft with suction and discharge connections cast integrally in the half casing to permit removal of the complete rotating element by removal of the other half casing, the bearing caps, and coupling bolts. The face of the each half shall be accurately machined and doweled for tight and accurate fit. The bearing brackets shall be cast separately and bolted to the half of the casing.

E The stuffing box shall be installed where the main shaft passes through the casing, and a set of gland packing shall be provided for each stuffing box. The construction shall allow easy adjustment and replacement of gland packing.

F Motors shall be high-efficiency squirrel cage induction type, TEFC and shall conform with the specifications of Section 16150.

2.05 Accessories, Tools And Spare Parts

A All special tools required for normal operation and maintenance shall be furnished with the equipment. In addition, accessories and spare parts shall be furnished with, but not limited to, the equipment as follows for <u>each</u> pump:

Couplings with guards	1 set
Bed plate	1 set
Compound and pressure gauge	complete set
Flange adapter with tie rods for discharge pipe	complete set
Foundation bolts and nuts	1 set
Air vent and other piping	1 set
Suction and delivery reducer with flanges	complete set
Special tools for maintenance as recommended by the manufacturer or as instructed by the Engineer	1 set

Complete set of bearings for pump	1 set
Complete set of bearings for motor	1 set
Complete set of pressure gauges	2 sets
Complete set of wearing rings	2 sets
Complete set of all gaskets	2 sets
Complete set of all packing	2 sets
Shaft sleeves	1 set
Lantern rings	2 sets
Complete set of all special bolts, screws and nuts	2 sets
Complete pump rotor assembly	1 set

B Other items shall be provided as recommended by the Manufacturer as spares for five years operation.

C All spare parts shall be properly preserved and packed for a long period of storage in a hot humid climate and shall be properly marked in the English language on the outside to permit easy identification of the contents without opening and exposing the contents

Part 3 Execution

3.01 Installation

Conform to the requirements of Section 11005.

3.02 Equipment Shop Testing

A Each major component of the pumping equipment shall be subjected to a complete shop test as specified herein, witnessed by the Engineer if so desired. All costs for the shop tests shall be borne by the Contractor.

B Each assembled pump shall be shop tested by the manufacturer to determine the following characteristics for the minimum and maximum speed and two intermediate speeds at which the pumps will be operated. All tests shall be performed in accordance with the latest Hydraulic Institute Standards or JIS B 8301 and 8302.
1 head-capacity curve,
2 power curve,
3 efficiency curve.

C Each motor shall be shop tested by the manufacturer in accordance with the requirements of Division 16.

3.03 Start-Up

A The Contractor shall provide the services of the pump manufacturer's representative for two days to operate the pumps of each type.

B The pump performance shall be documented by obtaining concurrent readings showing motor voltage and amperage, pump suction head, pump discharge head, and pump speed (rpm). Readings shall be documented for at least three pumping conditions to ascertain the actual pumping curve. One test shall be at shutoff head. Each power lead to the motor shall be checked for proper current balance.

C Bearing temperatures shall be determined by a contact type thermometer. Alternatively, lubricant temperature may be measured. A running time or at least twenty minutes shall

be maintained for this test.

D The pump shall be visually and manually checked for excessive vibration. If the pump vibration is excessive, it shall be checked and recorded. The vibration of the pump measured at any point on the pump and motor when operating at full speed shall not exceed the following:

Speed, rpm	Vibration Amplitude
minimum speed	as H.I. Standards
full speed	as H.I. Standards

E If pumps fail to meet specified requirements, adjustments shall be made and the test re-run until performance meets the requirements. Test results shall be recorded for each pump for each test and full reports shall be submitted to the Engineer. The costs of re-testing and reporting shall be borne by the Contractor.

3.04 Instruction

The Contractor shall conform to the requirements of Section 11005 and provide a minimum of one day of instruction for each pump class.

End of Section 11070

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Section 11071

End Suction Centrifugal Pumps

Part 1 General

1.01 Description

The Contractor shall furnish and install the specified horizontal or vertical end suction centrifugal pumps complete with motors and appurtenances as shown on the drawings and as specified herein.

1.02 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation, and installation data together with detailed specifications and performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams, and all other accessories of the equipment furnished. The submittals shall include, but not be limited to the following:

A Manufacturer's product data.

B Shop Drawings.

C Motor data, including:
1 Manufacturer.
2 Minimum guaranteed efficiency.
3 Power factor at full load, 3/4 load, and 1/2 load.
4 Locked rotor current.
5 Motor speed.
6 Mounting details.

D Pump characteristic curves.
1 Plot flow, total dynamic head, brake power, shutoff head, efficiency, and net positive suction head required for full operating range of pump.
2 Plot minimum of four curves for variable speed pumps covering required speed range (for variable speed pumps).
3 Show recommended limits of continuous operation.
4 Reflect operation with the specified fluid (e.g. include the effects of fluid viscosity).

E Certificates of compliance.

F Certified test reports.

G Operation and maintenance manuals.

H Training program.

1.03 Quality

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 pumping equipment. The pumps shall be the product of an experienced manufacturer and:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified;
4. the pump manufacturer's machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 Products

2.01 General

A. Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration. The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as throughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standards or Japan Industrial Standards. Excessive vibration shall be sufficient cause for rejection of the equipment. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty.

2.02 Materials

Materials of Construction:

1. Casing: Crey iron casting (ASTM A 48 Grade 35 or JIS G 5501 FC 200)
2. Impeller: Bronze Casting (ASTM B584 C90300 or JIS H5111 Class 2 BC2)
3. Wearplate: Bronze Casting (ASTM B584 C83600 or JIS H5111 Class 6 BC6)
4. Shaft: Carbon Steel (JIS G4051 535C or stainless steel ASTM A582. JIS G4303 SUS420 J2)
5. Shaft sleeve: Bronze Casting (ASTM BS84 C83600, JIS H5111 Class 6 BS6) shaft sleeve is not required for stainless steel shaft
6. Packing/Gland Housing: Gray Iron, ASTM A48, Grade 30 - 35

2.03 Design Conditions

Pumps shall be designed and constructed to satisfactorily meet the design conditions and requirements specified in the Particular Specifications.

2.04 Pump Construction

The following requirements shall apply:

A. Casing.
Grey iron castings (BS1452, JIS G5501 FC200, or ASTM A48 Grade 35, or better). The

casing shall be pull-out type and it shall permit removal of the complete rotating element without disconnection of suction and discharge pipes. The faces of casing and casing cover shall be accurately machined for tight and accurate fit. The suction and discharge flanges shall conform to BS4504 PN16. Pipe taps for pressure gauges, vent, drain, etc. shall be provided

B. Impeller
Bronze casting (BS 1400, JIS H5111 Class 2 BC2, or ASTM B584 C90300, or better). The impeller shall be of single stage, of one-piece construction, finished smooth. The impeller shall be dynamically balanced, tightly mounted on the pump shaft with a key/cotter to that it shall not become loose due to rotation either in the forward or in the reverse direction.

C. Casing Wearing Rings
Bronze casting (BS 1400, JIS H5111 Class 6 BC6, or ASTM B584 C83600, or better) removable wearing rings shall be provided on pump casing.

D. Shaft and Sleeves
Carbon Steel (BS970/I, JIS G4051 S35C, or better). Carbon steel shaft shall be protected from wear and corrosion by removable sleeves. Sleeves shall be of bronze casting conforming to BS1400, JIS H5111 Class 6 BS6, or ASTM BS84 C 83600, or better. The sleeves shall extend from the impeller to the outside of the stuffing boxes. Stainless steel (BS970 : En 57U, JISG4303 SUS420J2 or ASTEMA582, or better). Stainless steel shaft shall not required shaft sleeve.

E The bearings shall be of heavy-duty antifriction ball, or spherical roller type or sleeve type. The bearings shall be installed in bearing case to prevent the ingress of water to each bearing.

F. Stuffing boxes shall be large and deep and shall be provided with at least four rings of square packing and a lantern ring. Packing glands shall be of bronze casting, split horizontally to facilitate for installing packings. Piping with orifice and globe valve shall be provided for sealing water to each stuffing box from discharge volute casing. Drain pipes from the pumps shall be properly led to drain trenches in pump houses.

G. Bed Plates shall be of fabricated steel with web reinforcing or grey iron casting so designed that they can be grouted after alignment and leveling.

H Coupling between pump and motor shall be the gear flexible type, shall have sufficient capacity to develop the full strength of the shafting which they connect. The coupling shall be enclosed and sealed to retain the lubricant and exclude dust and moisture from the gear surface. Coupling shall be provided with guard.

I Pressure gauges not less than 100 mm diameter shall be provided at both the suction and discharge sides of each pump. The gauge ranges shall be approximately double the maximum operating pressure. The gauge on the suction side shall be compound gauge. The gauge shall have brass case and ring, and phosphor bronze Bourdon tube. The ranges selected shall be submitted to the Engineer for approval. The gauges shall have bottom connection with shut-off valves.

2.05 Motor

Motors shall be sized to drive the pumps throughout the pump operating curve on 400V, 3 phase, 50 Hz power. Motors shall be connected to the pump using a coupling with guards.

Motors shall be squirrel cage induction type with TEFC enclosure, 1.15 service factor as specified in Section 11510.

2.06 Accessories

Each pump shall be furnished with, but not limited to the following accessories:

Couplings with guard	: One (1) set
Bed plate (common)	: One (1) set
Compound and pressure gauge	: Complete set
Flange adapter with tie rods for discharge pipe	: Complete set
Foundation bolts and nuts	: One (1) set
Air vent and others piping	: One (1) set
Suction and delivery reducer with flange	: Complete set
Special tools for maintenance as recommended by the Manufacturer or as instructed by the Engineer	: One (1) set (for each pump station)

2.07 Spare Parts

A The Contractor shall provide the following spare parts for each unit of pump, and supply other items as recommended by the Manufacturer as spares for 5 years operation.

Complete set of bearings for pump	: One (1) set
Complete set of bearings for motor	: One (1) set
Complete set of pressure gauges	: Two (2) sets
Complete set of wearing rings	: Two (2) sets
Complete set of all gaskets	: Two (2) sets
Complete set of all packing	: Two (2) sets
Shaft sleeves	: One (1) set
Lantern rings	: Two (2) sets
Complete sets of all special bolts, screws and nuts	: Two (2) sets
Complete pump rotor assembly	: One (1) set

B All spare parts shall be properly preserved and packed for a long period of storage, and in a hot and humid climate and shall be properly marked in the English language on the outside to permit easy identification of the contents without opening and exposing the contents.

Part 3 Execution

3.01 Installation

Conform to the requirements of Section 11005.

3.02 Equipment Shop Testing

A Each major component of the pumping equipment shall be subjected to a complete shop test as specified herein, witnessed by the Engineer if so desired. All costs for the shop tests shall be borne by the Contractor.

B Each assembled pump shall be shop tested by the manufacturer to determine the following characteristics for the minimum and maximum speed and two intermediate speeds at which the pumps will be operated. All tests shall be performed in accordance with the latest Hydraulic Institute Standards or JIS B 8301 and 8302.

1 head-capacity curve,

2 power curve,
3 efficiency curve.

C Each motor shall be shop tested by the manufacturer in accordance with the requirements of Division 16.

3.03 Start-Up

A The Contractor shall provide the services of the pump manufacturer's representative for two days to operate the pumps of each type.

B The pump performance shall be documented by obtaining concurrent readings showing motor voltage and amperage, pump suction head, pump discharge head, and pump speed (rpm). Readings shall be documented for at least three pumping conditions to ascertain the actual pumping curve. One test shall be at shutoff head. Each power lead to the motor shall be checked for proper current balance.

C Bearing temperatures shall be determined by a contact type thermometer. Alternatively, lubricant temperature may be measured. A running time or at least twenty minutes shall be maintained for this test.

D The pump shall be visually and manually checked for excessive vibration. If the pump vibration is excessive, it shall be checked and recorded. The vibration of the pump measured at any point on the pump and motor when operating at full speed shall not exceed the following:

Speed, rpm	Vibration Amplitude
minimum speed	as H.I. Standards
full speed	as H.I. Standards

E If pumps fail to meet specified requirements, adjustments shall be made and the test re-run until performance meets the requirements. Test results shall be recorded for each pump for each test and full reports shall be submitted to the Engineer. The costs of re-testing and reporting shall be borne by the Contractor.

3.04 Instruction

The Contractor shall conform to the requirements of Section 11005 and provide a minimum of one day of instruction for each pump class.

End of Section 11071

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Section 11072

Multi-Stage Centrifugal Pumps

Part 1 General

1.01 Description

The Contractor shall furnish and install the specified horizontal or vertical multi-stage centrifugal pumps complete with motors and appurtenances as shown on the drawings and as specified herein.

1.02 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation, and installation data together with detailed specifications and performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams, and all other accessories of the equipment furnished. The submittals shall include, but not be limited to the following:

A Manufacturer's product data.

B Shop Drawings.

C Motor data, including:
1 Manufacturer.
2 Minimum guaranteed efficiency.
3 Power factor at full load, 3/4 load, and 1/2 load.
4 Locked rotor current.
5 Motor speed.
6 Mounting details.

D Pump characteristic curves.
1 Plot flow, total dynamic head, brake power, shutoff head, efficiency, and net positive suction head required for full operating range of pump.
2 Plot minimum of four curves for variable speed pumps covering required speed range (for variable speed pumps).
3 Show recommended limits of continuous operation.
4 Reflect operation with the specified fluid (e.g. include the effects of fluid viscosity).

E Certificates of compliance.

F Certified test reports.

G Operation and maintenance manuals.

H Training program.

1.03 Quality

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 pumping equipment. The pumps shall be the product of an experienced manufacturer and:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified;
4. the pump manufacturer's machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 Products

2.01 General

A. Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration. The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as throughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standards or Japan Industrial Standards. Excessive vibration shall be sufficient cause for rejection of the equipment. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty.

2.02 Materials

Materials of Construction:

1. Casing: Grey iron casting (BS1452, JIS G5501 FC200, or ASTM A48 Grade 35, or better)
2. Impeller: Bronze Casting (BS 1400, JIS H5120 CAC 402, ASTM B584 C90300, or better)
3. Wearplate: Bronze Casting (BS 1400, JIS H5120 CAC 402, ASTM B584 C90300, or better)
4. Shaft: Carbon Steel (BS970/I, JIS G4051 S45C stainless steel ASTM A582. JIS G4303 SUS420 J2 or better)
5. Shaft sleeve: Bronze Casting (BS1400, ASTM BS84 C83600, JIS H5120 CAC 406 or better)
6. Packing/Gland Housing: Gray Iron, ASTM A48, Grade 30 – 35 or better

2.03 Design Conditions

Pumps shall be designed and constructed to satisfactorily meet the design conditions and requirements specified in the Particular Specifications.

2.04 Pump Construction

The following requirements shall apply:

A. Casing.
Grey iron castings (BS1452, JIS G5501 FC200, or ASTM A48 Grade 35, or better). The casing shall be multi-stage turbine type and flanged and bolted together or machined and screwed into each other. The faces of each casing shall be accurately machined for tight and accurate fit. The suction and discharge flanges shall conform to BS4504 PN16 or more to meet the delivery pressure. Pipe taps for pressure gauges, vent, drain, etc. shall be provided

B. Impeller
Bronze casting (BS 1400, JIS H5120 CAC 402, ASTM B584 C90300, or better). The impeller shall be of multi-stage and finished smooth. The impeller shall be dynamically balanced, tightly mounted on the pump shaft with a key/cotter to that it shall not become loose due to rotation either in the forward or in the reverse direction.

C. Casing Wearing Rings
Bronze casting (BS 1400, JIS H5120 CAC 402, ASTM B584 C90300, or better) removable wearing rings shall be provided on pump casing.

D. Shaft and Sleeves
Carbon Steel (BS970/I, JIS G4051 S45C, stainless steel ASTM A582, JIS G4303 SUS420 J2 or better). Carbon steel shaft shall be protected from wear and corrosion by removable sleeves. Sleeves shall be of bronze casting conforming to BS1400, ASTM BS84 C83600, JIS H5120 CAC 406 or better. The sleeves shall extend from the impeller to the outside of the stuffing boxes.

E The bearings shall be of heavy-duty antifriction ball, or spherical roller type or sleeve type. The bearings shall be installed in bearing case to prevent the ingress of water to each bearing.

F. Stuffing boxes shall be large and deep and shall be provided with at least four rings of square packing and a lantern ring. Packing glands shall be of bronze casting, split horizontally to facilitate for installing packings. Piping with orifice and globe valve shall be provided for sealing water to each stuffing box from discharge volute casing. Drain pipes from the pumps shall be properly led to drain trenches in pump houses.

G. Bed Plates shall be of fabricated steel with web reinforcing or grey iron casting so designed that they can be grouted after alignment and leveling.

H Coupling between pump and motor shall be the gear flexible type, shall have sufficient capacity to develop the full strength of the shafting which they connect. The coupling shall be enclosed and sealed to retain the lubricant and exclude dust and moisture from the gear surface. Coupling shall be provided with guard.

I Pressure gauges not less than 100 mm diameter shall be provided at both the suction and discharge sides of each pump. The gauge ranges shall be approximately double the maximum operating pressure. The gauge on the suction side shall be compound gauge. The gauge shall have brass case and ring, and phosphor bronze Bourdon tube. The ranges selected shall be submitted to the Engineer for approval. The gauges shall have bottom connection with shut-off valves.

2.05 Motor

Motors shall be sized to drive the pumps throughout the pump operating curve on 400V, 3 phase, 50 Hz power. Motors shall be connected to the pump using a coupling with guards.

Motors shall be squirrel cage induction type with TEFC enclosure, 1.15 service factor as specified in Section 11510.

2.06 Accessories

Each pump shall be furnished with, but not limited to the following accessories:

Couplings with guard	: One (1) set
Bed plate (common)	: One (1) set
Compound and pressure gauge	: Complete set
Flange adapter with tie rods for discharge pipe	: Complete set
Foundation bolts and nuts	: One (1) set
Air vent and others piping	: One (1) set
Suction and delivery reducer with flange	: Complete set
Special tools for maintenance as recommended by the Manufacturer or as instructed by the Engineer	: One (1) set (for each pump station)

2.07 Spare Parts

A The Contractor shall provide the following spare parts for each unit of pump, and supply other items as recommended by the Manufacturer as spares for 5 years operation.

Complete set of bearings for pump	: One (1) set
Complete set of bearings for motor	: One (1) set
Complete set of pressure gauges	: Two (2) sets
Complete set of wearing rings	: Two (2) sets
Complete set of all gaskets	: Two (2) sets
Complete set of all packing	: Two (2) sets
Shaft sleeves	: One (1) set
Lantern rings	: Two (2) sets
Complete sets of all special bolts, screws and nuts	: Two (2) sets
Complete pump rotor assembly	: One (1) set

B All spare parts shall be properly preserved and packed for a long period of storage, and in a hot and humid climate and shall be properly marked in the English language on the outside to permit easy identification of the contents without opening and exposing the contents.

Part 3 Execution

3.01 Installation

Conform to the requirements of Section 11005.

3.02 Equipment Shop Testing

A Each major component of the pumping equipment shall be subjected to a complete shop test as specified herein, witnessed by the Engineer if so desired. All costs for the shop tests shall be borne by the Contractor.

B Each assembled pump shall be shop tested by the manufacturer to determine the following characteristics for the minimum and maximum speed and two intermediate speeds at which the pumps will be operated. All tests shall be performed in accordance with the latest Hydraulic Institute Standards or JIS B 8301 and 8302.

1 head-capacity curve,

2 power curve,
3 efficiency curve.

C Each motor shall be shop tested by the manufacturer in accordance with the requirements of Division 16.

3.03 Start-Up

A The Contractor shall provide the services of the pump manufacturer's representative for two days to operate the pumps of each type.

B The pump performance shall be documented by obtaining concurrent readings showing motor voltage and amperage, pump suction head, pump discharge head, and pump speed (rpm). Readings shall be documented for at least three pumping conditions to ascertain the actual pumping curve. One test shall be at shutoff head. Each power lead to the motor shall be checked for proper current balance.

C Bearing temperatures shall be determined by a contact type thermometer. Alternatively, lubricant temperature may be measured. A running time or at least twenty minutes shall be maintained for this test.

D The pump shall be visually and manually checked for excessive vibration. If the pump vibration is excessive, it shall be checked and recorded. The vibration of the pump measured at any point on the pump and motor when operating at full speed shall not exceed the following:

Speed, rpm	Vibration Amplitude
minimum speed	as H.I. Standards
full speed	as H.I. Standards

E If pumps fail to meet specified requirements, adjustments shall be made and the test re-run until performance meets the requirements. Test results shall be recorded for each pump for each test and full reports shall be submitted to the Engineer. The costs of re-testing and reporting shall be borne by the Contractor.

3.04 Instruction

The Contractor shall conform to the requirements of Section 11005 and provide a minimum of one day of instruction for each pump class.

End of Section 11072

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Section 11179

Submersible Pumps

Part 1 General

1.01 Description

There shall be furnished and installed submersible pumps complete including furnishing all labor, equipment, tools, materials, and performing all operations required for the construction and installation. Pumping equipment to be provided includes:

1 Submersible Pumps.
2 Guide Rail Systems.
3 Pump Bases.
4 Anchor Bolts.
5 Necessary Appurtenances.

1.02 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation, and installation data together with detailed specifications and performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams, and all other accessories of the equipment furnished. The submittals shall include, but not be limited to the following:

A Manufacturer's product data.

B Shop Drawings.

C Motor data, including:
  1 Manufacturer.
  2 Minimum guaranteed efficiency.
  3 Power factor at full load, 3/4 load, and 1/2 load.
  4 Locked rotor current.
  5 Motor speed.
  6 Mounting details.

D Pump characteristic curves.
  1 Plot flow, total dynamic head, brake power, shutoff head, efficiency, and net positive suction head required for full operating range of pump.
  2 Show recommended limits of continuous operation.

E Certificates of compliance.

F Certified test reports.

G Operation and maintenance manuals.

H Training program.

1.03 Quality

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 submersible pumps and ancillary equipment. The equipment shall be the product of an experienced manufacturer that:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.
4. the manufacturers' machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 Products

2.01 General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration. The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as throughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standards or Japanese Industrial Standards. Excessive vibration shall be sufficient cause for rejection of the equipment. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty.

2.02 Materials

Non-clog submersible pumps shall comprise:

1 Pump case and discharge elbow: Cast Iron, ASTM A48, Class 30 to 40B or JIS G5501 FC200.
2 Motor housing: Cast iron, ASTM A48, Class 30 to 40B or JIS G 5501 FC200
3 Impeller : Cast Iron, ASTM A48, Class 30 to 40B.
4 Pump/Motor Shaft:
  a With sleeve : Carbon Steel, ASTM A576 Gr. 1045.
  b Without sleeve : Stainless steel, ASTM A276 Type 420 or JIS G4303 SUS 403.
5 Wear ring, case : Cast Iron ASTM A48, 200 Brinell.
6 Wear ring, impeller : Stainless Steel, AISI 329, 300 Brinell.
7 Fasteners : Stainless Steel, ASTM A-276, Type 304 Or JIS G4304 SUS304.
8 Guide System : Dual Cables or Sch. 40 pipe, ASTM A-276, Type 304 Or JIS G4304 SUS304.
9 Lifting Chains and Cables : Stainless Steel, ASTM A-276, Type 304 Or JIS G4304 SUS304.

2.03 Design Conditions

Pumps shall be designed and constructed to satisfactorily meet the design conditions and requirements specified.

2.04 Accessories

In addition to the requirements of Section 11005 the following shall be provided:

1 Provide power cable form junction box to pump suitable for submersible applications in wastewater and indicate same by a code or legend permanently embossed on cable. Size cable in accordance with applicable IEC specifications. Provide 10m power cable and control cable, minimum. Provide each cable with a strain relief, cord grip, and explosion proof seal installed in accordance with IEC Article 500 to prevent entrance of wet well gases. Cable entry design shall insure that no entry of moisture is possible into the motor/terminal area even if the cable is damaged or severed below water level.

2 Each phase of the motor over 15 kWshall be fitted with a temperature monitor embedded in the motor windings and in series with each other. The control shall be arranged to open a normally closed contact for remote monitoring and stop the pump and shall automatically reset once the stator temperature returns to normal. The set temperature of the temperature monitors shall be as recommended by the manufacturer.

3 A leak detector shall be furnished to detect water in the stator chamber for motors over 15 kW. The sensor shall utilize a float switch and controls shall be arranged to open a normally closed contact for remote monitoring and stop the pump.

4 A bearing temperature monitor shall be furnished for the lower bearing arranged to open a normally closed contact for remote monitoring and stop the pump. The set temperature of the temperature monitor shall be as recommended by the manufacturer.

2.05 Fabrication

A General. The pumps shall:

1 be capable of handling liquids as specified in the Particulaf Speciications.

2 allow for removal without entering the wet well and without removal of bolts, nuts or other fastenings.

3 connect to discharge connecting with a simple downward motion without rotation.

4 include necessary sliding guide bracket and discharge connection, which, when bolted to the floor of the sump and to the discharge line, will receive the pump discharge connecting flange without need of adjustment, fasteners, clamp, or similar devices.

5 not bear directly on the of floor the wet well.

6 where watertight sealing is required, have mating surfaces machined and fit with O-rings.

7 be provided with pressure gauge taps and air bleed taps on each pump discharge, upstream of the discharge flange.

8 have castings produced in accordance with the pump manufacturers specifications under the manufacturers direct supervision.

B The impellor shall be dynamically balanced in accordance with Hydraulic Institute or Japanese Industrial Standards.

C Discharge connections and guide rails shall comprise a sliding guide bracket integral to pump unit which properly aligns the pump discharge with the discharge connection elbow for watertight seal during pump operation. The guide rail(s) shall not support any portion of the weight of the pump.

D The shaft design shall be of sufficient size to transmit full driver output and the shaft shall have a maximum deflection of 0.05mm measured at the stuffing box. The shaft shall be accurately machined and constructed with sufficient materials.

E Shaft Seal:
1 Seal shaft with tandem mechanical type seal operating in an oil filled chamber.
2 The lower seal between the pump and oil chamber shall contain one tungsten-carbide stationary and one tungsten-carbide rotating ring.
3 The upper seal between the oil sump and motor housing shall contain one stationary ceramic or tungsten-carbide ring and one rotating carbon or tungsten-carbide ring.
4 Provide seals requiring neither routine maintenance nor adjustment, but capable of being easily inspected and replaced.
5 Hold interface in contact by its own spring system.

F The shaft shall be supported on upper and lower permanently lubricated bearings with B-10 life of 40,000 hours. The bearing system shall be sealed from any outside contamination.

G Motors:
1 Provide motor of totally submersible design, constructed with epoxy or poly-seal encapsulated windings, air-filled or dielectric oil filled, with Class F insulation, enclosure protection of IP 68 and rated for continuous duty operation.
2 Assure motor is capable of running dry for extended periods without damage to motor or seal.
3 Motors shall be sized so that under maximum continuous load, motor nameplate kW is a minimum of 15 percent greater than the driven load.
4 All motors shall conform to the requirements of 11510.

2.06 Source Quality Control

A Secure from the pump manufacturer certifications that the following inspections and tests have been conducted on each pump before shipment from factory:
1 Check impeller, motor rating and electrical connections for compliance with Specification.
2 Test motor and cable insulation for moisture content or insulation defects.
3 Prior to submergence, run pump dry to establish correct rotation and mechanical integrity.
4 Run pump for 30 minutes submerged, a minimum of 2m under water.
5 After operational test #4, perform insulation test (#2) again.

B Factory test one pump of each service category.

C The manufacturer shall furnish, to the Engineer prior to shipment:
1 Certified copies of the curves and reports generated by the tests described above.
2 Foundry Composition Certificates for all major casting (pump case, impeller, motor housing) showing exact material composition and test conducted to insure compliance with the pump manufacturer material specifications.

2.07 Tools and Spare parts

All special tools required for normal service and maintenance shall be provided. In addition, spare parts shall be furnished for each pump as follows:
1 One set of complete bearings.
2 One set of wear rings.
3 One set of gaskets/"O" Rings, complete
4 Two sets of upper and lower seals
5 For each pump type - one pump, complete

Part 3 Execution

3.01 Installation and Start-up

The Contractor shall arrange to have the manufacturer or supplier of the equipment furnished under this Section, furnish the services of competent factory-trained personnel to supervise the installation, field testing and initial operation. A minimum of twenty days service shall be provided. Installation and erection of all assemblies and components shall be in accordance with the details indicated on the approved shop drawings and the printed instructions of the manufacturer.

3.02 Testing

A Pumps shall be shop tested as follows:
1 Factory test pumps to demonstrate compliance with specifications.
2 Plot flow rate, discharge pressure, operating speed, and power on certified performance curve for Engineer's approval.
3 Test one of each size and type of pump provided.
4 Submit three copies of certified test reports to engineer for approval. Reports shall be approved prior to shipping the equipment.
5 Include testing costs in the Contractor's bid price.

B Pumps shall be field tested as follows:
1 Manufacturer's representative shall operate each pump after installation.
a Monitor vibration and noise as well as specified performance parameters.
b All values shall be as specified; or if not specified, as recommended by the manufacturer.
2 Operate system in both hand and automatic modes.
a Flow pacing signals, if used, shall be operating.
b System shall operate as specified.

End of Section 11179

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Section 11190

Progressing Cavity Pumps

Part 1 - General

1.01 Description

The Contractor shall furnish and install the specified progressing cavity pumps complete with drives, motors, and appurtenances as shown on the drawings and specified herein.

1.02 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation, and installation data together with detailed specifications and performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams, and all other accessories of the equipment furnished. The submittals shall include, but not be limited to the following:

A. Manufacturer's product data.

B Shop Drawings.

C. Motor data, including:
   1. Manufacturer.
   2. Minimum guaranteed efficiency.
   3. Power factor at full load, 3/4 load, and 1/2 load.
   4. Locked rotor current.
   5. Motor speed.
   6. Mounting details.

D. Pump characteristic curves.
   1. Plot flow, total dynamic head, brake power, shutoff head, efficiency, and net positive suction head required for full operating range of pump.
   2. Plot minimum of four curves for variable speed pumps covering required speed range.
   3. Show recommended limits of continuous operation.
   4. Reflect operation with the specified fluid (e.g. include the effects of fluid viscosity).

E. Certificates of compliance.

F. Certified test reports.

G. Operation and maintenance manuals.

H. Training program.

1.03 Quality

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 progressive cavity pumps and ancillary equipment. The equipment shall be the product of an experienced manufacturer that:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;

2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.
4. the manufacturers' machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 - Products

2.01 General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration. The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as throughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standards. Excessive vibration shall be sufficient cause for rejection of the equipment. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty. Suction port shall be capable of being rotated in 90 degree increments around the pump centerline.

2.02 Design Conditions

The design conditions shall be as specified in the Particular Specifications.

2.03 Materials

Materials of Construction

1. Cast iron shall conform to ASTM A48 and be close grained, gray cast iron.
2. Steel fabrications shall conform to ASTM A36.
3. Stainless steel for pump construction shall be type 316.
4. Provide 316 stainless steel anchor bolts for each pump of sufficient length to allow 25 mm of grout under the baseplate.

2.04 Pump Construction

A. Pump construction shall be of cast iron for pump housing, supports, and packing gland and the following requirements shall apply:

B. Rotor
   1. Machined from tool steel containing 11 to 15 percent chromium
   2. Hardened to a Rockwell C of 57 to 60.
   3. Covered with hard chromeplate to a thickness of 0.254 mm.

C. Stator
   1. Formed of nitrile synthetic rubber of at least 70 durometer hardness or as otherwise

specified in the Particular Specifications.
2. Bonded to a steel sleeve.
3. Attached to suction housing so it can be easily removed.
4. Sealed to prevent pumped material from contacting the bonded area of the tube.
5. Packed type gland with grease seal required.

D. Universal Joints and Connecting Rod.
1. Grease lubricated, totally enclosed, sealed and shielded crown gear type.
2. Splined connecting rod shall connect the gear joints of the eccentrically moving rotor and drive shaft.
3. Connecting rod shall pass through the suction housing and shaft seal area within a solid or hollow drive shaft quill.
4. Quill shall be removable (for repair) and replaceable.
5. Quill removal shall not require bearing removal or disconnecting of the driver.
6. Provide shaft sleeve to minimize drive shaft wear.
7. Provide fibre deflector at universal joint assembly to minimize blockages.

2.05 Alternative Pump Construction

A. Pump construction shall be of 316 stainless steel for pump housing, supports, packing gland, and connecting rod and the following requirements shall apply:

B. Rotor
1. Machined from 316 stainless steel.
2. Covered with hard chromeplate to a thickness of 0.254 mm (0.010 inches).

C. Stator
1. Formed of nitrile synthetic rubber of at least 70 durometer hardness or as otherwise specified in the Particular Specifications.
2. Bonded to a steel sleeve.
3. Attached to suction housing so it can be easily removed.
4. Sealed to prevent pumped material from contacting the bonded area of the tube.

D. Universal Joints and Connecting Rod.
1. Pin type.
2. Splined connecting rod shall connect the pin joints of the eccentrically moving rotor and drive shaft.
3. Connecting rod shall pass through the suction housing and shaft seal area within a solid or hollow drive shaft quill.
4. Quill shall be removable (for repair) and replaceable.
5. Quill removal shall not require bearing removal or disconnecting of the driver.

2.06 Drivers

A. General.
1. Motor mounted “piggy-back” over the pump to conserve space.
2. Sheaves sized to provide required operating speed.
3. Belt guards conforming to OSHA or International Safety standards are required.
4. Pump and drive factory mounted on a structural steel baseplate.
5. Connected to pump via V-belts and sheaves.

B. Constant speed motor or gear motor shall be TEFC induction motor as specified in Section 16150

C. Variable speed.
   1. Motor
      a. TEFC induction motor as specified in Section 16150.
      b. Frame size selected to prevent overheating when continuously operated at 10 percent speed and constant torque load.
   2. Variable speed operation provided by variable frequency controller.
      a. The equipment shall be as specified in Section 16481.
      b. Suitable for continuous operation over a 10 to 1 speed range within plus or minus 2 percent of the selected operating speed.

2.07 Accessories

In addition to the requirements of Section 11005 the following shall be provided:
1. Loss of flow protection which automatically shuts down pump if flow is interrupted for any reason.
2. Over pressure protection which automatically shuts down pump if discharge pressure increases above a pre-set and adjustable value.
3. Suction and discharge pressure gauges including full circumference, pressure-sensing diaphragm mounted in pipeline.

2.08 Tools and Spare Parts

All special tools required for normal service and maintenance shall be provided. In addition, spare parts shall be furnished as follows:

1. Two stators
2. Two rotors
3. Two sets of packing
4. Eight litres of each oil and lubricant
5. Two sets of drive belts
6. Two O-ring kits
7. Two gear or pin joint kits
8. Two connecting rod kits
9. Four stator gaskets

Part 3 - Execution

3.01 Installation and Start-Up

The Contractor shall arrange to have the manufacturer or supplier of the equipment furnished under this Section, furnish the services of competent factory-trained personnel to supervise the installation, field testing and initial operation. A minimum of twenty days service shall be provided. Installation and erection of all assemblies and components shall be in accordance with the details indicated on the approved shop drawings and the printed instructions of the manufacturer.

3.02 Testing

A. Pumps shall be shop tested as follows:
   1. Factory test pumps to demonstrate compliance with specifications.
   2. Plot flow rate, discharge pressure, operating speed, and power on certified performance curve for Engineer's approval.
   3. Test one of each size and type of pump provided.
   4. Submit three copies of certified test reports to engineer for approval. Reports shall be approved prior to shipping the equipment.

B. Pumps shall be field tested as follows:
   1. Manufacturer's representative shall operate each pump after installation.
      a. Monitor vibration and noise as well as specified performance parameters.

b. All values shall be as specified; or if not specified, as recommended by the manufacturer.

2. Operate system in both hand and automatic modes.
   a. Flow pacing signals, if used, shall be operating.
   b. System shall operate as specified.

End of Section 11190

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Section 11196

Sump Pumps

Part 1 General

1.01 Description

Sump pumps shall be complete with drives, motors, and appurtenances.

1.02 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation, and installation data together with detailed specifications and performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams, and all other accessories of the equipment furnished. The submittals shall include, but not be limited to the following:

A. Manufacturer's product data.

B Shop Drawings.

C Motor data, including:
1 Manufacturer.
2 Minimum guaranteed efficiency.
3 Power factor at full load, 3/4 load, and 1/2 load.
4 Locked rotor current.
5 Motor speed.
6 Mounting details.

D Pump characteristic curves.
1 Plot flow, total dynamic head, brake power, shutoff head, efficiency, and net positive suction head required for full operating range of pump.
2 Plot minimum of four curves for variable speed pumps covering required speed range.
3 Show recommended limits of continuous operation.
4 Reflect operation with the specified fluid (e.g. include the effects of fluid viscosity).

E Certificates of compliance and certified test reports.

F Operation and maintenance manuals.

G Training program.

1.03 Quality

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 sump pumps and ancillary equipment. The equipment shall be the product of an experienced manufacturer that:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;

3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.
4. the manufacturers' machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 Products

2.01 General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration. The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as throughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute or Japanese Industrial Standards. Excessive vibration shall be sufficient cause for rejection of the equipment. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty.

2.02 Materials

A Pump Casing: Class 30 cast iron, ASTM A48 or JIS G5501 FC250 or ductile iron JIS G5502 FCD450.

B Impeller: Class 30 cast iron, ASTM A48 or JIS G5501 FC250 or ductile iron JIS G5502 FCD450.

C Shaft: Stainless Steel, ground and polished.

D Fasteners: 304 stainless steel.

E Motor Housing: Class 30 cast iron or JIS G5501 FC250 or ductile iron JIS G5502 FCD450.

F Motor lead cable:
1 Conductors: Copper stranded wire.
2 Jacket: Vinyl or neoprene.
3 Terminal head grommet: Epoxy sealed Buna - N.

2.03 Design Conditions

Pumps shall be designed and constructed to satisfactorily meet the design conditions and requirements specified.

2.04 Pump Construction

A Provide submersible, corrosion resistant, industrial quality pump complete with electric

motor, discharge piping, mercury switch actuated controls, power cord, control panel, vent flange, cover, and other accessories required for proper installation and operation.

B The impeller shall be semi-open statically, dynamically, and hydraulically balanced, accurately machined and filed for smoothness.

C Shaft:
1 Double mechanical seal.
2 Tungsten-Carbide carbon ring with stainless steel parts.
3 Oil filled chamber to lubricate running faces.

D Motors:
1 Comply with applicable portions of Section 16150.
2 Hermetically sealed, squirrel cage induction type in oil filled chamber.
3 415V, three phase, 50 Hz.
4 Motor and pump shaft to be integral
5 Provide waterproof, oil resistant, grounded, flexible power cord.
6 Non-overloading throughout entire pump curve.
7 Capable of running dry for extended periods without damage to motor or seal.
8 Provide motor of totally submersible design, enclosure IP 68.

2.05 Accessories

In addition to the requirements of Section 11005 the following shall be provided:
1 Provide a unit control panel (UCP) with padlockable main disconnect to control the simplex/duplex sump pump station. Provide pump stop, start 1st pump, start 2nd pump (if required), & high level alarm.
2 Provide pump with submersible cable, including power & control.
3 Size cable in accordance with applicable NEC specifications.
4 Field verify exact length of cable required.
5 Float switches to be mercury tube switches in sealed polypropylene case.
6 Height of float to be field adjustable.

2.06 Tools and Accessories

All special tools required for normal service and maintenance shall be provided. In addition, spare parts shall be furnished for each pump as follows:
1 One set of complete bearings.
2 One set of wear rings.
3 One set of gaskets/”O” Rings, complete
4 Two sets of upper and lower seals
5 For each pump type - one pump, complete

Part 3 Execution

3.01 Installation and Start-up

The Contractor shall arrange to have the manufacturer or supplier of the equipment furnished under this Section, furnish the services of competent factory-trained personnel to supervise the installation, field testing and initial operation. Installation and erection of all assemblies and components shall be in accordance with the details indicated on the approved shop drawings and the printed instructions of the manufacturer.

3.02 Testing

Manufacturer's representative shall operate each pump after installation and shall monitor vibration and noise as well as specified performance parameters. All values shall be as specified; or if not specified, as recommended by the manufacturer. Systems shall be operated in both hand and automatic modes. Flow pacing signals, if used, shall be operating and systems shall operate as specified.

End of Section 11196

Section 11199

Surge Control Systems

Part 1 General

1.01 Scope

The Part specifies the requirements for the design, manufacture, construction, installation, testing and commissioning of complete surge protection systems, including flywheels, surge vessels, compressors, air valves and necessary accessory items.

1.02 Reference Standards

Applicable standards referred to in this section

BS 449,	The use of structural steel in building
BS 729 (ISO 1459, 1460, 1461)	Hot dip galvanised coatings on iron and steel articles
BS 970 (ISO 683)	Wrought steels for mechanical and allied engineering purposes
BS 1387 (ISO 65)	Screwed and socketed steel tubes and tubulars and for plain end tubes suitable for welding or screwing to BS 21 pipe threads
BS 1571 (ISO 1217)	Testing of positive displacement compressors and exhausters
BS 2872,	Copper and alloy stock and forgings
BS 3601 (ISO 2604)	Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes
BS 4504,	Circular flanges for pipe, valves and fittings
BS 5304,	Code of practice for the safety of machinery
BS 5500 (ISO 2694)	Unfired fusion welded pressure vessels

1.03 System Description

A Hydraulic Design. Surge control devices are to be provided where necessary at all pumping stations. The Contractor shall assume no inertia assistance from any air valves fitted. Air valves will not be accepted as a primary means of surge suppression. Flywheels may be used. In the case of multiple pumping mains separate surge suppression systems shall be provided for each main. The design shall include for the worst case i.e. surge conditions existing when the system is pumping at maximum rate and a power failure occurs. Surge analysis shall be based on the friction factor used for new pipelines.

B System Design. The following types of system may be used for surge protection:

1 flywheels. These shall be used where there is sufficient reserve capacity of liquid in the wet well or surge tower {see 2} at all times to allow the flywheel to continuously recharge the main with liquid

2 surge towers. Their use is only applicable when the total head developed by the pump is low

3 hydropneumatic atmospheric surge vessels. Their use is only applicable when the static head in the rising main is low. They shall incorporate a dip tube and a float air valve which allows air in and out of the vessel depending on the liquid level in the vessel.

4 bladder type pressure vessels. Their use is only applicable when no negative pressures occur in the main in either a surge condition or normal operation

5 hydropneumatic surge vessels with compressors. Their use is only applicable where there is a substantial static head in the rising main

C Air Valves. Air valves shall be installed on the rising main as specified or required to optimise the hydraulic efficiency of the main.

1.04 Submittals

The following data shall be submitted by the Contractor.

1 Design Data:
   a Hydraulic Calculations. The Contractor shall submit a complete computer based hydraulic transient analysis showing the performance of the surge control system under various model scenarios. Normal operating modes and the sudden shut down of the pump following a power failure shall be simulated. The program shall have the facility to model the characteristic of the different manufacturer's air and reflux valves, and any other proprietary equipment
   b structural calculations. Structural calculations for the design of the pressure vessel and its supports shall be provided.
2 Shop drawings shall be provided for the fabrication and erection of the whole system, including air compressors, air valves, surge vessels. Layout drawings, pressure vessel calculations, schematic drawings and electrical drawings shall be provided. Catalogue pages, manufacturers' detail instructions, templates and installation methods shall be provided.
3 tests as described below shall also be included. Documentation for the compressors in accordance with BS 1571 shall be provided

1.05 Quality Assurance

Both the company carrying out the surge analysis and the software used for the computer transient analysis shall have a proven record in surge analysis. Software used shall be a recognised water industry standard. The out surge analysis shall be carried out on the force main on the basis of data of rotating element, characteristic of reflux valve and force main to ensure if moment of inertia of the rotating elements has to be increased or not. If the moment of inertia has to be increased, a flywheel shall be added between pump and motor with shaft and plummer block. The magnitude of flywheel and detailed construction of the plummer block shall be proposed by the pump manufacturer for the engineer's approval along with report of surge analysis.

Part 2 Products

2.01 Design Conditions and Performance Characteristics

A Unless specified otherwise in the particular Project Specification, transient surge pressures shall be limited as the following paragraphs.
   1 Positive (over) pressure - Positive surge pressures shall not exceed the design pressure of the pipeline, taking into account any derating for temperature. The rating of pipeline restraints and thrust blocks shall be considered in limiting the positive pressure.
   2 Negative (under) pressure - Negative surge pressures shall not exceed the following:
      a GRP, asbestos cement, and cement lined ductile/cast iron and steel-limit 1 metre of vacuum (-1 m)
      b Bitumen lined ductile/cast iron and steel-limit 3 metres of vacuum (-3 m)
      c uPVC, ABS, HDPE, MDPE - limit 3 metres of vacuum (-3 m).
   3 Stress cycling. Certain types of plastic pipeline can fail prematurely due to duty

cycling. Where the pump start/stop cycling is likely to be high this should be considered.

4 Pipeline Manufacturer's Recommendations. In all instances the recommendations of the pipeline manufacturer with respect to positive and negative pressures and stress cycling must be followed. Pipeline seals must be included in these recommendations.

5 Surge Vessels. These must be designed, inspected and tested in accordance with BS 5500 Code 2 with a 2.0 mm corrosion allowance Design pressure ratings shall be 1.25 times the greatest pressure the vessel will be subject to. Vertical vessels shall be used wherever possible for sewage. Any supports or plinths shall be designed for the vessel to be completely full of liquid.

2.02 Materials

A Surge Towers. If these are constructed in concrete, then Section 8 shall apply. If in the same material as the pipeline, then the specifications applying to the pipeline shall apply.

B Surge vessels. These shall be constructed from steel in accordance with BS 5500.

C Coatings. Surge vessels shall be coated internally with an epoxy paint system of minimum thickness 300 microns. The system shall be proven in use in this application. The external coating system shall be in accordance with Section 9.

2.03 Fabrication

A Surge Towers (stand pipes). These may be constructed in concrete, G.R.P or steel. The top of the tower shall be vented back to the wet well or through a suitable de-odouriser as specified. An emergency overflow shall be provided, routed to a drain. They shall be capable of withstanding the maximum pressure generated by the pumps or surge transients, assuming the tower is full of liquid. Means shall be provided for draining the tower and cleaning it out.

B Hydropneumatic Atmospheric Surge Vessels. These shall be constructed in steel as specified above for surge vessels. They shall include the following features:

1 facility for draining the vessel. If possible, this shall be using the pressure pipeline
2 manway access if the vessel is large enough to accommodate this, or inspection hatch for cleaning the vessel out
3 air/float valve on top of the vessel. This shall be readily accessible for cleaning and maintenance
4 vent back to the wet well or a suitable drain for the above valve
5 pressure gauge with isolating cock to measure the maximum and minimum pressures
6 flanges shall be to BS 4505 PN 16.

C Bladder Type Pressure Vessels. These shall be constructed in steel as specified above for surge vessels. They shall include the features 1, 2, 5 and 6 described in B above and in addition the following:

1 food grade iso-butyl rubber bladder. This shall have a guaranteed life of three years in contact with the liquid pumped and at the specified temperatures
2 bladder pressurisation valve and gauge. This is for recharging the bladder. Access ladders/platforms shall be provided as necessary.

D Hydropneumatic Surge Vessels with compressors. The vessel shall be constructed in steel as specified above. The vessel shall include the features 1, 2, 5 and 6 described in B above and in addition the following:

1 liquid level gauges
   a tubular glass, liquid-level gauges with 20 mm tube outside diameter shall be provided. The minimum viewing length shall be 600 mm per gauge. Sufficient gauges shall be provided to view the entire operating range of water levels in the pressure vessel. Threaded 20 mm connections shall be provided. Isolation valves with ball checks shall be provided to prevent loss of liquid upon gauge breakage. Valves shall be of an offset pattern with integral bonnet. Valve bodies shall be bronze. A drain cock shall be provided on the lower valve. Valves shall have pressure ratings of 1.5 times the maximum surge pressure anticipated, or NP 16, whichever is greater
   b flanges shall be provided, NP 16 for the maximum and minimum level probe locations, respectively.
2 safety relief valves shall comply with BS 5500 and shall be capable of passing air and water. Valves shall have a bottom inlet and side outlet. The inlet shall incorporate a calibrated spring set to allow the valve to open at the vessel design pressure.
3 air pipework. Air piping shall be galvanised to BS 729 and conform to BS 1387 or BS 3601, of a minimum of 25 mm diameter. A brass ball valve shall be provided as a block valve at the pressure vessel. Brass check valves shall be provided in the air line. All shall be rated for 16 bar.
4 air compressor assembly
   a the compressor unit shall be self-contained and consist of a single-acting, two-stage, if necessary, air-cooled, reciprocating-type compressor motor with V-belt drive and regulation, on a fabricated steel skid. Valves shall be of stainless steel and shall be easily removed or inspected without use of special tools.
   b the compressor shall be driven by an electric motor which shall comply with Section
   c the air inlet filter silencer shall be of the dry replaceable cartridge type
   d the compressor shall shut down at unsafe oil level and shall not restart without adding oil
   e if necessary, the compressor shall be provided with finned tube, air-cooled intercooler to remove the heat of compression. The compressor shall have an automatic centrifugal starting unloader valve which will cause the pressure in the compressor cylinders to be vented to atmosphere upon compressor stopping, thereby allowing the compressor to start against minimum load
   f rotating parts shall be guarded in conformance with BS 5304
   g the oil sump on each compressor shall be fitted with a valve and drain extension pipe of sufficient length to enable the oil to be drained without spilling over the base. Sumps containing 1.0 or less may be fitted with a capped pipe.
5 automatic air volume control system
   a the automatic air volume control system, in conjunction with pressure vessel-mounted sensor probes and the air compressor unit, shall control the air/water ratio in the hydropneumatic pressure vessel and maintain the air/water ratio within a range compatible with the surge control system design and established system static and maximum operating pressures
   b contacts shall be provided for remote indication of excessive high or low water level in the vessel. Capacitance type level probes with a probe well plumbed to the side of the hydropneumatic vessel shall be provided as Section 10. A control panel with all necessary controls, relays and time delay circuits to actuate the air add/vent solenoid valves, and signal a high or low tank water level shall be provided.
   c solenoid valves of sizes 5 mm through 40 mm for air service shall have forged bronze bodies to BS 2872 with Teflon seats. Internal plunger, core tube, plunger spring, and cage assembly shall be stainless steel BS 970 Part 1 316S12. Solenoid enclosures shall be IP 68. Valve actuators shall be 240 V a.c. Seals shall be

Teflon. Valves shall have a maximum operating pressure and a maximum differential pressure of 16 bar. Solenoid valves shall be energised to open.

2.04 Factory Inspection and Testing

A The Contractor shall secure from the pump manufacturer certification that the following inspections and tests have been conducted at the factory and submit to the Engineer prior to shipment.

B Surge Vessels. These shall be inspected and tested in accordance with BS 5500 Code 2.

C Compressors. These shall be inspected and tested in accordance with BS 1571.

2.05 Spare Parts and Tools

The Contractor shall provide from the specialist manufacturers of the surge equipment all the spares and tools required during the commissioning and maintenance periods as specified. Special tools, if required for normal operation/or maintenance of any component of the surge control system, shall be supplied with the equipment.

Part 3 Execution

3.01 Installation

A All equipment shall be installed and commissioning in accordance with the manufacturer's recommendations and under the supervision of the surge control system supplier's factory trained personnel.

B Surge protection system performance shall be verified by field tests at pumping rates specified for each pressure main and for power failure at the maximum pumping rate. The surge control system supplier shall provide a chart recorder and pressure transducer system to develop a permanent record for each pressure main test.

End of Section 11199

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Section 11210

Gates and Stoplogs

Part 1 General

1.01 Scope

This Part specifies the requirements for the design, manufacturer, construction, installation, testing and commissioning of gates, stoplogs and appurtenances.

1.02 Reference Standards

Applicable standards referred to in this section - AWWA C501.

1.03 System Description

Equipment shall be capable of extended and continuous operation under the specified conditions and at the specified operating pressures.

1.04 Quality

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 gates and ancillary equipment. The equipment shall be the product of an experienced manufacturer that:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.
4. the manufacturers' machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 Products

2.01 Gates, Stoplogs and Appurtenances

Equipment shall be furnished as indicated on the drawings, and as further described in this specification. The gates shall be manufactured complete with wall thimbles, operating stems, electric motorized or hand operated floor stands, whichever is indicated or specified, and all other incidental appurtenances and accessories.

2.02 General

A All equipment parts, including the structural elements of lift mechanisms, shall be designed for the heads shown, with a minimum safety factor of 5.0 in respect of the tensile strength of the material. The safety factor of 5.0 shall be applied in respect to the material's ultimate compressive and shearing strength except for stems. The compressive strength of stems shall be determined by slenderness ratio (= L/r, L: shaft length, r: 0.25 x shaft diameter). Gates shall be designed and manufactured basically in accordance with AWWA C501, or requirements for various materials specified in JIS, BS, or other

standards. The gates, stoplogs and appurtenances shall be designed for installations as shown on the drawings.

B All materials used in the construction of the gates and appurtenances shall be the best suited for the application. All work shall be carried out in accordance with best modern practice for the manufacture of high grade machinery.

C All parts having mountings and bearings shall be machined accurately so that they can be assembled without chipping or re-machining. All parts shall conform accurately to the design dimension and shall be free of all defects in workmanship or material that will impair their service. All attaching bolt holes shall be accurately drilled to the layout indicated on the shop drawings. The gates shall be completely shop assembled to ensure the proper fit and adjustment of all parts.

2.03 Materials and Construction - Gates

A All materials used in the construction of the gates shall be allowable materials under AWWA C501 or equivalent unless otherwise noted herein.

B Gate shall have square opening, rising stem and conventional closure type. The gates shall consist of frames, gate slides, wedging devices, stems and stem couplings, stem guides and lifting devices. The gates shall be cast iron, fully bronze mounted with side wedges for seating head conditions. All gate components shall be designed to safely withstand the water head to be encountered. Seating and unseating conditions shall be specified in the Gate Schedule. Water head conditions shall be measured from the bottom of the gate.

C The frame shall be cast iron, one piece and flat back, flange back or projected back edge around opening type.

D The gate slide shall be of cast iron, and shall have one piece with strengthening ribs where required, and reinforced section to receive the seating faces.

E Seating faces shall be made of bronze or stainless steel. They shall be assembled firmly in the frame and the slide faces.

F The gate shall be equipped with adjustable side wedging devices to provide a tight contact between the slide and the frame facing when the gate is in the closed position. Wedges shall be fully adjustable and so designed that they will remain in the fixed position after adjustment.

G The operating stems shall have a size to safely withstand, without buckling or permanent distortion, the stresses induced by normal operating forces. The stems shall be made from solid bar stock of stainless steel. The stems shall be designed-to transmit in compression at least two times the rated output of the operator. Where stems are furnished in more than one piece, the different sections shall be joined together by solid couplings.

H Manual lift mechanisms shall be the crank operated or hand wheel with handle operated type with either a single or double gear ratio, depending on the lift load. Each type shall have a cast bronze lift nut threaded to fit the operating stem. Ball thrust bearings shall be provided above and below the flange on the lift nut to take the load developed in opening and closing the gate. Gears shall be of cast iron or steel accurately machined with cut teeth, and smooth running with suitable shafts in bronze sleeve bearings or roller bearings or ample size.

I All gears and bearings shall be enclosed in a cast-iron housing. Fittings shall be provided so that all gears and bearings can be periodically lubricated. The removable cast-iron crank or cast-iron hand-wheel shall be fitted with a brass, rotating handle. The lift mechanism shall be supplied with a cast-iron pedestal, machined and drilled to receive the gear housing and drilled for bolting to the operating floor.

J The design of the lift mechanism shall be such that the slide can be operated with an effect of no more than 18 kilograms on the crank or handwheel. The maximum crank or handwheel radius shall be 400 mm unless otherwise specified. The direction of wheel or crank rotation to open the gate shall be indicated on the lift mechanism.

2.04 Materials and Construction - Stoplogs - composite materials

A Stop logs of composite materials shall be provided with appurtenant seals, guides, frame, lifting lugs and accessories, required for the complete and proper operation of the system. All materials used in the construction of the stoplogs and appurtenances shall be the best suited for the application. Stoplogs shall conform to the specified dimensions and be complete with a lifting device. A storage rack for each set of stop logs shall be installed as located by the Engineer.

B Guide angles and frames, anchor bolts and grab bars shall be of stainless steel AISL 304.

C Frame, side seals and inter log seals shall be of EPDM (ethylene propylene).

D The logs shall be of reinforced composite plastic material stabilized against ultra-violet light. Composite stop logs shall have the following properties.

Tensile strength	85 N/mm^2
Flexural strength	124 N/mm^2
Compressive strength	76 N/mm^2
Water absorption	0.38%
Specific gravity	1.75

Each log shall be designed for a deflection of not less than 1/360 of the span under the design head.

E Logs shall be constructed of composite sandwich construction comprising a light-weight, rigid, cellular core with fully welded stainless steel box section matrix between two outer skins of rigid compressed plastic. Each log shall have four face rounded stainless steel grab bars. Logs shall be of sufficient weight to be submerged under their own weight.

F Frames and guides shall be constructed of stainless steel, built in or anchored to the structure walls with 12 mm anchor bolts. The frame seals shall be EPDM wiper type having on angled lip fitted to both sides of each frame with stainless steel AISI 304 strips and fasteners.

G Inter log seals shall be two strips bonded to be base of each log along the other edges. Leakage rate shall not exceed 0.05 litres per minute per metre of wetted seating perimeter.

H One lifting device shall be provided for each stop log width. The lifting device shall be equipped with suitable connecting points for crane operation. The device shall be guided by the slot of the guide and shall be capable of securing and releasing the stop logs with the use of a lanyard from the operating floor.

I The storage racks shall be capable of storing all stop logs at each location and be fabricated of 304 stainless steel. Clearance for lifting beam insertion and retraction shall

be provided. Posts shall be fitted with Ultra High Molecular Weight Polyethylene (UHMWPE) rubbing surfaces to protect the stop log.

2.05 Materials and Construction - Stoplogs - aluminium

A Aluminium stop logs shall be provided with appurtenant seals, guides, frame, lifting lugs and accessories, required for the complete and proper operation of the system. All materials used in the construction of the stoplogs and appurtenances shall be the best suited for the application. Stoplogs shall conform to the specified dimensions and be complete with a lifting device. A storage rack for each set of stop logs shall be installed as located by the Engineer.

B All component parts will be of the type of material shown and conform to the standards designated.

Component	Material
Log, Lifting Lugs, Frame	Aluminium, B 306,6061T6
Seals - Bottom:	Neoprene, D2000, Grade AA625
Seals - Sides:	Neoprene, D2000, Grade 2BC515

C The logs shall be of one-piece extruded aluminium. The logs shall not deflect more than 1/360 of the span of the log under the design head. The bottom of the log shall be extruded in a way to accept a specially extruded resilient seal to provide a flush bottom closure. The shape of the lip seal shall provide a seating surface having a minimum width of 25 mm. The vertical face of the seal shall be in contact with the seating surface of the guide or seal located on the frame to provide a proper seal at the corners. End caps will not be allowed on the stop logs. Logs shall be of sufficient weight to be submerged under their own weight.

D The guides shall be of extruded aluminium. The guides shall be designed for maximum rigidity and will be provided with a flange on the back of the guides for the embedded type to lock it into the concrete, or with a side angle for surface mounting using anchor bolts. The invert of the frame shall be a channel welded to the lower ends of the guides to form a sealing surface for the resilient seal mounted on the disc. All necessary attaching bolts and anchor bolts shall be stainless steel and furnished by the stop log manufacturer.

E All welding will be done in accordance with AWS D1.2 for aluminium and AWS D1.3 for stainless steel.

F One lifting device shall be provided for each stop log width. The lifting device shall be equipped with suitable connecting points for crane operation. The device shall be guided by the slot of the guide extrusion and shall be capable of securing and releasing the stop logs with the use of a lanyard from the operating floor.

G The storage racks shall be capable of storing all stop logs at each location and be fabricated of 304 stainless steel. Clearance for lifting beam insertion and retraction shall be provided. Posts shall be fitted with Ultra High Molecular Weight Polyethylene (UHMWPE) rubbing surfaces to protect the stop log.

2.06 Materials and Construction – Flap Gates

A Flap gates shall have circular or rectangular openings, be single or double door and be wall or thimble mounted as specified.

B The doors and frames shall be manufactured of BS EN 1561 min. 250 cast iron with

lifting lugs cast integrally. Other component materials shall be:

sealing faces	copper alloy to BS 1400L G2 or copper alloy to BS 2874 grade PB 102 or copper alloy to BS 2874 grade CZ 114;
hinge links	spheroidal cast iron or mild steel BS 4360 grade 43A
fasteners	grade A4 stainless steel
hinge pins	stainless steel BS 970 grade 316

Part 3 Execution

Equipment shall be installed and commissioned in accordance with manufacturer's instructions.

End of Part 11210

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Section 11221

Mixers

Part 1 General

1.01 Scope

This Part specifies the requirements for the design, manufacturer, construction, installation, testing and commissioning of mixers and appurtenances.

1.02 System Description

Mixers be capable of extended and continuous operation under the specified conditions.

1.03 Quality Assurance

The mixers shall be the product of a single current manufacturer having five years or more experience in the manufacture of similar sized mixers as required in the specifications.

Part 2 Products

2.01 General

The mixer assembly shall consist of impeller mounted on a vertical shaft suspended from a pedestal, a constant drive unit., shaft bearings, coupling, heavy duty motor, and a one-unit type base. There shall be no submersible bearing.

2.02 Impeller

The impeller shall be of stainless steel (JIS G 4303 or ASTM A276 or equivalent) of 6 mm thickness and mounted to the shaft of stainless steel tubes JIS G 4303 or ASTM A276 or equivalent. The length of shaft shall be sufficient to drive the impeller for proper mixing of the specified chemical and water solution. Anti-friction type thrust and guide bearings shall be located above the supporting slab for supporting and guiding the shaft and impeller and to resist all hydraulic loading on the shaft.. Bolts and nuts for submerged parts shall be of stainless steel.

2.03 Drive Unit

The motor shall be connected to the input shaft of the speed reducer which in turn shall drive the impeller shaft through suitable gearing. The drive unit shall be fitted with a flanged base and mounted on a supporting frame work. The drive assemblies shall be suitable for use outdoors and shall be of weatherproof construction, so protected that water, dust and dirt will not interfere with its proper operation.

2.04 Accessories

The mixer shall be furnished with, but not limited to the following:

a for each set of mixer:

drive unit base	1 set
foundation bolts and nuts	complete set

b for total set of equipment:

special tools for maintenance 1 set
as recommended by manufacturer
and approved by the Engineer

2.05 Spares

The Contractor shall provide the following spare parts for each mixer and supply other items as recommended by the manufacturer as spares for two years operation.

oil seals	1 set
bearings for motor and reduction gears	1 set each

2.06 Painting

The submerged parts of the mixer shall be given three coats of tar epoxy resin at the factory, and the atmospheric parts shall be given two coats of epoxy resin at the factory. Painting schedule shall be in accordance with Division 9.

Part 3 Execution

Mixers shall be installed and commissioned in accordance with manufacturer's instructions.

End of Part 11221

Section 11261

Chlorination Equipment

Part 1 General

1.01 Description

A. The Contractor shall furnish and install chlorination equipment, located and installed as specified herein and shown on the Drawings. All accessories not specifically mentioned herein that are required to make the system operable shall be furnished and installed by the Contractor. The system provided shall meet or exceed the Chlorine Institute guidelines.

B. The work included in this Section shall consist of manufacturing, furnishing, installing, and testing of all equipment necessary to provide complete and operable chlorination systems. The equipment shall be as described in the Particular Specifications and shall include some, or all, of the following:
   1. Chlorinators.
   2. Evaporators.
   3. Ejectors.
   4. System controller.
   5. Chlorine residual analyzer.
   6. Vacuum regulator.
   7. Automatic changeover system.
   8. Chlorine scales, and cylinder accessories.
   9. Instrumentation and controls.
   10. Piping, motorized valves, pressure regulators, and ancillary fittings, etc..
   11. Safety equipment, including atmospheric chlorine gas detectors, gas masks, and cabinets.

1.02 Submittals

Shop drawings showing fabrication, assembly and installation drawings, together with detailed specifications and data covering performance and materials of construction, parts, devices, and other accessories forming a part of the equipment furnished shall be submitted in accordance with Section 01300 and all requirements specified herein.

1.03 Quality

The complete system shall be provided by one supplier, having unit responsibility for the operation of all chlorine systems and equipment. The chlorination facilities shall be the product of an experienced manufacturer and:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified;
4. the manufacturer's machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 Products

2.01 General

(Type I: With Evaporator)

A. Chlorine cylinders shall be connected to the fixed piping system with flexible connections for liquid drawoff to the chlorine supply header(s). If specified, the liquid supply header(s) shall be connected to the chlorinators via evaporator and vacuum regulator and motorized valving which shall automatically connect only one chlorine cylinder to each supply header at any time. When the "operating" cylinder becomes exhausted, the change-over controls shall shut off that cylinder and connect the "standby" supply cylinder and it shall become the "operating" supply. If specified liquid chlorine is vaporized at the evaporators and the gas pressure reduced at the outlet to produce superheat. Once superheated, the gas is piped to a vacuum regulator which maintains and controls system vacuum caused by the vacuum producing ejector. Beyond the regulator, the gas flows to the chlorinator which meters the chlorine for system distribution.

B. The chlorinators operation shall be either fully manual or operator selected for automatic or manually operation to meter chlorine gas to the ejectors. The ejectors provide a source of operating vacuum for the chlorinators mixing the chlorine gas in a water solution for transport to the points of injection.

C. In automatic operation the chlorinators meter chlorine gas in proportion to flow signals from a remote meter or residual analyzer.

(Type II: Without Evaporator)

D. Chlorine cylinders shall be connected to the fixed piping system with flexible connections for chlorine gas drawoff to the chlorine supply header(s). If specified, the chlorine gas supply header(s) shall be connected to the chlorinators and vacuum regulator and motorized valving which shall automatically connect only one chlorine cylinder to each supply header at any time. When the "operating" cylinder becomes exhausted, the change-over controls shall shut off that cylinder and connect the "standby" supply cylinder and it shall become the "operating" supply. Chlorine gas is piped to a vacuum regulator which maintains and controls system vacuum caused by the vacuum producing ejector. Beyond the regulator, the gas flows to the chlorinator which meters the chlorine for system distribution.

E. The chlorinators operation shall be either fully manual or operator selected for automatic or manually operation to meter chlorine gas to the ejectors. The ejectors provide a source of operating vacuum for the chlorinators mixing the chlorine gas in a water solution for transport to the points of injection shown on the Drawings.

F. In automatic operation the chlorinators meter chlorine gas in proportion to flow signals from a remote meter, or residual analyzer as shown on drawings.

2.02 Evaporators

A. The evaporator shall be of the electrically heated type with a thermostatically controlled water chamber. The evaporator shall automatically vaporize and superheat liquid chlorine at a rate controlled by the using system, with a flowrate rangeability of 20:1. Additional superheat shall be furnished by the pressure reducing regulator at the evaporator outlet.

B. The vaporizing chamber shall be constructed of Schedule 80 welded steel pipe having a minimum wall thickness of 12 mm with forged steel fittings and shall be designed, constructed and tested to conform to the lethal substances section of the ASME code,

Section VIII, for unfired pressure vessels. The chamber shall be provided with a "U" stamp to meet unfired pressure vessel requirements. The chamber shall also be supplied with an "L" Certification which includes the additional stamps: "W-L" welding meets lethal gas requirements; "S-L" fabricated using seamless pipe; "HJT" whole vessel has been post-weld heat treated and "RT-1" complete chamber satisfies the full radiography requirements (100 percent) of all welded joints for lethal substances. The vaporizing chamber shall be hydrostatically tested at 5688 kPa. The water jacket shall be composed of stainless steel with a minimum wall thickness of 6 mm. The water heater shall be of the electric immersion type 15 kW maximum capacity. The electric heater shall be mounted in the lower portion of the water jacket to insure proper heat distribution. A magnetic contractor shall be required for operating the heater and shall be furnished.

C. The evaporator shall be equipped with a front panel mounted control thermostat, water level gauge, gas pressure and temperature gauges. A front panel mounted low temperature switch shall also be provided to cause the closing of the gas pressure reducing and shut off valve in the event of low water temperature. The thermostat and switch shall have calibrated gauges for ease of adjustment. A gas pressure relief valve complete with a safety head/rupture disc and pressure switch with diaphragm protector shall be provided for venting.

D. The evaporator shall be housed in a color impregnated, corrosion resistant, cabinet which shall be removable from the front. This shall permit multiple evaporators to be mounted 25 mm apart in order to minimize floor space requirements. The unit shall be supplied with adequate insulation for the water chamber in order to conserve energy.

2.03 Chlorinators

A. Chlorinators shall be of the floor-mounted, free standing, and of the manual or automatically-controlled type. Units shall be configured to automatically control the feed rate of chlorine to the vacuum powered system using continuously monitored parameters of flow and chlorine residual as input data; or a combined signal from system magnetic flow meters; or at a manually adjusted fixed feed rate, as specified. All chlorinators shall be designed and constructed to ensure maximum safety for operating personnel. All dispensers shall consist of a positive acting chlorine gas shutoff valve, remote mounted vacuum regulator, pressure relief valve, independent vacuum breaker, electric motor-actuated control valve, and a differential pressure regulator to ensure reproducible accuracy.

B. The electric motor operated valve actuator on automatic chlorinators shall accept a 4-20 mA DC flow and or chlorine residual signal. An integral signal conditioner shall automatically position the control valve to provide the required chlorine feed rate. The electric valve positioner shall utilize a heavy-duty motor. The positioner components shall be housed in a NEMA 4X, fiberglass-reinforced-plastic enclosure and factory-installed in the chlorinator module. Provide non-adhesive wire markers or, plastic sleeves at both ends of conductors in the control panel. The unit shall be provided with front panel-mounted off-on switch, manual-auto selector, and increase-decrease switches for local manual feed rate control. In the event of local power failure, gas flow shall be manually adjustable.

C. A separate control shall be provided to adjust feed rate such that full-scale output may be obtained with half-scale inputs and half-scale output with full-scale inputs. Chlorinator accuracy shall be plus or minus 4 percent of indicated flow rate over a 20:1 range.

D. A rotameter shall be provided on the cabinet face to indicate chlorine gas flow. The chlorinator shall be furnished with a gauge for indication of ejector vacuum. The

rotameter and vacuum gauge shall be graduated in metric units. A loss of vacuum alarm switch shall be provided with dry contacts for actuating remote alarm devices.

E. The chlorinator shall be constructed entirely of materials resistant to the corrosive attack of chlorine gas. The unit shall be floor-mounted with operating components, except the injector and the vacuum regulator, housed within a polyester-impregnated fiberglass cabinet.

F. Accessory equipment for each vacuum regulator shall include one chlorine strainer, one chlorine heater, one set of extra gaskets, and twelve lead gaskets. One bottle of chlorine testing ammonia, one tube of thread lubricant, three sets of special tools or wrenches, and one vent screen. Each chlorinator shall be equipped with one set of extra gaskets, lubricants, strainers, O-rings, filters, and spare parts normally supplied. Parts shall be stocked in a 22-gauge, minimum, steel enclosure with locking handle.

2.04 Chlorine Ejector

Each chlorinator shall be provided with a remotely mounted ejector to generate the vacuum required for chlorinator operation and for mixing the metered chlorine gas with the solution water in preparation for piping it to the diffusers at the points of application. The chlorine ejectors shall have built-in back flow preventers. The chlorine ejectors shall be sized for chlorine delivery equal to the maximum capacity of the associated chlorinator, and shall be furnished with PVC "Y" type strainers.

2.05 Vacuum Regulator

The vacuum regulators shall be wall mounted and shall close automatically if the operating vacuum fails. The vacuum regulator shall be provided with an integral liquid trap and inlet heater to reduce the likelihood of liquid reaching the regulator. The heater shall operate from 240/415 VAC, 50 Hz electric power. A pressure check-pressure relief valve shall be furnished with each vacuum regulator. The vacuum regulator-pressure check units shall be constructed of metal and plastic materials. They shall be designed to withstand full supply pressure. They shall have built-in filters to minimize the effect of contaminants in the gas, and they shall be capable of a flow rate rangeability of 20:1.

2.06 Automatic Changeover System

A The automatic changeover system, if specified, shall provide liquid chlorine under pressure without interruption from the ton containers. It shall consist of a changeover module which shall sense from the low weigh switch when the "on-line" container is empty and automatically switch the system over to the "standby" container. Indication of which container is "on-line" and which is "standby", shall be provided. One spare changeover module shall be furnished and shall be packaged for prolonged storage. This package shall clearly identify the contents and equipment to which it applies.

B The automatic change over system shall be furnished with all required motorized valves, expansion chambers, graphic display panel, external malfunction sensors for gas, fire, and smoke and which will automatically close all line valves on detection of hazardous conditions.

C The system shall be capable of operation from a 240/415 VAC, 50 Hz, single or three phase electrical source.

2.07 Ton Container Scales

A. Individual chlorine container scales with hydraulic load cells, dials, and low weight switches shall be provided for each cylinder connected to the discharge port. The scales shall be provided with heavy duty bushed trunnions to allow easy rotation of the cylinders. The load cell shall be of the temperature stable rolling diaphragm type.

B. Provide sufficient flexible hose (3 m minimum) to lead from the cells to a 200 mm diameter dial for each connected cylinder with provision for tare adjustment so as to read net weight. Accuracy shall be better than one percent.

C. Dials shall be suitable for remote mounting on brackets and shall be temperature stable with damper installed to prevent shock damage. An adjustable pointer and low weight switch shall be provided to produce a contact closure on sensing a preset weight. The contact shall be capable of actuating an external control and alarm circuit.

D. Provide sufficient flexible hose (2 m minimum) for connection to the vent manifold.

2.08 Chlorine Leak Detector

A. Atmospheric chlorine gas detectors shall be supplied which have a minimum sensitivity of 1 ppm by volume of chlorine gas in air. The units shall be completely self-contained with a die cast aluminum or fiberglass case, for wall mounting. All materials of construction shall be entirely suitable for operation in an atmosphere as may be encountered in a chlorination room. The unit shall include an air sampling pump, a rotameter electro-chemical sensing cell and indicating meter with alarm contacts and indicating light. A separate light shall indicate instrument failure. Two sets of independent contacts shall be provided for actuation of remote alarms and fans.

B. In operation the unit shall pump in a filtered air sample, the rate of which may be set by a control valve. The air sample shall enter the sensing cell and produce a signal proportional to only the concentration of chlorine gas in the air. A sensing meter with adjustable contacts shall measure the generated signal, and actuate the alarm circuit. A one year supply of chemicals shall be included. Sufficient flexible sampling hose shall be provided to obtain the sample approximately 75mm above the floor in the locations shown on the plans.

2.09 Chlorine Residual Analyser

A. The chlorine residual analyser shall consist of a sensor, analyser transmitter and sample pump.

B. The sensor shall measure total available chlorine and shall be of the amperometric type with automatic compensation thermistor for 0 to 50^{o}C range, and automatic pressure compensation to 1000 kPa. Electrolyte reservoir shall be a minimum of 75 ml. Membrane change shall be by screw cap. Stability shall be plus or minus one percent for 30 days. Sensor range shall be 0 to 20 mg/l. Sensor shall be designed for flow through surface mounting. Accuracy shall be plus minus three percent. Electrolyte shall not need replacement for six months. The sample pump shall be sized to be compatible with the analyzer and provided with pressure regulation if required by the manufacturer for the operating conditions shown.

C. Analyzer transmitter shall have a range of 0 to 1, 0 to 5, and 0 to 10 mg/l and shall be designed for surface (wall mounting). Case shall be NEMA-4 moulded fiberglass.

Analyzer-transmitter shall be suitable for operating temperatures of -5 to +50°C and relative humidity range 0-100 percent. Accuracy shall be plus or minus three percent of full scale or better; repeatability, plus or minus one percent per 24 hours at a given temperature; stability, plus or minus one percent per 24 hours at a given phase. Output signal shall be 4 to 20 mA dc proportional to full scale. Analyzer shall have a 115 mm indicating scale.

2.10 Vacuum Gauges

A. Vacuum gauges shall be of the diaphragm-protected type and shall be suitable for dry chlorine liquid or gas service. Vacuum gauges shall have a range of 0 to 760 mm Hg. and the dial shall be 65 mm with scale graduated 0 to 760 linear.

B. The gauges shall be suitable for panel or pipe mounting. The gauges shall be equipped with an integral diaphragm seal protector having a vinylidene fluoride polymer diaphragm and PVC body. Body assembly shall be sealed with epoxy adhesive. The seal and gauge shall be factory-filled with a fluid recommended by the Chlorine Institute. The gauge protector shall be permanently plugged after filling.

2.11 Gas Mask

Two twin-lens full vision gas masks with air breathing canisters suitable for use in chlorine gas complete with chest style carrying harness shall be provided. The mask face piece shall be close fitting and provide for wide angle vision, anti-fogging and shall incorporate a speaking diaphragm. The equipment shall be installed in a wall mounted cabinet located as shown on the Drawings.

2.12 Cylinder Accessories

Cylinder roller trunnions shall be provided as shown on the Drawings. Trunnions shall be fabricated steel with epoxy finish, cast aluminium alloy or cast iron. Rollers shall be cadmium plated steel with cadmium plated pins and grease lubricated bronze bushings. Cylinder storage blocks of concrete and ton container lifting beam to match the cylinders provided and as approved by the Chlorine Institute shall be furnished.

2.13 Tonne Cylinder Fittings

Tonne container valves and fittings shall be furnished and installed for each cylinder connected to the discharge ports. Each set shall consist of one yoke and adapter type auxiliary tonne cylinder valve, two header valves, two flexible connection each 2 m long, and 25 lead gaskets.

2.14 Cylinder Emergency Kit

Two tonne cylinder emergency kits as approved by Engineer shall be supplied in a metal cabinet suitable for wall mounting outside the storage room.

2.15 Amperometric Titrator

An Amperometric Titrator shall be furnished for calibration of the residual analyzer. The titrator shall be complete with 200 ml plastic cup, squeeze pump with supply bottle, pipettes, instructions and necessary chemicals plus dropper bottles including 100 ml bottle of phenylarsene oxide solution, 100 ml bottle of potassium iodide solution, 100 ml bottle of

buffer solution pH 7, 100 ml bottle of buffer solution pH 4, and one bottle of electrolyte tablets.

2.16 Wall Chart Safe Handling Procedures

Wall charts, in the specified languages, depicting safe handling procedures for Chlorine and First Aid instruction shall be provided.

2.17 Tools, Spare Parts and Consumables

All special tools required for normal service and maintenance shall be provided. In addition, spare parts and consumables shall be furnished as follows:

1. One set of rotameter tubes for each chlorinator.
2. Sufficient chlorine for one year of operation.
3. One year's supply of all necessary reagents, charts, pH test papers, lubricants, and other expendable items necessary for the operation and calibration of the chlorination system
4. additional spare parts and consumable items that the manufacturer recommends to satisfy operation of the equipment for five years. The spare parts shall be boxed or packaged separately.

Part 3 Execution

3.01 Installation and Start-up

The Contractor shall arrange to have the manufacturer or supplier of the equipment furnished under this Section, furnish the services of competent factory-trained personnel to supervise the installation, field testing and initial operation. A minimum of twenty days service shall be provided. Installation and erection of all assemblies and components shall be in accordance with the details indicated on the approved shop drawings and the printed instructions of the manufacturer.

3.02 Instruction

The Contractor shall provide the services of trained and competent manufacturer’s personnel to instruct the Employer’s operating personnel in the use and maintenance of the equipment, in accordance with the requirements of all of these Specifications. The instruction shall be conducted at the job site for up to five plant operators designated by the Employer. The duration of the instruction shall not be less than ten working days. The cost of instruction shall be included in the price.

End of Section 11261

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Section 11262

Chemical Dosing Systems

Part 1 General

1.01 Description

A. The Contractor shall furnish and install chemical dosing equipment, located and installed as specified herein and shown on the Drawings. All accessories not specifically mentioned herein that are required to make the system operable shall be furnished and installed by the Contractor.

B. The work included in this Section shall consist of manufacturing, furnishing, installing, and testing of all equipment necessary to provide complete and operable chemical dosing system

1.02 Submittals

Shop drawings showing fabrication, assembly and installation drawings, together with detailed specifications and data covering performance and materials of construction, parts, devices, and other accessories forming a part of the equipment furnished shall be submitted in accordance with Section 01300.

1.03 Quality

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 chemical dosing systems and ancillary equipment. The equipment shall be the product of an experienced manufacturer that:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.
4. the manufacturers' machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

B The complete system shall be provided by one supplier, having unit responsibility for the operation of the chemical dosing systems and equipment.

Part 2 Products

2.01 Design Conditions

The design conditions shall be as specified in the Particular Specifications.

2.02 General

A This equipment shall consist of dissolving tanks (if specified) and mixers, feeding pumps, header tank and auxiliary devices. These must be able to perform at a suitable feeding according to raw water quantity and quality for continuous operation.

B Chemical solution with the specified strength will be prepared in mixing tanks and pumped to a header tank with feeders to deliver chemical to the feeding point. The feeding equipment shall be able to feed solution at variable rates as needed by the quantity and quality of water to be treated. The control and adjustments of feed rates shall be manually set at the location of the feeder.

2.03 Materials and Construction

A A corrosion proof mixer shall be provided for mixing the solution. The mixer assembly shall consist of a double impeller mounted on a vertical shaft, suspended from the pedestal, shaft bearings, a drive unit with a reduction gear or v-belt and cover and heavy duty motor. The mixer shall be suitable for long periods of continuous operation. The impeller and main shaft shall be made of stainless steel and shall be rigidly fixed to the drive shaft. The motor shall be mounted on the pedestal.

B Diaphragm pumps shall be variable capacity type of simplex or duplex arrangements to suit capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrically or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted TEFC motor, via an oil bath reduction gearbox and variable stroke mechanism giving step-less adjustment between zero and maximum stroke length. Where flow-proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length. The materials of pump shall be corrosion resistant and suitable for handling the specified chemical. They shall be as follows or as otherwise specified:

Pump head:	Stainless steel or equivalent
Valve ball:	Hastelloy, stainless steel or equivalent.
Diaphragm:	PTFE coated EPDM or equivalent
PRFE:	Polytertrafuoroethylene
EPDM:	Ethylene propylene dine methylene

Suction and discharge valve shall be the single ball type allowing a free flow self-cleaning action. Ball and seat materials shall be resistant to abrasion.

C Centrifugal pumps shall be vertical split, rubber-lined type. The casing shall consist of two halves of split type casings, and the liners shall be fit-in type to the casings. The construction of the casing and liners shall be simple and suitable for maintaining the impeller and replacing the liners. Pumps shall be driven by a TEFC motor, via V-belts. The wet parts of pump shall be corrosion resistance and suitable for handling the specified chemical.

D Each chemical feeder shall consist of a tank with two chambers, a ball tap, a slide type orifice device, supports and connections for inlet, outlet and drain. the tank and appurtenances shall be of stainless steel.

2.04 Tools and Spare Parts

All special tools required for normal operation and maintenance shall be furnished with the equipment. In addition, spare parts shall be furnished with the equipment as follows, together with any other items recommended by the manufacturer for two years operation:

for each mixer:

v-belt:	1 set

bearing:	1 set
for each diaphragm pump:	
pressure gauge:	1 set
safety valve:	1 set
accumulator:	1 set
foundation bolts and nuts:	1 set
strainer (PVC):	1 set
for each centrifugal pump	
liner	1 set
gland packing	5 sets
seal washer	1 set
foundation bolts and nuts:	1 set
strainer (PVC):	1 set
for each tank:	
ball tap:	1 set
orifice:	1 set
general:	
tool box:	1 set (for total sets)
other necessary accessories:	Complete set

Part 3 Execution

3.01 Installation

Conform to the requirements of Section 11005.

3.02 Instruction

The Contractor shall conform to the requirements of Section 11005 and provide a minimum of one day of instruction for each system.

End of Section 11262

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Section 11326

Fine (Net) Screens

Part 1 - General

1.01 Description

Provide fully automatic, self cleaning fine mesh screens complete with drives, motors and appurtenances as shown on the drawings and as specified herein. The screenings shall be discharge onto the screenings trough.

1.02 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation, installation and maintenance data together with detailed specifications and performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams, and all other accessories of the equipment furnished in accordance with Section 01300 and all the requirements specified therein.

1.03 Quality

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 net screens. The fine (net) screens shall be the product of an experienced manufacturer and:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.

Part 2 - Products

2.01 General

A The fine screens shall be used to collect and remove the screenings that accumulate on the nets of the fine screens. The nets shall be furnished on the traveling chains with the frames and shall travel along guide rails on the structure walls to remove the screenings to the trough installed on the top slab of the structure. Traveling velocity shall be variable from 1.0 m/min to 3.0 m/min.

B The screenings caught on the nets shall be removed by flushing water from sprays. The water shall be supplied by raw water submersible pumps. Removed screenings shall be collected into the trough and discharged into a skip.

2.02 Design Conditions

A The design conditions shall be as specified in the Particular Specifications

B Design Features

1. Fully automatic and designed to totally eliminate the possibility of jamming.
2 Shall present a clean filtration surface to the oncoming liquid stream at all times

during operation.

2.03 Materials

A All wetted parts except for the screening elements shall be constructed of type 304 stainless steel or wear resistant, heat treated type 400 stainless steel as appropriate for the application. These parts shall include but not necessarily be limited to:
1 all moving wetted parts,
2 all wetted parts on which the moving parts ride,
3 all screen components under guiding, bearing or driving loads such as shafts, links, guide rails and drive sprockets inserts.

B The stationary frame shall be constructed of 304 stainless steel plate a minimum of 5 mm thick. Cross support members shall be a minimum of 5 mm 304 stainless steel.

C The drive unit shall be designed in accordance with AGMA recommendations for continuous (24 hours per day, 7 days per week) Class II service or equivalent. The speed of the screen shall be infinitely variable from 1 to 3 m/min and shall be equipped with a TEFC electric motor.

D The electrical control equipment shall be located as described in the Particular Specifications. Limit switches, receptacles, conduits, and other accessories shall be mounted as needed. Alarms shall be both visual and audible. Visual alarms shall be easily visible at 100 metres in full daylight.

E All grease fittings shall be extended to a centrally located area accessible from the operating floor.

F The operating mechanism shall be housed in a suitable non-corrodible, removable enclosure bolted to the foundation structure or fastened to the frame, complete with doors and windows arranged for maintenance purposes.

2.04 Construction

Structural members shall be fabricated in accordance with the American Welding Society Structural Welding Code; AWS D1.1 or equivalent. Welded connections shall develop the full strength of the connected elements. All joined or lapped surfaces shall be seal welded using a minimum 6 mm fillet weld. Intermittent welding shall not be allowed. All welding shall be performed in accordance with the latest AWS code or equivalent. Sharp projections of cut or sheared edges of ferrous metals shall be ground to a radius using multiple passes of a power grinder to ensure satisfactory coating adherence.

2.05 Tools

Provide all special tools required to service and maintain the screens and all components. This shall include but not necessarily be limited to tools produced specifically to service the screens and which are not available from local tool suppliers and tools or assemblies produced by the screen manufacturer. Provide all non-metric tools required to service and maintain the screens and all components.

2.06 Spare Parts

One set of special tools required for normal operation and maintenance shall be furnished with the equipment. In addition, spare parts shall be furnished with the equipment as follows:

net	10 percent of required quantity
frame	10 percent of required quantity
chains	10 percent of required quantity

Part 3 - Execution

3.01 Factory Assembly And Testing

A Each screen shall be factory assembled and tested for a minimum of 16 hours prior to delivery to the project site.

B The screen assembly shall be delivered to the site in the maximum sizes possible to minimise site fabrication.

3.02 Installation

All equipment shall be installed in accordance with Section 11005 and the manufacturer's instructions and recommendations. The technical representative of the manufacturer shall be present during the full erection period.

3.03 Field Testing

Equipment operation and performance shall be tested after installation to verify that equipment is operating as designed. The equipment shall be operated in all control modes and the level control signals shall be operated. The system shall operate as specified in Section 13415.

3.04 Instruction

The Contractor shall conform to the requirements of Section 11005 and provide a minimum of one day instruction.

End of Section 11326

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Section 11356

Sludge Collector (Reciprocating Scraper Type)

Part 1 General

1.01 Description

The Contractor shall furnish and install the specified sludge collector (reciprocating scraper type) complete with motors and appurtenances as shown on the drawings and as specified herein.

1.02 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation, installation and maintenance data together with detailed specifications and performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams, and all other accessories of the equipment furnished in accordance with Section 01300 and all the requirements specified therein.

1.03 Quality

The complete system shall be provided by a single supplier, having unit responsibility for the equipment and shall be the product of an experienced manufacturer and:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.

Part 2 Products

2.01 General

A The sludge collector shall be used to collect and remove the sludge that settles and accumulates at the bottom of the sedimentation basins. The scraper consists of a series of wedge shaped sections fixed together to form a continuous unit so that they function as a moving floor over the bottom of the tank.

B The direction of movement of the collector is such that when the scraper sections move forwards, towards the sludge hopper, they transport the sludge with them. During the return movement the wedge shape of the scraper slides under the blanket of sludge, so that the top layer flows over them.

C The forward motion is approximately 700 mm and the speed of the return movement is approximately three times that of the forward movement.

D The scrapers movement is induced by a system of levers attached to the drive mechanism located at one end of the tank above water level.

E The scraper blades travel over low-friction strips laid on the tank floor.

2.02 Design Conditions

The design conditions shall be as specified in the Particular Specifications.

2.03 Materials

A The frames and scrapers shall be welded construction using shaped steel and plate made of stainless steel JIS G 4313 SUS 304 or equivalent.

B The low-friction pads laid on the floor of the tank shall be fabricated from high density polythene.

2.04 Construction

A Fabrications shall conform to ASTM Designation A36 for fabricated steel or equivalent.

B The scraper sections shall be wedge shaped with a concave face for movement of the sludge to the sludge hopper. The shape of the inclined slope, on the return movement side, shall be such as to cause minimum disturbance to the sludge.

C Sufficient lengths of low-friction strips shall be fixed longitudinally to the floor of the tank to provide minimum frictional resistance to the motion of the scraper blades and to reduce the wear on the steel sections. The strips shall be firmly fixed to the floor of the tanks with stainless steel bolts. The strips shall be supplied in the longest lengths possible to minimise the number of joints in the strips perpendicular to the scraper movement.

D The reciprocating movement for the scrapers is achieved by a system of levers transferring the motive power from the electric motor located at one end of the tank on the slab of the sedimentation basin above water level, down the end wall and then horizontally to the scrapers.

E When the power is turned on, the mechanism starts scraping. As the lever arm from the motor rotates and the scraper reaches the limit of forward travel, the motor control changes the speed of the motor to achieve the faster return motion of the scraper. On return to the start position the speed control again adjusts the speed of the motor to provide the slower forward motion.

F The motor shall be directly coupled to the lever arm and with variable speed control. The equipment shall be fixed onto a common floor panel. The drive unit shall perform cyclic operation through the various control selection switches once it is turned on.

G For safety, the driving gear shall be provided with torque limiter device to protect the machine and motor from overload, etc.

H This equipment shall delivered after completion of manufacturing and after it has passed all the tests and inspections carried out. For the delivery, the equipment shall be packaged carefully so that the equipment is not deformed or damaged during normal transportation. Stainless steel material shall be used for all the bolts and nuts for fixing the equipment and anchors. Painting shall be carried out on all surfaces other than stainless steel.

2.05 Tools and Spare Parts

All special tools required for normal operation and maintenance shall be furnished with the equipment. In addition, spare parts shall be furnished with the equipment as follows:

scraper blades	:	four for each unit
lever arm system	:	one set
end wall support framework	:	one set
drive unit (motor, reduction gears etc.)	:	one
lubricating oil	:	2 cans

Part 3 Execution

3.01 Installation

A Conform to the requirements of Section 11005.

B Each motor shall be shop tested by the manufacturer in accordance with the requirements of Division 16.

3.02 Instruction

The Contractor shall conform to the requirements of Section 11005 and provide a minimum of one day of instruction for each pump class.

End of Section 11356

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Section 11369

Sand Filters

Part 1 General

1.01 Description

A. The scope of work includes complete sets of underdrain systems and sufficient filter media, including sand and gravel, along with all necessary operation instrumentation controls and local panels. The underdrain systems shall be suitable for the concrete structure and the piping arrangement as shown on the Contract Drawings, and shall include all the necessary appurtenances to allow the filters to function properly as shown on the drawings and specified herein. The underdrain system for the filters shall be a suspended filter floor with adjustable nozzles.

B The physical characteristics of the filter media shall ensure that backwashing is carried out efficiently and requires the minimum amount of backwash water and scouring air, and that the filter media is not fluidised during backwash to minimize loss of media.

C The backwashing operation shall effectively scour and remove the solids trapped by the sand media during the filtration operation. Backwashing of one filter cell shall not exceed fifteen minutes (including water and air scour) and shall not require more than one backwash per day.

D A technical representative of the filter underdrain manufacturer shall supervise the installation of the complete underdrain system and be responsible for testing and satisfactory operation of the system.

1.02 Submittals

A. Manufacturer's product data.
For filter media and gravel, all submittals and technical information shall be provided and approved by a professional engineer regularly employed by the filter manufacturer. The engineer shall have at least fifteen years experience in sand filter filtration.

B. Shop Drawings.
1. Filter underdrain systems, including:
   a assembly drawings for all components;
   b detailed structural drawings for underdrain flooring, dwarf walls; side supports and backwash channels
   c installation and testing drawings and procedures;
   d component specifications;
   e data covering performance and materials of construction, parts, devices and other specified accessories;
   f operation control sequence.

C. Structural calculations for underdrain flooring and support system.

D Certificates of Compliance JWWA – A103 or equivalent.

E. Certified test reports.

F Samples of filter media. The Contractor shall submit to the Engineer for approval samples of the filter sand and gravel which he proposes to use. No sand shall be shipped to the site prior to approval. Samples shall be placed in tight glass jars holding not less than 2 litres and shall be properly labeled. The filter sand and gravel delivered to the plant site shall be equal in all respects to the approved samples and similar samples for test purposes shall be furnished as required during the preparation and placing of the sand. The samples shall include the following information as a minimum:

1 name of supplier;
2 resume of Engineer providing submittals;
3 quality control manual;
4 gradation of each media type;
date of sampling / lot number;
complete sieve analysis of representative samples;
(i.e. effective size and uniformity coefficient, all other characteristics will be as described in the Quality Control Manual.);
5 material quantities;
6 diagram with type of material and depth of each material on nozzle filter floor;
7 estimated shipping and placement schedules;
8 media loading procedure to protect nozzles.

G Sample of nozzle including bushing, stem, dome, sealing cap and preformed formwork;

H Operation and Maintenance Manuals.

I Training Program

1.03 Manufacturer

A. Nozzle type as manufacturer by Paterson Candy Limited, UK

B. Or approved equal.

1.04 Quality

A. The product shall be new and be the product of an experienced filter equipment manufacturer and filter media supplier who must:
1. demonstrate equal or larger capacity installations using similar system and media.
2. System and media installed and successfully operating for at least 5 years.
3. Provide names and phone numbers of contacts at referenced installations to verify performance.
4. Demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.

B. The Quality Control Manual submitted by the filter equipment manufacturer shall demonstrate that the filter media and gravel furnished shall comply with the requirements of the Contract specifications herein. The Quality Control Manual shall define the following:
1. Qualification of the raw feedstock
2. Control procedures at the screening mill
3. Independent testing laboratories
4. Packaging definition
5. Purchase orders
6. Storage procedures.

C. Standards applied for filter media shall be AWWA A103, "Standard for Filtering Material." or equivalent.

Part 2 Products

2.01 General

A. The filter underdrain system shall be specifically designed for supporting gravel and sand medium and capable of evenly distributing air, water and a combined flow of air and water in the intended application.

B. The underdrain system shall comprise dwarf and side walls and on which is cast the concrete filter floor. The formwork shall also serve as an accurate assembly jig to ensure precise spacing of the moulded airscour/backwash nozzles.

C The reinforcement from the dwarf and side support walls shall tie into the reinforcement mesh of the filter floor to produce a monolithic structure.

D The preformed formwork shall be vacuum formed in light weight, high impact polystyrene, with ribbed reinforcement and sockets to hold the snap-in nozzle bushes.

E The nozzle bushes shall be injection moulded in polypropylene. They shall be inserted into preformed holes in the permanent formwork panels and shall be held in position by two-staged snap lock. The bush shall be fitted with a pressure-tight, screwed sealing cap and gasket to prevent the ingress of concrete during the casting of the filter floor and to permit pressure testing of the floor.

F The nozzle dome shall be a precision polypropylene or ABS injection moulding, slotted to suit the medium in the filter. The dome shall be provided with moulded lugs which engage with ratchet teeth in the bush to lock the dome and prevent loosening during filter washing. The dome shall screw into the bush after pressure testing of the floor slab.

G The nozzle stem shall be formed from injection moulded polypropylene and shall incorporate a top air control orifice sized to meet the specified air flow requirements. Three slots shall be provided in the tail of the stem to provide secondary air control. the stem shall be vertically adjustable through 50 mm to compensate for variations in the finished floor level. A fin shall be moulded to the sides of the stem to engage with the lugs on the inside of the bush to prevent rotation during filter washing.

H Gravel shall consist of hard, durable, rounded particles of high specific gravity containing not more than three percent of thin, flat, or elongated pieces. The gravel shall be washed and screened, and shall not contain a total of more than one percent of loam, clay, shells, dirt, and organic impurities or other foreign matter. The average specific gravity of gravel shall be not less than 2.5.

I Sand shall be composed of hard, durable, uncoated grains, and shall contain not more than 5 percent of flat particles and not more than a total of one percent of clay, loam, dust, and other foreign matter. The sand shall be free from any significant amounts of iron or manganese compounds. Sand shall have specific gravity of not less than 2.5. The sand shall have an effective size of 1.0 to 1.2 mm and a uniformity coefficient of less than 1.4 with a thickness of 1200 mm. Effective size is defined as that size of grain in a sample which is smaller than 90 percent by weight of all other grains in the sample; i.e. the effective size is the theoretical size of a sieve in millimetres that will pass 10 percent of the sample. Uniformity coefficient is defined as the theoretical size of a sieve in

millimetres that will pass 60 percent of tile sample divided by the theoretical size of a sieve in mi1limetres that will pass 10 percent of the sample. ANSI/AWWA B100 shall be referred to for these definition.

J Special care shall be taken in transporting and placing the media and to avoid the possibilities of contamination and to prevent the media from becoming dirty. Any media which may have become dirty, either before, or after, it has been placed in the filters shall be removed and washed or replaced by clean media in a satisfactory manner. All media which has been contaminated by organic matter will be rejected. In placing the media in the filters, extreme care shall be taken to avoid disturbing the lower layers of media.

2.02 Tools

A. Provide all special tools required to install, service and maintain the filter underdrain systems and all components. This shall include but not necessarily be limited to:
   1. Tools produced specifically to service the units provided and which are not available from local tool suppliers.
   2. Tools or assemblies produced by the filter equipment manufacturer.

B. Provide all non-metric tools required to service and maintain the pumps and all components.

2.03 Spare Parts

Spare parts shall be provided as specified in the Particular Specifications

Part 3 Execution

3.01 Installation

A. All equipment shall be installed in accordance with the manufacturer's approved instructions and recommendations.

B Construction of the filter floor, leveling, pressure testing, leakage testing, cleaning the filter and installing nozzle stems and domes, and flow distribution tests shall be carried out in accordance with the requirements of, and under the supervision of, the filter nozzle and floor system manufacturer.

C All gravel and filter media shall be shipped in "semi-bulk" containers having lifting loops and bottom discharge spout, weighing approximately 1 to 2 metric tons each. A four point lifting bar shall be provided if cranes are to be used for handling.

D Delivery of "bulk" shipments shall not be permitted unless the contractor can demonstrate that the materials can be handled and stored without contamination.

E Materials will not be shipped until the submittals are approved by the Engineer. Approval of the submittals, including the Quality Control Manual, samples and independent testing, shall constitute acceptance of media.

F Before beginning the placing of any gravel and sand the Contractor shall carefully determine that all nozzles in the filter underdrains are open, free of obstruction, and shall thoroughly clean, sweep and vacuum the walls of the filter units, the surface and interior of the underdrain system and shall remove all foreign matter found therein.

G The media shall be deposited in such a manner as to avoid endangering the underdrains. Provision shall be made to protect the nozzles with adequately supported planking at all locations where media is lowered into place. Each layer shall be filled up to the required elevation and made level over the entire filter bed area, and shall be smoothed down to a true surface. The placement of different sized media in each layer shall be approved by the Engineer before the next layer is placed. The placing of each size of media shall be finished in anyone filter unit before beginning the placing of the next size. Care shall be taken not to damage equipment, nozzles and piping in the filler units by walking on or dropping media upon them.

H After the filter media has been placed, it shall be washed at least three times under the direct supervision of the Engineer by the washing devices connected with the filters. Each of these separate and distinct washings shall be of at least 10 minutes duration at the maximum wash rate.

I All materials which accumulate at the surface of the bed shall be scraped off and removed by the Contractor at the end of each period of backwash as directed by the Engineer. The filters shall be washed and tested one at a time. Only clean water shall be used for washing. The removed amount shall be replenished with new sand as stipulated herein.

3.02 Testing

A. Shop tests
1 factory test equipment to demonstrate compliance with specifications.
2 submit three copies of certified media test reports to Engineer for approval. Reports shall be approved prior to shipping the media.
3 the filter manufacturer shall, at their own facilities, if requested by the Engineer, set up a test run to provide an opportunity for the Employer to visit the facilities to witness a full scale demonstration of the headloss and flow distribution during backwash.

B Filter floor pressure testing
1 after the concrete has fully cured and the 28 day strength has been confirmed, the filter should be air pressure tested by pressurising the underside of the filter floor. A pressure relief system shall be set to relieve at the test pressure.
2 the floor shall be able to withstand an upward test pressure of 5 metres head of water to the underside of the slab when there is no media or water above it. The filter floor shall be covered with water to a minimum depth of 12 mm and a maximum depth of 50 mm, pressurised and the nozzles system checked for leaks. The pressure shall be maintained for a period of 1 hour from a continuous pressure source. If the pressure cannot be maintained the leaks shall be rectified and the floor re-tested. The procedure shall be repeated until the pressure can be maintained.

C Filter floor water leakage testing shall be carried out with the under-floor pressure set at one metre head of water and any leaks in the floor structure rectified.

D Flow distribution testing shall be by visual observation before placing the filter media in each filter. The filter shall be filled with water to a level 25 mm above the highest point of the slab and air introduced into the system at the design rate. Air distribution should be uniform with all nozzles blowing. Testing of each filter shall be for a minimum period of two minutes, or as long as is needed to make uninterrupted observations.

E Field tests

1 the manufacturer's representative shall operate each filter after installation and shall monitor and record all specified design requirements and performance parameters.

2 all values shall be as specified; or if not specified, as recommended by the manufacturer.

3 the system shall be operated in both manual and automatic modes.

End of Section 11369

Section 11373

Rotary Positive Displacement Blowers

1.01 Description

A. The Contractor shall furnish and install rotary positive displacement blower systems complete with blowers, motors, control equipment, bases, valves, appurtenances and anchor bolts all as shown on the drawings and specified herein. The Contractor shall provide the services of the blower manufacturer who shall be responsible to him for the satisfactory installation, operation validation testing, start-up and instruction of the entire system as a complete unit of construction.

B. All items and components specified in this section shall be provided by the blower manufacturer. The suitability and compatibility of such items shall be the blower manufacturer's sole responsibility.

1.02 Submittals

The following data shall be submitted in addition to the required submittals:

1 Certified curves shall show the total inlet capacity in cubic metres per minute versus discharge pressure for the entire range of operation from surge point to maximum capacity. Curves shall also show blower brake power and motor power versus actual inlet capacity in cubic metres per minute for the same range of operation. Each of the performance curves specified above shall be drawn for inlet air temperatures of 20^{o}C, 100 percent relative humidity, and 1 bar barometric pressure.

2 The manufacturer shall submit a report on transient torque analysis of motor, gears, and compressor verifying that the system is free from harmful modes of operation during start-up and operation.

3 The manufacturer shall provide calculated full voltage performance curves showing rpm versus amperage, rpm versus torque and efficiency versus power for 75 percent to 115 percent of rated load.

1.03 Quality Assurance

The blowers shall be the product of an experienced manufacturer and:

1. must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5 years;
2. provide names and phone numbers of contacts at referenced installations to verify performance;
3. demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified;
4. the blower manufacturer's machining and assembly shops must be ISO 9001 certified in order to assure conformance to the highest quality standards.

Part 2 Products

2.01 General

A The blowers shall be designed for outdoor use and shall be of the positive displacement, two lobe involute type. All connection flanges shall be rated at a minimum of NP 16. The operational characteristics of the blower system are described in the Particular Specifications.

B The impeller shall be close grain ductile iron with internal ribbing. Impellers shall be machined on all exterior surfaces for operation at close clearances and shall be securely fastened to alloy steel-machined shafts.

C The impeller case shall be strongly ribbed to eliminate distortion when operating at rated pressure, and shall have an elliptical inlet port and multiported discharge area to achieve maximum attenuation of air borne noise.

D Gears shall be manufactured with alloy steel and be accurately finished on all surfaces. They shall be securely attached to shafts by means of wedge rings permitting easy re-timing of the unit.

E The shaft centres shall be maintained by at least four heavy-duty anti-friction bearings. Bearings shall have a B-10 life of 20,000 hours and be located in bearing cartridges of the flanged type for easy field removal.

F Gears shall be enclosed in an oil tight housing and shall be lubricated by a splash oiling system from a reservoir in the gear housing. Gear and bearings shall be splash lubricated by the same reservoir. Drive and bearings shall be splash lubricated by a splash oil system from the reservoir in the drive end cover plate.

G Air vents shall be located between the seals and the impeller chamber to relieve the air pressure on the seals.

H The blower shall be supplied with an intake silencer. The intake silencer shall be of the combination acoustical- reaction type with acoustical material located in the transition area adjacent to the blower intake. The silencer shell shall be constructed of fabricated steel with double wall thickness, and shall have multiple chambers for attenuation of both high and low frequency noise. Silencers shall have inlets located in the end and outlets on the side with mounting brackets supplied to mount silencers vertically.

I The blower shall be supplied with a discharge silencer. The discharge silencer shall be of the combination acoustical-reaction type with the acoustical material located in the transition area connected directly to the blower discharge flange. The silencer shell shall be fabricated with double wall thickness, and shall have multiple chambers for attenuation of both high and low frequency noise.

J Each blower shall be supplied with one intake filter. The filter housing shall be fabricated from heavy gauge sheet steel, welded and caulked to provide a weatherproof housing. The filter elements shall be of the panel type and shall have a pleated paper media, held in place by a metal holding frame.

K Each blower shall be supplied with a pressure relief, check and isolation butterfly valve located on the discharge piping. The pressure relief and check valves shall be provided by the blower manufacturer and sized for the operating conditions.

L The air flow meter shall be sized and provided by the blower manufacturer. The unit shall be of durable construction and proven design and be compatible with the operation of the system as shown on the Drawings and described in the Particular Specifications.

M Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be furnished

with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.

2.02 Acoustical Enclosure

A. Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel.

B. Provide clear, transparent Lexan or plastic windows to visually observe gauges and lever arms of the variable guide vanes and diffusers.

C. Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40°C.

D. The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations. The meter shall comply with IEC 6S1 and ANSI S1.4, Type S1A.

2.03 Instrumentation

Instrumentation components shall be provided by the blower manufacturer and these components shall be mounted on the blower assembly as far as possible.

2.04 Surface Preparation and Shop Painting

All surfaces shall be prepared, shop primed and shop finish painted with two finish coats of Manufacturer's standard paint system. Machine surfaces that are not painted shall be protected by coating with a corrosive-protective compound.

2.05 Tools And Spare Parts

A The equipment manufacturer shall furnish all special tools and appliances necessary to disassemble, service, repair and adjust the equipment and appurtenances. These shall include but not necessarily be limited to:
1. tools produced specifically to service the units provided and which are not available from local tool suppliers;
2. tools or assemblies produced by the blower or component manufacturer.

B. The following spare parts shall be furnished:
1. one complete set of all bearings for the blowers and motors;
2. one complete set of "O" rings, gaskets and seals for the blowers and motors;
3. one servomotor for inlet guide vanes;
4. one servomotor for variable diffuser vanes;
5. one main and one auxiliary oil pump, complete with electric motor;
6. one set of oil filter cartridges for each unit;
7. two sets of spare primary inlet air filters and one set of spare secondary air filters for each unit;
8. one set of check valve return springs;

9. one valve actuator (complete) for blow-off and discharge isolation valve.

Part 3 Execution

3.01 Testing

A. Factory Tests
   1. Each motor shall be tested in accordance with IEEE test procedures. Also, test for noise and vibration. A certified motor data sheet shall be submitted for approval prior to shipment.
   2. Test each blower in accordance with the ASME Power Test Code for Centrifugal Compressors and Exhausters, PTC-10, latest edition. Tests may be conducted using either the job motor or a calibrated test motor.
   3. Submit a blower test report upon completion. Present computations in accordance with Section 5, 6 & 7 of ASME PTC-10, (latest edition) with performance curves showing capacity, pressure and horsepower inputs, for Class I Tests.

B. Field Tests
   1. Equipment operation and performance shall be tested after installation.
      a. Verify that equipment is operating as designed.
      b. Operate in all control modes.
   2. Test each blower system for vibration levels.
      a. Perform vibration testing using an independent vibration testing firm having a minimum of five years experience.
      b. Test each system separately without duplicate equipment running.
      c. Test at various positions of inlet guide vanes and variable discharge diffuser vanes.
   3. Test each blower system for vibration.
   4. Submit copies of test results to the Engineer for review and approval.
      a. Should the vibration and noise field test results exceed the limits specified herein, the Contractor shall correct the deficiencies.
      b. After corrections have been completed, repeat vibration and noise testing and resubmit the results to the Engineer for review. Corrections shall continue until results meet the Specifications.

3.02 Installation

Install the blowers and motors in accordance with the instructions of the manufacturer and as shown on the drawings.

End of Section 11373

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 sludges 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 in accordance with the Technical Schedules. 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 authorized 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 job site.

Part 2 Products

The laboratory equipment, fittings, and furniture is detailed in the Particular Specification.

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

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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 Work Included in the ICM Section 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 Furnish all tools, equipment, materials, and supplies and perform all labor 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 Provide all the necessary equipment components and interconnections and the services of the manufacturers, engineering representatives for the engineering, implementation, startup, 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 references shall only mean that responsibility shall pass through the electrical installation contractor but in the final analysis shall rest with the Contractor.

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 labeling 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 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 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 labeled 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 trouble shooting 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 labeled 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 startup 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.

End of Section 13410

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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 which shall be driven through the control logic circuit of PLC.

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

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

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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 and 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

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.
   2. Flowmeters shall be certified intrinsically safe and suitable for hazardous area class 1, division 1, Group D, where specified in the schedule.
   3. Manufacturer shall calibrate and pressure test the flowmeters and provide certificates.
   4. Overall accuracy better than $\pm$ 1.0 percent throughout the operating range.

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 earthing ring or electrode
   5. Lining material suitable for withstanding abrasion of the fluid
   6. Enclosure fully submersible, protected to IP 68
   7. Sensor/transmitter cable to be fitted and potted by manufacturer. Screened and waterproof cable shall be used.

C. Transmitter
   1. Remotely installed from sensor
   2. 230 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 relay 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. $\pm$ 2% accuracy
8. Rangeability 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. 230 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 $\pm$ 1 percent 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. 230 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 percent 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 speicified in schedule.
   2. Overall accuracy shall be better than ± 1 percent with a repeatability of ± 0.5 percent

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. 230 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 molded 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.
1. Contact shall be isolated from process and magnetically actuated SPDT rated 230 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 230 Vac, 5A.

2.10 Hydrostatic Level Transmitter (Submersible Pressure Detection Level Transmitter)

Submersible pressure detection type level transmitters shall be used for wet well level measurement as per the following specifications.

1. Capacitance sensor – Piezo electric 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 ± 0.5 percent 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. ± 1% accuracy
4. 1/2" NPT connections
5. Complete with micrometer 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 ± 1 percent 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 ± 0.1 percent
4. In built zero and span adjustments
5. Over pressure limits shall be at least 50 percent above the specified process pressure in the schedule.
6. Enclosure shall be weatherproof 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 pecent 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 230 Vac 5A
4. 12 mm 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 230 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. 125 mm 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 230 Vac 2A
   6. Analog 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 sulfur gases.
   2. Explosion proof enclosure
   3. 0-100 LEL range full scale

E. Hydrogen Sulfide 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. 230 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 percent

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 platinum electrode and temperature compensation is not required.
   8. Ultrasonic cleaner to be provided where specified in schedule.

D. Residual Chlorine Sensor:
   1. Amperometric sensor with gold cathode, PVC anode
   2. PH and temperature compensated
   3. 0-20 ppm range
   4. Flow through installation.

2.22 Ultrasonic Flowmeters

A. General

1. The transmitter shall be certified intrinsically safe and suitable for hazardous area class 1, divisions 1, group D where speicified in schedule.
2. Overall accuracy shall be better than ± 1 percent with a repeatability of ± 0.5 percent
3. Stainless steel 304 support wire
4. Stainless steel 304 probe case

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 flow 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.

2.23 Positive Displacement Flowmeter

1. The meter shall be of high capacity in-line helical rotary type the meter with a precision injection moulded mechanism eminently suitable for high and sustained flow associated with bulk water metering.
2. For maintenance purposes the complete measuring mechanism shall be quickly replaced with pre-calibrated measuring mechanism or alternatively a blank cover shall be fitted.
3. The magnetic drive between the measuring element and sealed register enables easy fitment of ancillary attachments at any time between measuring element and sealed counter without stopping the water supply.
4. Overall accuracy shall be betten than ± 1 percent
5. Max. working pressure shall be 10 bar
6. The meters shall comply with ISO4064, BS5728, JIS Z8765, Z8766, or equivalent.

2.24 Hydrostatic Level Transmitter

Hydrostatic pressure 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 ± 0.5 percent

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 801, RF Protection
5 IEC 1131-3, 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. 230 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 230 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 230 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 230 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 230 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 230 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 230 V a.c.

2.07 Programmable Logic Controllers (PLCs)

A Each PLC System shall comprise of 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 EEPROM 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 Analog 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. Analog 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 1131-3 standard on programming languages for PLCs.

G PLC shall be provided with serial interface ports for peer to peer communication, MMI for operator interface or Telemetry, as specified in the Project Specification. Communication protocol shall conform with 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 Man-Machine Interface (MMI).

I A panel mounted VDU shall be provided for the PLC when specified, as follows:
1 a panel mounted CRT or liquid crystal display unit for graphic, numeric and message display
2 membrane keypad with one million cycles minimum operation
3 230 V a.c. 50Hz power supply
4 enclosure protected to IP65
5 EEPROM 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 ruggedised. 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. Uninteruptible Power Supply (UPS) with 30 minutes autonomy shall be provided to facilitate orderly shut-down. Power supply 230 Va.c. 50 Hz.
2 The following software functions shall be provided for the control stations:
a windows/MS-DOS operating system.
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 ICA 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 230 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

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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 earthing
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

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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 annuciators 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 seggregated 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 slamp 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 plate 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

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Section 13450

General Distributed Control 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 Distributed Control System (DCS) 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 ands stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) 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 DCS 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 MCR. Each LCR 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.

Intelligent Input Output Processors (IOPs) 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 data highway.

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 that 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 there 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 center 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 apart 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 off site 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 ± 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 mold, 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

Section 14650

Lifting Equipment

Part 1 - General

1.01 Scope

This Section specifies the requirements for the design, manufacture, construction, installation, testing and commissioning of hoists, monorails, bridge cranes trolley assemblies and davits.

1.02 Reference Standards

Applicable standards referred to in this section:

BS 302	Stranded steel wire ropes
BS 449	The use of structural steel in building
BS 466	Power driven overhead travelling cranes, semi Goliath and Goliath chain for general use
BS 729	Hot dip galvanised coatings an iron and steel articles
BS 2573	Rules for the design of cranes
BS 2853	The design and testing of steel overhead runway beams
BS 2903	Higher tensile steel hooks for chains, slings, blocks and general engineering purposes
BS 3114	Alloy steel chain, grade 80. Polished short link calibrated load chain for pulley blocks
BS 3243	Specification for hand operated chain blocks
BS 4941	Specification for motor starters up to and including 1000 V a.c and 1200 V d.c.
BS 4942	Short link chain for building purposes
BS 5304,	Code of practice for safety of machinery
BS 5744	Code of practice for safe use of cranes
BS 6231	PVC insulated cable for switchgear and control gear wiring
BS 6346	PVC insulated cables for electricity supply
BS 6405	Non calibrated short link chain (grade 30) for general engineering purposes
BS 6994	Steel shackles for lifting purposes
BS 7121	Code of practice for safe use of cranes
BS 7613	Hot rolled quenched and tempered weldable structural steel plates
BS 7668	Weldeable structural steels. Hot finished structural hollow sections in weather resistant steels
BS 7671	Requirements for electrical installations
BS EN 287	Approval testing of welders for fusion welding
BS EN 288	Approval of welding procedures for metallic materials
BS EN 10113	Hot rolled products in weldable fine grain structural steels
BS EN 10155	Structural steels with improved atmospheric corrosion resistance
BS EN 10210	Hot finished structural hollow sections of non alloy and fine grain structural steels
BS EN 60947	Low voltage switch gear and control gear

1.03 System Description

Lifting equipment shall be provided as required to remove equipment for replacement and/or maintenance purposes and to lift or remove chemicals. The design shall ensure safe access is provided for the operation of the lifting equipment. Overhead cranes will also be required to grant access for maintenance of roof mounted equipment such as light fittings or fans, etc., and shall be designed to facilitate this. Davits shall only be used to lift submersible pump sets

and other equipment from wells. Lifting equipment shall be supplied with all the necessary hooks, spacers, clamps, harnesses, slings, D links and eye bolts to lift any of the installed plant.

1.04 Submittals

The following data shall be furnished by the Contractor :

1 Complete structural calculations of crane and monorail member and component sizing and design, shall be submitted, as required by BS 2573, BS 2853.

2 Shop drawings shall be submitted as required by Section 01300. Lay-out drawings shall clearly show the lifting height of the equipment and clearances in relation to other equipment and structures where the largest items are lifted.

3 The Contractor shall include all the documentation required by Section 01300 on the lifting equipment in the operation and maintenance manuals. A copy of the design data, factory and site tests shall be included in the manuals.

Part 2 - Products

2.01 General

A Hoist monorails, bridge cranes, davits and 'A' frames shall include all equipment, appurtenances and auxiliaries to make the lifting equipment fully operational and capable of performing under the specified load conditions.

B Lifting systems, including hoists, as far as feasible, shall use the standard components of one manufacturer to simplify maintenance.

C Nameplates shall be permanently attached to the monorail hoist and bridge crane hoist assemblies. The lifting capacity shall be stencilled in tonnes on each side and shall be clearly legible from the working level.

D Warning signs shall be provided to the approval of the Engineer and affixed to the bottom lift blocks or pendant controllers.

2.02 Design Conditions

A Cranes and lifting equipment shall be suitable for indoor or outdoor installation, as shown and designated. The high ambient temperature in which lifting equipment and particularly cranes may be required to operate shall be taken into consideration, particularly with respect to the electrical load ratings of motors, switchgear, resistors, cables and wiring, as well as mechanical heat sources such as brakes, bearings and gearing. Due allowance shall be made for possibly higher temperatures than the maximum recorded shade temperature near the roofs of buildings, if the lifting equipment is mounted in a building, or for the effect of direct sunlight if mounted externally.

B Design of travelling monorail hoist and bridge crane hoists and incidental accessories shall be based upon the use of a factor of safety of 5, structural beams shall have a factor of safety of 2 with capacity load on all mechanical parts of the system. The factors of safety shall be based upon the ultimate strength of the material used. The equipment shall be of ratings and sizes designated in the Particular Specifications.

C Lifting equipment shall be rated for the load of the heaviest installed item of plant, and designed such that one man can operate it without difficulty.

D Hooks and load chains shall reach to the floor of the lowest level.

E Lifting equipment installations shall comply with BS 5744 and BS 7121.

2.03 Davits

A Davits and sockets shall be fabricated from fully welded mild steel, to BS 7668, BS 7613, BS EN 10155, BS EN 10013, galvanised and protected in accordance with BS 729.

B Davits too heavy to manhandle shall consist of a davit arm, with removable pillar, and rotating removable jib arm.

C Davits shall have a roller thrust bearing swivel for the upright pillar, with a locking mechanism.

D Sockets shall be cast-in, unless bolted sockets are specified, or it is not possible to fix cast-in sockets. A rubber socket plug with a stainless steel chain shall be provided to prevent ingress of undesirable materials when the davit is not in use.

2.04 Monorail Travelling Hoists

A Each hoist shall comprise a manually operated geared travelling pulley block complete with steel runway beams, "A" frame supports where specified and all accessories including slings and spreaders.

B Pulley blocks may be manually operated up to a height of 6 to 8 m. Above 8 m electric hoists shall be provided. Stops shall be provided on all monorails and rails

C The runway beams shall be designed, tested and certified in accordance with BS 2853.

D The blocks shall run on the lower flange of the runway beam and shall be of the spur geared close haul type.

E The blocks shall be complete with a geared travelling trolley and shall be capable of being easily removed from the trolley without the necessity for dismantling. The operating chain for the longitudinal motion of the trolley shall extend to within 600 mm of the floor.

F Load chain collection boxes shall be provided.

G Monorail systems shall not be used for loads exceeding 2000 kg.

2.05 Cranes

A Cranes shall comprise end carriages and bridge units to be bolted together on site, during erection.

B Cranes shall be single girder or double girder as designated.

C All exposed moving parts of the drive mechanisms shall be fitted with safety guards wherever possible.

D The bridge girders, end carriages and crab structures of the crane shall be designed and constructed in accordance with all the relevant requirements of BS 466 and BS 2573. With the crane operating under maximum service load, the stress in any operating component shall not exceed the permissible values stipulated in Part 1 of BS 2573. The crane manufacturer shall supply all the information required in Appendix B of BS 466.

E The main bridge girders shall be plate or box girder designed as compound beams with the

rails for the crab track secured on the top flange.

F Jacking points and tie downs shall be provided for both bridge and crab.

2.06 Manually Operated Chain Blocks

A The hoisting wheel shall be grooved and pocketed to receive the load chain. The load chain shall be stainless steel chain Grade 80 to BS 3114.

B Hand chains shall be to Grade 30 BS 6405 or better.

C Chain guides shall be provided to ensure effective guidance of the load chain into the load chain wheel pockets. A stripper shall be provided to ensure effective disengagement of the load chain from the load chain wheel.

D The idler wheel scores shall be so shaped as to avoid twisting the chain as it passes round. The pitch diameter of the idler wheels shall not be less than 16 times the size of the chain, unless they are so shaped as to avoid a bending action on the link.

E The load chain anchorage, associated fittings and framework at the slack end shall be rated at 2.5 times the maximum tension in the load chain when the working load limit is being lifted. Any link used for connecting the load chain to a terminal fitting shall be of the material specified for the chain and heat treated to provide mechanical properties and strength equivalent to those of the load chain.

F The hook shall be made from high grade forged stainless steel complying with BS 2903 'C' type and provided with a safety catch. The hook shall be supported on a ball thrust bearing to allow free swivelling under full loads.

G The sheaves of the hook block shall be guarded to prevent a hand or fingers being trapped.

H The crab hoisting gear shall be such that one man is capable of easily raising the maximum load.

I A galvanised mild steel chain collecting box shall be incorporated.

J A reliable and effective braking and locking arrangement shall be provided.

K Lifting blocks supplied for lifting equipment shall be of stainless steel and shall include the facility for obtaining a fresh lift on the equipment lifting chains at 1 m intervals.

2.07 Electrically operated Rope Lifting Hoist

A All hoists above a height of 8 m shall be electrically operated.

B The hoist rope drum shall be of high quality cast iron with left and right hand spiral grooves to accommodate the hoist rope in one layer. As far as possible, the drive gearing shall be fixed directly to the rope drum to obviate high torsional stress in the drum shaft. The rope shall be securely clamped to the drum.

C The hoist drum shall incorporate a wire rope rewind system and guides to prevent the hoist rope skipping and damaging the lay.

D The hoist braking system shall be of the automatic electro-mechanical fail safe type which, when the current is cut off or fails will automatically arrest the motion and hold at rest any load up to and including the rated load. The system shall safely control the

lowering of the same load form the highest to the lowest point of lift and shall not allow any slippage of the suspended load to occur when the 'Raise' motion is initiated.

E The hoist rope shall be a flexible wire rope specially designed for usage with cranes and in accordance with BS 302, with a safety factor of not less than six times the maximum tension induced by the safe working load.

F The crane hook shall be of high grade forged steel trapezoidal section in accordance with BS 2903, 'C' type. The hook shall be supported on a ball thrust bearing to allow free swivelling under full loads and shall also be fitted with a safety catch. The safe working load shall be marked in the hook in accordance with BS 2903.

G The sheaves of the hook block shall be guarded to prevent a hand or fingers from being trapped between the sheaves and the in-running rope.

H A limit switch shall be fitted to prevent over hoisting. This shall be self-resetting, closing automatically when the hoist motor is put in reverse.

I Brakes shall be well protected from oil and grease leakage or spillage, and from adverse effects of atmospheric condensation or dust. A simple and easily accessible means of carrying out adjustment for wear of the shoes or linings shall be provided for all brakes.

J Automatic brakes, operating when the drive motor stops shall be supplied for the long and cross travel motions.

2.08 Mechanical Components

A End Carriage
1 both end carriages of electrically operated cranes shall be powered either by a duplicate geared motor drive, or by a single motor unit and a lay-shaft system. Longitudinal and cross traverse motions shall be provided on the crane such that the operation is speedy without impairing safety in working. The hook and load chain shall be such that the hook will reach to the lowest floor level.
2. The runner wheels shall be of cast steel, with double flanges, mounted on roller bearings, or fitted with phosphor-bronze bushes running on hardened steel axles.

B Crab Unit(s)
1 the crab frame shall be in accordance with BS 466 and shall provide a strong rigid framework for the hoist and cross-travel machinery mounted thereon. The placement and layout of mechanical and electrical items shall facilitate easy inspection, service and maintenance of the motors, reduction gearing and braking system
2. the runner wheels shall be of cast steel with double flanges and mounted on roller bearings. Gearing shall be of totally enclosed type with machine cut gears. Bearings shall be ball or roller.

C Endstops. Resilient or spring type buffers shall be provided on all runway/cross beams and crane rails. Where carriages are equipped with electric travel the end stops shall be provided with limit switches at the end of each direction of travel.

D Crane Rails. These shall comply with BS 449 and BS EN 10155 The line of the rails shall not vary by more than 3 mm, horizontally and vertically, throughout the whole length of travel. Whenever possible, rails shall be one piece. Where rails are to be jointed this shall be by electrical induction welding.

E Access Platforms and Ladders
1. safe means of access shall be provided for examination and maintenance of the crane

or other equipment only accessible from the crane. Guards shall be fitted where possible under the crab and long travel motor and gearbox assembly to prevent persons on the ground being endangered by falling objects during maintenance

2. all ladders, platforms and access ways shall comply with Section 8. Open mesh flooring shall not be used. Access ways shall be not less than 800mm wide. The platforms and access ways shall be securely fenced with double tiered guard rails and steel 'toe boards' or 'kicking plates'.

F Materials.

Steel used for the fabrication of the lifting equipment shall comply with BS 449, BS 7613, BS 7668, BS EN 10113, BS EN 10155 and BS EN 10210 as applicable. Welding procedures shall comply with BS EN 287 and BS EN 288

2.09 Electrical Components

A Motors

Motors shall be rated for 150 starts per hour (Duty type S7) for not less than one hour with a shaft output power at least 15% greater than the maximum power which will be required for operation and testing of the crane in the ambient temperature specified, at the maximum rated load.

B Control Gear

1. A triple pole isolating switch with HRC fuses shall be provided at ground level for each lifting assembly. This switch shall be lockable in the 'OFF' position only and shall be provided with a Yale type lock and three keys. The switch shall have a label marked 'CRANE ISOLATING SWITCH'
2. Starters and controllers for the crane motors shall be designed and constructed in accordance with the requirements of BS 466, BS 4941, BS EN 60947. All control circuits shall operate at 110 volts
3. Mechanically and electrically interlocked reversing contactors shall be provided for each motion including speed control of the hoist. Accelerating contactors shall cut out the rotor circuit resistance of the motor in steps with suitable delays. Contacts shall be adjustable and renewable
4. controller and resistors shall be rated such that temperatures do not exceed the limits specified in BS 4941 during operation of the crane under maximum temperature conditions. Starting resistors shall have not less than a 'ten minute' rating. Speed control resistors shall be one hour rated
5. Control gear and cabling shall be suitable for 'inching' i.e. many repeated small movements at both creep and normal speed, in any direction of motion
6. Starters and controllers shall be housed in well constructed sheet steel panel cabinets of not less than 2mm thick, sprayed and painted with an anti-condensation paint. The enclosures shall be protected against dust and damp to classifications IP 54. Starting resistors shall be mounted in a ventilated section of each control cubicle. The resistors shall all be fitted with terminal bars. The control cubicles shall be provided with lockable hinged access doors, also interlocked with the main isolating switch.

C Controls

1 Long-travel, cross-travel and slow and normal speed hoist motions of each crane shall all be controlled from the lowest level by a pendant push button station. The controls shall operate on a low voltage system supplied by a double wound isolating transformer. Both primary and secondary sides of the transformer shall have HRC fuse protection. One pole of the secondary winding shall be effectively earthed

2. Push button controls shall be of the pendant type with 'hold-on' type push buttons automatically returning to the 'off' state on release of the button. Push buttons shall be provided for 'SLOW UP', SLOW DOWN' 'NORMAL UP', 'NORMAL DOWN', 'LEFT', 'RIGHT', 'FORWARD' AND 'REVERSE'. A larger size red 'Emergency

Stop' button shall initiate tripping of the control gear main circuit breaker and automatic application of the brakes on all motions. Reclosure of the main circuit breaker shall be initiated by a separate 'Reset' button also on the pendant. The pendant shall be oil tight polyethylene, totally enclosed to IP65, shockproof, and shall be suspended from the crab unit. The voltage at the pendant shall not exceed 55 volts to earth

3 Limit switches shall be provided for all motors at the end of each direction of travel

4 Infrared or radio remote control shall be provided, where specified, or if necessary for safe operation of the crane. Two battery packs with battery charger, sensors, sensor connecting cables with clips, receiver and decoder shall be provided. Adequate sensors shall be provided at each level (minimum three) to ensure continuous control in all zones of operation. If radio control is used then approval shall be obtained by the Contractor for the frequencies used.

D Cables wiring and earthing

1. An insulated conductor system shall be provided for electrically powered cranes supply. The insulated conducted system shall be of the type where each phase is individually insulated and supported on a metal support. The type where all conductors are contained within a single extruded or moulded insulation will not be permitted. A 'festoon' insulated cable system shall be provided for the cross-travel supply
2. Wiring and earthing of the cranes shall conform to BS 466. Cables and wiring shall be of 600/1,000 volt grade PVC insulated cables in accordance with BS 6231 and BS 6346. Wherever possible, the cables shall be run in screwed heavy gauge galvanised steel conduit. All cable ends shall be clearly labelled with identification of the appropriate terminals
3. The selection installation and testing of cables and wiring shall be in accordance with BS 7671 except that maximum current ratings shall be raised by a factor of 1.4 times the rating for continuous duty obtained (after applying all necessary derating factors for high ambient temperature, grouping and disposition form of installation, etc). The up-rating factor of 1.4 is based on the one hour motors specified for crane operation
4. The crane structure, tracks, motor frames and metal cases of all electrical equipment, including metal conduit and cable guards, shall be earthed in accordance with BS7671.

2.10 Factory Inspection and Testing

A The Contractor shall secure from the lifting equipment manufacturer certification that the following inspections and tests have been conducted on each crane or hoist system at the factory, and submit to the Engineer prior to shipment.

B Cranes shall be inspected and tested in accordance with the requirements of BS 466 with the difference that the "Tests on Purchaser's Premises" (Clause 54) shall also be carried out in the manufacturer's works and witnessed by the Engineer.

C The works tests shall include overload tests during which a 25 percent overload shall be lifted by the hoist at the middle of the crane span and sustained under full control whilst it is moved up and down at both normal and creep hoist speeds. Whilst still under overload the crab unit of each crane shall be operated from end to end of its travel and in both directions.

D The mechanism and controls for the long travel motions shall be tested under light running conditions without moving the crane.

E Tests on manually operated cranes and hoists shall comply with the above insofar as they are applicable.

2.11 Spare Parts and Tools

Two years supply of spare parts and lubricants shall be supplied for each lifting device supplied.

Part 3 - Execution

3.01 Installation

Lifting equipment shall be installed in accordance with the requirements and instructions of the manufacturer. If specified in the Particular Specification, the lifting equipment manufacturer shall provide a representative to supervise the installation and testing.

3.02 Site Tests

After erection cranes and hoists shall be inspected, tested and certification provided by a qualified independent crane testing specialist in accordance with the requirements of Clause 54 of BS 466 and the tests witnessed by the Engineer. Hand cranes shall be similarly tested.

End of Section 14650

Section 15060

Process Pipework

Part 1 General

1.01 Description

The requirements of Section 02700 also apply to this section. The work included in this section comprises that for pipework above ground and inside structures.

1.02 System Description

A General Requirements:

1 Sizes shown are nominal diameter, unless indicated otherwise.

2 Drawings do not show all fittings, offsets, unions, hangers, supports, and the like. Such items shall be provided as required by the approved layouts prepared by the Contractor.

3 The Contractor shall verify dimensions of valves and fittings to ensure work will fit together properly and conform to the arrangement shown on the Drawings.

4 Prior to fabrication the Contractor shall accurately determine dimensions essential to: correctly locate pipe; fit pipe to equipment and valves; properly locate and orientate pipe sleeves and wall castings; avoid obstructions or conflicts with other Work.

5 The systems shall conform to, or exceed, the minimum requirements of the manufacturer for the installation procedures and methods for given service conditions.

6 The actual dimensions of equipment, to which connections are made, shall be used, and not by the indicated dimensions on the drawings, as a guide in selecting laying lengths of fittings.

7 For modifications to any existing piping, existing gaskets or bolts shall not be re-used. Where an existing pipe is to be cut and a new pipe is to be connected, either remove a length of pipe that is to be re-used back to its last connection and install a new flange, or provide a new length of pipe. Where drawings show a pipeline to be cut and new piping added, more pipe may be removed if approved.

8 Joint types shall be provided as shown on the Drawings and as specified.

B Design Requirements:

1 Runs shown on the drawings shall be followed as closely as possible, except for minor adjustments to avoid architectural and structural features. Relocations shall be approved and recorded on the shop drawings.

2 Horizontal piping shall be run parallel to the building walls and sloped to permit drainage where practical, except where shown or specified otherwise. Intermediate low points in a run are not allowed.

3 Parallel lines shall be grouped on the same horizontal or vertical plane wherever possible.

4 Vertical piping shall be plumbed, and the entire piping configured to allow clearances for convenient access for painting and preventive maintenance of valves.

5 Obstructions shall be cleared, headroom preserved, and openings and passageways kept clear.

6 Long radius flanged elbows shall be provided unless otherwise noted.

7 Eccentric reducers shall be installed with the straight side at top of piping system, unless otherwise indicated.

8 Hubs, spigots, and flanges shall be provided at right angles to the axis of the opening, and openings at the exact angle specified.

9 Isolating valves shall be provided at each piece of equipment or appliance on both the supply and return lines. Valves shall be located to be easily accessible to operator of equipment.

10 Slab, floor, wall and roof penetrations and closures:
   a wall sleeves shall be used for all piping penetrations of slabs, floors, walls and roofs unless otherwise noted on the Drawings. The size and location of all building and structure penetrations shall be verified prior to pouring concrete. Holes drilled with a suitable rotary drill will be considered in lieu of sleeves.
   b material orders shall be placed early so they are available for placement in concrete forms.
   c the annular space between the pipe and the sleeve in exterior walls shall be caulked, or a modular mechanical closure unit used. The mechanical closure unit is preferred and shall be installed where possible.
   d wall pipes and sleeves shall be supported by formwork to prevent contact with reinforcing steel.

11 Piping Thrust Protection:
   a thrust protection shall be provided for all unrestrained pipe joints except expansion joints. Pipe thrust protection data shall be submitted for each piping system as part of the requirements for submittals specified herein.
   b no references to thrust protection details have been shown on the Drawings unless special details are required. The absence of detail references on any Drawings does not relieve the Contractor of the responsibility for providing thrust protection throughout the plant.
   c general details referenced show acceptable methods for piping thrust protection. Alternative thrust restraint systems may be used by the Contractor only where approved by the Engineer. Structural design shall incorporate a factor of safety of three against yield of thrust restraining elements. Systems incorporating anchor studs placed perpendicular to the longitudinal axis of the pipe are unacceptable.
   d on steel piping, thrust ties and welded or flanged tie rod lugs shall be provided for protecting unrestrained joints.
   e on flanged ductile iron piping, thrust ties attached to the pipe with flange lugs shall be provided for protecting unrestrained joints.
   f on ductile iron piping with mechanical or push-on joints, restrained mechanical joints or mechanical or push-on joints, restrained by tie rods shall be provided for thrust protection. Retainer gland type thrust protection systems shall be used only where shown on the drawings or specified in the applicable detail piping specification or where approved by the Engineer.
   g All unrestrained joints in nonferrous exposed and submerged piping shall be thrust protected as specified herein.
   h Where modifications to existing pipework are shown, thrust protection shall be provided for all unrestrained joints in the piping system whether new or existing.

C Connection Requirements:
1 a sufficient number of screw unions, flanged joints, or mechanical couplings shall be provided to allow any section or run of pipe to be disconnected without taking down adjacent runs and on runs into non-flanged valve or equipment connections.
2 transition couplings shall be provided to connect pipes with small difference in outside diameter.
3 If couplings are to be encased in concrete, sleeve type couplings shall be used. Grooved-end type couplings are not acceptable.
4 Expansion joints:
   a expansion joints shall be provided where pipework crosses expansion joints in the structure, where shown on the drawings and where required to prevent undue strain on the pipe, or connecting equipment.

b piping shall be installed to allow for thermal expansion due to the differences between installation and operating temperatures. Anchor walls shall be installed to withstand the hydraulic thrust and thermal forces and to direct and control thermal expansion.

c Grooved-end piping:
  i couplings shall be installed on 6m maximum centers to provide for piping expansion.
  ii couplings and end caps shall be set so that half of the total axial movement in a run of piping is available for pipe expansion and half of the total axial movement is available for pipe contraction.
  iii half of the couplings shall be installed with no end gap and half with maximum end gap; or all coupling end gaps shall be set at the centre of their travel.
  iv all end gaps shall be set and the closing pipe segment installed while the pipe temperature is between 25°C and 40°C.
  v the end gap shall be set before the final pipe segment is cut and installed.

d Screwed, Soldered, and Socket-weld Piping:
  i expansion joints shall be used to provide for expansion of rigid piping systems. Alignment guides shall be used at each support,
  ii oversize pipe sleeve guides shall be provided to maintain clearance of 3 mm minimum at each support,
  iii for piping 20 mm and larger, formed U-bolts shall be provided with double nuts to provide 6 mm minimum clearance around the pipe. U-bolt stock size shall be as follows:

Pipe Dia(mm nom.)	Maximum Spacing(m)	Hanger rod dia(mm)
Up to 25	2.0	8
32 to 50	3.0	10
65 and 75	3.6	12
100 to 150	4.0	16
200 to 300	4.5	20
350 and over	5.0	22

e Process pipework shall be provided with flexible couplings or expansion joints and at connections to equipment where shown. The Contractor may install additional flexible couplings to facilitate piping installation, provided that complete details describing location, pipe supports, and hydraulic thrust protection are submitted.

2 Joints for Dissimilar Pipe:
  a dielectric joints shall be provided at connections of dissimilar metals and joints shall be tested to verify non-conductivity.
  b for buried piping, flexible mechanical compression joint couplings or concrete closure collar shall be provided, as directed by the Engineer.
  c for exposed piping, materials and ratings of insulating flanges, couplings and unions shall be in accordance with the appropriate Specification.

Part 2 Products

2.01 General

Products shall be as specified in Section 02700 and, wherever possible, items shall be the standard product of the manufacturer.

Part 3 Execution

3.01 General

Execution shall be carried out as specified in Section 02700.

End of Section 15060

Section 15101

Valves

Part 1 General

1.01 Scope

This Part specifies the requirements for the design, manufacturer, construction, installation, testing and commissioning of valves and appurtenances.

1.02 Reference Standards

Applicable standards referred to in this section
AWWA C500
AWWA C509
BS 1400
BS 1452
BS 4504
BS 5153
BS 5163
DIN 1693
DIN 3352
DIN 17440
JIS B 2031
JIS B 2032
JIS B 2051
JIS B 2062
JIS B 2063
JIS B 2064
JIS B 2071

1.03 System Description

Valves shall be capable of extended and continuous operation under the specified conditions and at the specified operating pressure.

Part 2 Products

2.01 Valves and Appurtenances - General

A All valves shall be suitable for use with water temperature up to 50^{o} C and in climatic and soil conditions encountered in the country of installation. Valves shall be of the same pressure rating as the adjoining pipe, but with a minimum rating of 10 bar. Unless otherwise specified, all valves and appurtenances shall be externally and internally fusion bonded epoxy coated using electrostatic/ fluidized bed process conforming to DIN 30766 or approved equivalent. The coating shall have a minimum thickness of 300 microns, be Holiday-free, non-toxic and colour code RAL 5015. Before application of epoxy coating the surface shall be sand blasted to a minimum SA 2.5 and air blown to ensure a good bond with the epoxy coating. A certificate verifying the suitability of the epoxy coating for use with drinking water is required from the manufacturer, endorsed by the National Water Council, UK, or a similar independent national body acceptable to the Engineer. Valves shall be supplied complete with flanges, gaskets and stainless steel nuts, bolts,

and washers. Flange gaskets shall be of the metal reinforced type. Nuts, bolts, screws and fittings shall be of stainless steel with 2 washers per bolt. Bolt length shall be such that after the joints are made-up, the bolt protrudes through the nut but not more than 12 mm. Unless otherwise detailed or specified here-in, valves shall be supplied complete with stainless steel extension spindles and appurtenances such that the square-nut operator is within 300 mm of the underside of the valve chamber cover slab. Where required, special couplings shall be incorporated to absorb the weight of the extension spindle at no extra cost to the Employer. Stem cap of all valves and square nut operator in case of extension spindles shall be in accordance with BS 5163. One extra stem cap to be supplied for each valve at no extra cost to the Employer. Unless otherwise specified here-in, all attaching hardware of all valves and appurtenances including the nuts, bolts and washers for flanged valves shall be stainless steel.

B Marking of valves shall include the; manufacturing standard; manufacturer's name or trademark; nominal diameter (N.D.) in mm; pressure rating in bars; an individual serial number which relates directly to the manufacturer's test certificate; and month and year of manufacture.

C All gate and butterfly valves shall be clockwise closing and the direction of opening and closing shall be clearly marked. Position indicators shall be provided on all gate and butterfly valves and shall have adjustable end limit stops at both open and closed end positions to prevent damage by excessive operating force. The maximum effort required to operate the valve against the maximum unbalanced head applied at the circumference of the handwheel or end of the tee-key shall not exceed 15 kg and where necessary gearing shall be provided as specified to achieve this. Handwheels shall be provided for all valves when installed above ground, when operation is within reach. Valves installed deeper than 300 mm shall be provided with an extension spindle and Tee-key. Valves installed out of reach above ground shall be provided with chain drive or remote control drive as shown or specified.

D All gate and butterfly valves shall be designed to provide 100 percent water tight shut off at all specified pressures and suitable for installation of electrical actuators when required. Line valves of 300 mm diameter and smaller shall be double flanged gate valves, unless otherwise indicated. Butterfly valves shall be used as line valves for sizes larger than 300 mm diameter and shall be flanged. Where flanges are required they shall be drilled to PN 16 unless specified or directed otherwise.

E Valve packing shall be manufactured from pure TFE/PTFE fibres/filament in square plait or multi lock braid construction and shall be lubricated with a suspensoid of TFE/PTFE before braiding and an inert softener/lubricant.

2.02 Gate Valves

A Gate Valves shall conform to the provisions of AWWA C509; JIS B 2062; DIN 3352 Part 4A & B or approved equivalent and as further specified herein. Valves shall be inside screw, non-rising stem, clockwise closing, wedge, gate valves suitable for underground use and flow in both directions. Valves pressure rating shall be equal to, or greater than the adjoining pipe or fitting but a minimum of 10 bar. Valves shall be designed for the "Closed End Test" and shall be of resilient seal design with bolted bonnet connection and straight-through port. Wedges shall be low clearance - guided in the body and shall have an inner core of ductile iron GGG500 conforming to DIN 1693 or approved equivalent. They shall be encapsulated with a synthetic EPDM rubber covering on the inside and outside by vulcanizing. The rubber covering shall have a minimum thickness of not less than 2.5 mm on both flow sides and 2.0 mm on sealing

surfaces with no body-metal exposed. EPDM wedge rubber shall be approved to be used for potable water and be selected to meet the chemical properties and temperatures of the fluid being handled by the valves.

B Stems shall be non-rising and manufactured of stainless steel 1.4462 to DIN 17440 or approved equivalent. Stem threads shall be of the rolled type. Sealings and bearings shall be corrosion proof and maintenance-free and shall be designed in the form of a series of 'O' - rings of synthetic rubber. Stem bearing gap shall be sealed against entry of dust by a wiper ring. Stem sealing should be replaced when required. Stem nuts shall be of zinc-free bronze 2.1050.01 to BS 1400 CT 1-C or approved equivalent.

C The body and bonnet shall be ductile iron GGG 500/400 to DIN 1693 or approved equivalent and shall be internally and externally fusion bonded epoxy coated as specified here-in. Prior to assembly, the entire valve body and bonnet shall be holiday tested internally and externally at not less than 3.0 kV to DIN 30677 or approved equivalent.

D Manual operation shall be by handwheel or by Tee-key as shown on the Drawings. Gear operated valves shall be provided with operating nuts and Tee-keys as specified. Gear cases shall be totally enclosed and equipped with indicators to show valve position and designed for full differential pressure of 10 bars.

2.03 Butterfly Valves

A Butterfly valves shall conform to one of the following standards: BS 5155; JIS B 2064; DIN 3354; AWWA C504 or ISO 5752 with a rating equal to, or greater than the adjoining pipe or fitting but with a minimum of 10 bar. They shall be double flanged, short body type with worm type manual operating gear with stem cap and shall be manufactured from the following materials:

1	body and flange	: ductile iron/grey cast iron to BS 1452 Grade 260.
2	disc	: aluminum bronze to B.S. 1400 AB2
3	internal body lining	: EPDM rubber bonded to body by vulcanizing.
		: min. thickness 18 mm for valves of diameter 1000-2000 mm
		: min. thickness 12 mm for valves of diameter 700-900 mm.
		: min. thickness 9 mm for those less than 700 mm.
		: temperature resistant to 100^{o}C.
		: suitable for use with potable water.
4	shaft and gear spindle	: stainless steel 1.4462 to DIN 17440.
5	shaft bearing	: self lubricating type with EPDM 'O' ring seals

B All the valves shall be of high reliability, of robust design and tropicalized in accordance to the worst prevailing ambient conditions. Valves shall be coated externally with blue colour (RAL 5015) non-toxic polyurethane to a minimum dry film thickness of 150 microns. All the valves shall be designed for no leakage under flow from either direction tested at a differential pressure across the seal of rated working pressure. Each valve shall be subject to a body pressure/leakage test of 1.5 times the design pressure before leaving the manufacturer's works. A certificate showing that any rubber lining used is non-toxic to potable water in accordance to international standards shall be obtained from an internationally recognised authority.

2.04 Air and Vacuum Valves

A Air and vacuum valves shall be designed to discharge air during filling of pipelines, admit air during emptying of pipelines and discharge air accumulated at high points in pipelines during normal operation. For both double orifice air valves and single orifice

air valves the material of construction shall be:

1 body/cover/dust cover :grey cast iron to BS 1452 grade 220 or approved material,
2 all working parts :bronze, stainless steel or other non-corroding material,
3 coating :shall be in accordance with the Particular Specifications.

B Detailed catalogues with drawings and graphs showing air inflow/outflow curves shall be submitted for approval. Valves shall be supplied with rubber gasket, stainless steel nuts, bolts and washers.

C Double orifice air valve shall combine both large and small orifices within one valve. The large orifice shall be sealed fully and automatically by a buoyant rigid ball. The chamber housing shall be designed to avoid premature closing of the valve by the air being discharged. Small orifices shall be sealed by a buoyant ball at all pressures above atmospheric, except when air accumulates in the valve chamber. Valve will be double flanged drilled to BS 4504 PN 10 pattern and valve construction shall be without integral isolating valve. Valves shall be dynamic type and effective sealing pressure required at valve to give effective sealing shall be 0.1 bar.

D Single orifice air valve shall be of screw down type and of 25/50 mm size. Valves shall be supplied with gunmetal cock, gunmetal strap and stainless steel pipe.

E Air valves unless otherwise specifically indicated on the drawings shall be of the following type and size depending on the size of pipeline in which they are installed.

Type & Size of Pipe (mm)	Nominal Size of Air Valve (mm)		Type of Air Valve
	Body Size	Flange Size	
Up to 225 PVC	25	Saddle	Single Orifice with an isolating cock, 25 mm BSP Threaded Male ferrule
250 - 300 DI	60	80	Double Orifice with flanged inlet and an isolating Gate valve, (type Stanton N2516 or equivalent)
400 - 600 DI	100	100	Double Orifice with flanged inlet and an isolating gate valve, (type Stanton N2522 or equivalent)
800 - 1200	150	150	Double Orifice with flange inlet and an isolating gate valve, (type Stanton N2525 or equivalent)

2.05 Check Valves

Check valves shall be of lever and weight operated type to BS 5153 or other approved standard with cast iron body, bronze trim and rubber faced. Flanges shall be in accordance with BS 4504 and drilled to BS 4504 Pattern 10.

2.06 Butterfly Float Valve

A Butterfly float valve to be used shall be designed to mechanically and automatically open and close according to the water level in the reservoir.

B Butterfly float valve shall be the all stainless butterfly float valve type LD-B-1/2 of Daiwa Tekkosho of Japan or approved equal. The valve shall consist of a rubber sheeted butterfly valve, gear unit, float and a connection rod to support the float. The gear unit shall be so designed to operate the butterfly valve between full opening and full closing positions in the range of 45 degree vertical move of the connection rod which shall be

operated with float. Gear unit shall be provided with a stopper to prevent the connection rod from moving exceeding 45 degree. The float shall have the enough volume and weight for operating the valve gear unit. The operating level of the float shall be adjustable. The float shall be suspended with stainless steel (JIS G4303 SUS316) wire from the ceiling of the reservoir/tower so as to prevent the float from falling down during low level water storage.

C The valve shall have flanged ends conforming to the working pressure of 10 kgf/cm^2 for reservoirs. Mating dimension of flange and number of bolt hole shall be according to the manufacturer's recommendation.

D The material to be used for the construction shall be stainless steel, stainless steel castings or rubber. Materials of major parts are as follows;

Valve body	:	Stainless Steel, JIS G5121 SCS 13
Valve disc	:	Stainless Steel, JIS G5121 SCS13, Rubber Sheeted
Valve shaft	:	Stainless Steel, JIS G4303 SUS304
Short pipes	:	Stainless Steel, JIS G4303 SUS304
Connection Rod	:	Stainless Steel, JIS G5121 SCS 14
Float	:	Stainless Steel, JIS G4303 SUS 316

E The Contractor shall submit for approval by the Engineer the design data and other engineering information of the butterfly float valve.

Part 3 Execution

A Valves shall be installed and commissioned in accordance with manufacturer's instructions. The Contractor shall co-ordinate the valve requirements with those of the actuators and instrumentation to ensure compatibility of control interfacing and operations.

B All valves shall be tested to the appropriate test pressure at the manufacturer's works, and shall be supported by a test certificate from the manufacturer. Work tests on all valves shall witnessed by an approved independent testing agency at no extra cost to the Employer. The Contractor shall supply the original manufacturer's test certificate endorsed by the approved independent testing agency for each valve supplied. The certificate shall relate to the individual number cast on each valve and shall give the date of test. The manufacturer shall factory test each valve 600 mm or larger in diameter for performance, leakage and hydrostatic pressure in accordance with AWWA C500.

End of Part 15101

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Section 15102

Electric and Pneumatic Actuators

Part 1 General

1.01 Scope

This Part specifies the requirements for the design, manufacturer, construction, installation, testing and commissioning of electric and pneumatic actuators for valves and penstocks.

1.02 Reference Standards

Applicable standards referred to in this section
BS 5501 (IEC 79) Electric apparatus for potentially explosive atmospheres
BS 5793 (IEC 534) Industrial process control valves
BS EN 60534, Industrial control valves
PNEUROP, (European Committee of manufacturers of compressors, vacuum pumps and pneumatic tools) Recommendations

1.03 System Description

Actuators shall be capable of extended and continuous operation under the specified conditions and at the specified valve operating pressure. Submersible actuators, if required, shall operate at the specified temperature.

1.04 Submittals

The following data shall be furnished by the Contractor:

1 Design Data. These shall include calculations justifying the sizing of valves and actuators for the hydraulic and system requirements.
2 Shop Drawings. Complete shop drawings for each type of actuator shall be provided, including:
  a specifications for materials of construction of actuators and all appurtenance
  b wiring diagrams
  c ratings for actuator torque, power input, cylinder or diaphragm pressures, motor ratings and enclosures, operating speeds, and other information requested by the Engineer
  d actuator dimensions.
3 Operation and maintenance manuals and instructions. These shall be provided for each type of actuator, including:
  a list of lubricants
  b lubrication instructions
  c complete assembly and wiring diagrams
  d results of all tests specified above and carried out on site

Part 2 Products

2.01 Electric Actuators

A Electric type actuators shall include the motor, heaters, operators unit gearing, limit switches, torque switches, declutch lever, auxiliary handwheel, reversing starter,

switches, mechanical position indicator, and accessories as required.

B The valve and gate actuator motor and all electrical enclosures shall be waterproof, IP 67, as a minimum unless explosion proof, to BS 5501, EEXD II BT4, or submersible, IP 68 is specified.

C When specified, a hammer blow mechanism, that travels sufficiently enough to allow the motor to reach full speed before imparting a hammer blow, to start the valve or gate in motion in either the closing or opening direction, shall be incorporated.

D The power gearing shall consist of helical gears of heat-treated steel, and worm gearing of hardened alloy steel. All power gearing shall be grease lubricated with high speed parts on anti-friction bearings.

E It shall be possible to remove the motor operator from the valve and gate without taking the valve or gate out of service.

F The valve actuating speed shall be at 300 mm per minute unless specified otherwise.

G Pneumatic type actuators shall include the cylinder or diaphragm actuator, solenoid valves, pneumatic positioners, pressure gauges, manual testing station, and other accessories, as designated to provide a complete, functional actuator.

H Motors

1 Motors shall be totally enclosed non-ventilated construction with Class F insulation with temperature rise limited to Class B.
2 Available operating torque shall be at least two times the valve manufacturer's maximum torque requirements. The motor shall be designed specifically for use on valve operation, having high torque capacity coupled with low inertia.
3 The motor shall be of sufficient size to open or close a valve against the maximum specified differential pressure when the voltage drop at the motor is 10 percent of the nominal voltage.
4 Electrical power to the motor shall be 3 phase, 50 Hz, 400V for 0.4 kW or larger and 1 phase, 230V, 50 Hz, for smaller than 0.4 kW.
5 The motor shall be pre-lubricated and all bearings shall be of the anti-friction type.
6 Motor rating shall be continuous duty unless otherwise designated.
7 Heaters and thermostats shall be provided for high humidity conditions.
8 Electrical and mechanical disconnection of the motor shall be possible without draining the actuator grease or lubricant

I Controls

1 Each actuator shall be equipped with a reversing starter, control relays, 2-position limit switches and torque limiting switches.
2 Additional position, limit switches, hand-off-auto switch, open-auto close hand switch, open, close, stop push-button switches, position indicating potentiometer, position indicating lights, electric braking or a position controller, or both, shall be provided for the specified analogue signal input, unless otherwise specified.
3 Position limit switches shall be double pole, double throw and provided for both open and close positions of travel. They shall be connected directly to the valve through continuous gearing and follow its position at all times. Switches shall be rated 10 amps at 230 V a.c. The actuating point shall be adjustable over at least 50 percent of the travel.
4 Torque limiting switches shall be provided and be responsive to the mechanical torque developed in seating, back-seating, or by obstruction. The torque switch shall

operate a calibrated dial integrally mounted and directly related to the torque output of the operator. Torque control accuracy shall be within ± 5 %. The use of torque wrenches for calibration will not be required.

5 Reversing starters shall include a reversing contactor, mechanical and electrical interlocks, and thermal overload relays as required. The contactor shall break all lines to the motor. All controls shall operate on 110 V.a.c.

6 Push-button switches (open-stop-close) shall be located for ease of accessibility. The controls shall be arranged for remote operation by isolated momentary or continuous contact switches rated not less than 2 A at 230 V a.c. Terminals shall be wired such that open and close operation only is possible by appropriate external connections.

7 The hand-off-auto switch shall select between local (HAND) and remote (AUTO) control for open, close, stop operation. In the OFF position both local and remote controls shall have no effect.

8 For all modulating duty operations, a 4-20 mA convertor shall be provided, powered internally from a 24 V supply, to transmit the valve position remotely.

9 Position indicator lights shall be at least 2 W, green lens for open, red lens for close; shall be interchangeable and located near the push-button switches. Both shall light when the valve is between open and closed limits.

10 Additional position limit switches shall be fully adjustable, of the same rating, and driven in the same manner as the other limit switches provided.

11 The position controller shall utilise an independent position feedback potentiometer and shall accept a 4-20 mA d.c. signal for modulating the valve position, unless otherwise specified. The final positioning accuracy shall not be less than 1 % of position specified by the signal. A damping circuit shall prevent overshoot in excess of 2 % for a full-scale step input. The controller may be separately housed but must be of the same class as the actuator housing. Power shall be derived from the actuator power supply.

J Special mounting requirements, such as shaft and neck extensions, shall be provided as shown on the Contract Drawings, and as required for safe operation.

K The Contractor shall secure from the actuator manufacturer, certification that each actuator has been performance tested at the factory and individual test certificates shall be supplied for each actuator. The test equipment shall simulate a typical valve load and the following information shall be recorded, and included with the test certificate.

a current at maximum torque setting
b torque at maximum torque setting
c test voltage and frequency
d flash test voltage
e actuator output speed or operating time

In addition, the test certificate shall display details of specifications such as gear ratios for both manual and automatic drive, closing direction, wiring diagram code number, remote position transmitter resistance and interposing relay voltage, etc.

2.02 Pneumatic Actuators

A The available instrument and operating air pressures and quality are as specified in the Particular Specifications. Pressure reducing valves shall be provided where required for each actuator.

B Direct mounted pneumatic positioners shall be provided for each valve, mounted on the valve, unless specified otherwise. Positioners shall provide 0.1 to 1 bar (gauge) output. Electrical output of 4 to 20 mA shall be provided.

C Wrench or handwheel operated manual override shall be provided for each actuator, unless otherwise specified. The force to operate these shall not exceed 25 Kgf.

D Throttling manual override shall be provided for actuators where specified.

E Where potentiometers are specified for positioning cylinder actuators they shall be 1000 Ω, mounted, enclosed and provided with double pole double throw position indicating switches.

F Test points shall be provided at each actuator to allow an external supply of compressed air to be connected to checked the operation of the actuator and the position indicator.

G Where required fail-safe actuators (fail open or fail closed, as required) shall be provided.

H Pressure gauges for pneumatic signal and operating air supply links shall be provided.

I A filter shall be provided for each pneumatic actuator, unless specified otherwise.

J Special mounting requirements, such as shaft and neck extensions shall be provided as shown on the Drawings.

K Cylinder actuators shall be as follows:
1 type: double acting cylinder, unless otherwise specified or shown. In compliance with
BS 5793, BS EN 60534 and PNEUROP recommendations as applicable;
2 actuator cover : cast iron or steel, complete with gaskets and seals, internally coated with epoxy;
3 piston : cast iron or steel, epoxy coated;
4 piston rod : chrome plated carbon steel;
5 solenoid control valves shall be provided with mountings and piping;
6 actuators shall be suitable for operation at 5-7 bar, unless designated otherwise. Test pressure shall be 10 bar

L Diaphragm type actuators shall not be provided for valves larger than 150 mm nominal diameter unless approved by the Engineer. They shall confirm to the standards in Part 2.02 L 1 above. Diaphragm actuator construction shall be as follows:
1 diaphragm case and mounting hardware: cast iron, steel, or stainless steel; aluminium is not acceptable;
2 diaphragm : flexible neoprene or Buna N;
3 spring : enclosed and corrosion resistant.

M Solenoid valve actuators shall be as follows, and to the standards in Part 2.02 L 1 above
1 electrical characteristics : 230 or 110 V a.c., 50 Hz, single phase;
2 enclosure : IP 68, unless otherwise designated;
3 rated for continuous operation;
4 fitted with spring return unless otherwise specified;
5 the inlet shall be normally open or normally closed as required by the control system.

2.03 General

Each actuator shall be supplied with a start-up kit including wiring diagram and start-up instructions in the terminal housing, together with spare cover O rings or gaskets and cover screws to make good site losses.

2.04 Spare Parts and Tools

A One set of manufacturer's recommended spare parts for two years shall be provided for each actuator.

B One set of cover screws, gaskets, 'O' rings and ram seals shall be provided for each actuator.

C Two years' requirement of consumable supplies shall be provided for operation and maintenance of all actuators.

Part 3 Execution

A Electric and pneumatic actuators shall be installed and commissioned in accordance with manufacturer's instructions.

B The tests listed under Part 2.02 L shall be repeated at site. In addition the actuator performance shall be tested as part of the control system.

C The Contractor shall co-ordinate the actuator requirements with the with the instrumentation requirements to ensure compatibility of control interfacing and operations.

End of Part 15102

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Section 15140

Supports and Anchors

Part 1 General

1.01 Summary

A Work includes pipe, hangers, supports, and associated anchors.

B. Work furnished but installed under other sections:
1. Furnish hanger and support sleeves to Section 03300, Cast-In-Place Concrete for placement into formwork.
2. Furnish hangers and supports to Section 15060, Pipes Pipework and
3. Furnish hangers and supports to Section 02700 Pipework.

1.02 References

The following standards and codes of practice are referred to in this Section:
ANSI/ASME B31.1 - Power Piping.
NFPA 13 - Standard for the Installation of Sprinkler Systems.
NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.
ANSI/MSS SP -58- Pipe Hangers and Supports - Materials, Design and Manufacture.
ANSI/MSS SP -69- Pipe Hangers and Supports - Selection and Application.
ANSI/MSS SP -89- Pipe Hangers and Supports - Fabrication and Installation Practices.

1.03 System Description

A. General:
1. Support piping as described hereinafter and as shown by the support details on the Mechanical Drawings. Special support and hanger details are shown to cover locations where standard supports are inapplicable.
2. Unless otherwise specified herein, all standard pipe hanger and support materials, design, manufacture, selection and installation shall comply with the standards of the Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS), Vienna, Virginia (001703-281-6613).
3. See Figure 1 for MSS pipe support element types. Element types are presented to aid the Contractor in identifying and providing acceptable pipe supports.
4. No attempt has been made to show all required pipe supports in all locations on the Drawings. The absence of pipe supports and details on any drawings shall not relieve the Contractor of the responsibility for providing them throughout the plant.
5. Where piping connects to equipment support the piping by a pipe support and not by the equipment.
6. Size pipe support systems to withstand the dead loads imposed by the weight of the pipes filled with water, plus any insulation. Select commercial pipe supports and hangers for a minimum safety factor of 5.
7. Design anchors for the design load specified under paragraph Horizontal Pipe Supports. The direction of the applied load shall be either parallel to, or perpendicular to the pipe, whichever produces the greatest stress in the anchor.

B. Pipe support component types shall comply with the following requirements:

Application	Type (MSS SP-58)	Notes
1. General Service (0°C to 50°C):		
Horizontal Bare Pipe:		
Attachments		
U-bolt Hangers	24	
Rings	6,11	1
Clevis Hanger	1	
Clamps	3	
Hanging Rollers	41,43	
Supporting Rolls	44,46	
Saddles	36,37,38	
Horizontal Insulated Pipe:		
Attachments		
Clips	26	
Clevis Hanger	1	2
Hanging Rollers	41,43	2,3
Supporting Rollers	44,46	2,3
Protective Shields	39,40	
Saddles	36,37,38	2
Vertical Pipe:		
Riser Clamps	8,42	
Hanger Rod Fixtures:		
Turnbuckles	13,15	
Swing Eyes	16,17	
Clevises	14	
Building Structural Attachments:		
Inserts	18	4
C-Clamps	19,23	
Beam Clamps	20,21,25,27,28,29,30	
Welded Attachments	22,57,58	
Brackets	33,34	
2 Hot Pipe Service (50° C - 225°C):		
Horizontal Bare Pipe:	--	5
Horizontal Insulated Pipe:		
Attachments		
Clevis Hangers	1,2	
Hanging Rollers	41,43,2,3	
Protective Shields	39	
Supporting Rolls	44,46,2,3	
Saddles	36,37,38	2
Vertical Pipe:		
Variable Spring Hanger	51	5
Hanger Rod Fixtures:	--	5

Notes:

1. Use for piping 60 mm and smaller.
2. Provide insulated piping with rigid pipe insulation insert specified under Section 15260.
3. Provide insulated piping with protective shield.
4. See Section 05500 for acceptable anchors or fasteners.
5. Required support components are the same as for general service.

C. Building Piping:

1. Support stacked horizontal runs of piping along walls by a metal framing system. Pipes can not be supported from the pipe above.
2. Support horizontal runs of piping 300 mm and smaller along concrete or masonry walls with welded steel wall brackets.
3. Single runs of un-insulated pipe smaller than nominal 75 mm may be supported from masonry walls with steel clips. Piping clamps which resist the axial movement of the pipe through the support shall not be used for plastic pipe.
4. Support grouped horizontal piping from ceilings with trapeze type metal support system:
   a. Piping larger than 300 mm shall not be supported with trapeze type support systems.
   b. Trapeze beam allowable stress: per ANSI/MSS SP-58.
   c. Base beam stress on a concentrated load located at the midpoint of the beam span. The beam load shall include the total weight of the supported pipe full of water, flanges, fittings, valves, and insulation, as well as the weight of the support assembly.
   d. Do not exceed the allowable load of the trapeze hanger connection or attachment.
   e. Trapeze support spacing: limited to the spacing for single rod hangers for the smallest pipe being supported.
   f. Pedestal pipe supports: adjustable with stancion, saddle and anchoring flange. Provide waffle type isolation pad under anchoring flanges, adjacent to equipment or where otherwise required to provide vibration isolation.

D Horizontal Pipe Support:

1. Support spacing and minimum hanger rod size (steel pipe):

Pipe size (mm)	Maximum spacing (m)	Hanger rod dia (mm)
Up to 25	2.0	8
32 to 50	3.0	10
65 and 75	3.6	12
100 to 150	4.0	16
200 to 300.	4.5	20
350 and over	5.0	22

2. Cast iron soil pipe: same as for steel pipe. Maximum support or hanger spacing shall be1500 mm. Support within 300 mm of each joint.
3. Copper pipe:
   a. Pipe sizes smaller than100 mm minimum rod sizing same as for steel pipe.
   b. Horizontal support or hanger spacing: 600 mm less per size than steel pipe. Support pipe smaller than 30 mm every / 500 mm.
4. Insulated piping: Support or hanger spacing shall not 3000 mm for all services.
5. The minimum design load rating for structural building attachment shall be based on an allowable stress of 1/5 of the minimum tensile strength of the material at service temperature. Castings shall include a casting quality factor of 0.80 of the allowable stress specified.
6. Attach hanger support rods to steel beams with beam clamps, to concrete with inserts or flanges fastened with flush shells.

1.04 Submittals

Indicate hanger and support framing and attachment methods.

1.05 Quality Assurance

A. Supports for sprinkler piping: in conformance with NFPA 13.
B. Supports for standpipes: in conformance with NFPA 14.

Part 2 Products

2.01 Materials

A. General:
1. All submerged piping supports, guides, and fasteners or those installed below channel and wet well cover slabs shall be Type 316 stainless steel.
2. Acceptable piping hanger and support component materials for exposed piping shall comply with the requirements of ANSI/MSS SP-58.
3. Provide hangers, rods, clamps, protective shields, metal framing support components, and hanger accessories for exposed piping hot-dipped galvanized in accordance with ASTM A153 or A386 unless noted otherwise on the Drawings.
4. Copper Piping: Use copper-plated hangers or cushioned clamp type system.

B. Steel hanger rods: threaded both ends, threaded one end, or continuous threaded.

C. Inserts: malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

D. Sleeves:
1. Pipes through non-fire rated beams, walls, footings, and floors: form with steel pipe.
2. Pipes through fire rated and fire resistive floors and walls, and fireproofing: prefabricated fire rated sleeves including seals, UL listed.
3. Round ductwork: form with galvanized steel.
4. Rectangular ductwork: form with galvanized steel.
5. Fire stopping: a sealant system to match the fire rating of the barrier.

E. Fasteners: bolts, nuts, concrete anchors and anchor bolts shall be as specified in Section 05500.

Part 3 Execution

3.01 Installation

A. Pipe Supports:
1. Pipe support design and manufacture: comply with ANSI/MSS SP-58.
2. Pipe support fabrication and installation: comply with ANSI/MSS SP-89.

B. Pipe Hangers and Supports:
1. Submit details of hanger attachments to the Engineer for review prior to installation of the supports.
2. Install hangers to provide minimum 5 mm space between finished covering and adjacent work.
3. Use hangers with 15 mm minimum vertical adjustment.
4. Support piping to prevent undue strain on any valve, fitting, or piece of equipment.
5. Support horizontal cast iron pipe adjacent to each hub, with 1500 mm maximum spacing between hangers.
6. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
8. Support riser piping independently of connected horizontal piping.

9. Provide pipe support at both sides of changes in direction, at both sides of non-rigid joints and at changes in elevation.
10. Place a hanger within 300 mm of each horizontal elbow.
11. Provide vertical sway bracing on 3000 mm maximum centres.
12. Design hangers without disengagement of supported pipe.

C. Sleeves:
   1. Set sleeves in position in formwork. Provide reinforcing around sleeves.
   2. Extend sleeves through floors one inch above finished floor level. Calk sleeves full depth and provide floor plate.
   3. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with fire stopping or insulation and calk seal as required to match the fire rating of the barrier. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
   4. Install stainless steel escutcheons at finished surfaces.
   5. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

D. Finish: Prime coat exposed steel hangers and supports per section 09870. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

End of Section 15140

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Section 15410

Plumbing

Part 1 General

1.01 Scope

This part specifies the requirements for the installation, testing and commissioning of services supplying water for use within buildings. It covers the system of pipes, fittings and connected appliances installed to supply any building with water for ablutionary, cleaning, sanitary and laundry purposes.

1.02 Reference Standards

Applicable standards referred to in this section
BS 417 Galvanised mild steel cisterns and covers, tanks and cylinders: Part 2
BS 864 Capillary and compression fittings for copper tubes and copper alloy.
BS 1010 Specification for draw-off taps and stop valves for water services (screw-down pattern).
BS 1212 Specification for float operated valves (excluding floats).
BS 1968 Specification for floats for ball valves (copper).
BS 1972 Specification for polythene pipe (Type 32) for above ground use for cold water ervices.
BS 2494 Specification for elastomeric joint rings for pipework and pipeline.
BS 2580 Specification for underground plug cocks for cold water services.
BS 2871 Specification for copper and alloys Tubes.
BS 2879 Specification for draining taps (screw-down pattern).
BS 2505 Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water.
BS 4127 Specification for light gauge stainless steel tubes.
BS 4213 Cold water storage cisterns (polyolefin or olefin copolymer) and cistern covers
BS 4346 Joints and fittings for use with unplasticized Plc pressure pipes.
BS 5114 Specification for performance requirements for joints and compression fittings of use with polyethylene pipes.
BS 5154 Specification for copper alloy globe, globe stop and check, check and gate valves.
BS 5163 Specification for predominantly key-operated cast iron gate valves for waterworks purposes.
BS 5412 Specification for the performance of draw-off taps with metal bodies for water services.
BS 5413 Specification for the performance of draw-off taps with plastics bodies for water services.
BS 5433 Specification for underground stop valves for water services.
BS 5281 Devices without moving parts for the prevention of contamination of water by backflow.
BS 6282 Devices with moving parts for the prevention of contamination of water by backflow.
BS 6437 Specification for polyethylene pipes (type 50) in metric diameters for general purposes.
BS 6572 Specification for blue polyethylene pipes up to nominal size 63 for bellow ground use for potable water.
BS 6700 Specification for design, installation, testing and maintenance of services supplying water supplying water for domestic use within buildings and their curtilages.

BS 7671 Requirements for electrical installations.

1.03 Cold Water System

The cold water system shall be capable of providing cold water at the locations and in the quantities required and specified. All cold water draw-off points shall be served via a cold water storage system, mounted at high level in each building.

1.04 Hot Water System

The hot water system shall be capable of providing hot water at the locations, in the quantities and at the temperatures required and as specified. Hot water systems shall be of the storage tank type.

Part 2 Products

2.01 General

Every pipe, pipe joint and connected fitting shall be capable of withstanding, without damage or deterioration, sustained temperatures of up to 40°C for cold water installations and up to 70°C, with occasional short-term peaks of up to 100°C to allow for malfunctions, for heated water applications. If pipes, pipe joints or fittings are of dissimilar metals, measures shall be taken to prevent corrosion. Dissimilar metals shall be avoided in below ground installations.

2.02 Pipe Materials

A Copper pipework shall comply with the relevant provisions of BS 2871: Part 1. Copper and copper alloy tube fittings should comply with the relevant provisions of BS 864: Part 2.

B The use and installation of polyethylene pipework shall comply with the relevant provisions of BS 1972 (above ground use), BS 6437 (general purposes) and BS 6572 (below ground use). Copper alloy tube fittings for polyethylene pipes shall comply with the relevant provisions of BS 864: Part 3, Joints for polyethylene pipes shall comply with the relevant provisions of BS 5114 and BS 3505.

C The use and installation of unplasticized PVC pipework shall comply with the relevant provisions of BS 3505. Solvent welded joints and fittings for PVC-U pipes shall comply with the relevant provisions of BS 4346: Part 1. Mechanical joints and fittings for PVC-U pipes shall comply with the relevant provisions of BS 4346: Part 2.

D Stainless steel pipework shall comply with the relevant provisions of BS 4127.

2.03 Draw-off Taps

A Metal bodied taps shall conform to the relevant provisions of BS 5412: Parts 1-5.

B Plastic bodied taps shall confirm to the relevant provisions of BS 5413: Parts 1-5.

C Taps not fixed directly to an appliance shall be screwed into a suitable pipe fitting.
D The fitting, or the pipe immediately adjacent to the tap, shall be firmly secured to a suitable support so as to prevent strain on the pipe and its joints when the tap is operated.

2.04 Stop valves

The use and installation of stop valves shall comply with the relevant provisions of BS 6700. Stop valves fitted to service pipes shall comply with the relevant provisions of the British Standards referenced below. Stop valve components of fittings incorporating stop valves shall comply with the requirements for stop valves. When a stop valve is installed on an underground pipe it shall be enclosed in a pipe guard or chamber under a surface box of the correct grade for the traffic loading relevant to the location.

Nominal Size of Pipe	British Standard	
	Above Ground	Below Ground
50mm or small	BS 1010: Part 2 BS 2580 BS 5433	BS 2580 BS 5433
50mm or larger	BS 5163	BS 5163

2.05 Drain Taps

Draining taps shall comply with the relevant provisions of BS 2879, shall be of the screw down type with a removable key and shall be fixed over a drain or have provision for discharging the water to the nearest convenient point for disposed.

2.06 Ball Float Valves

A Except for interconnected cisterns arranged to store water at the same level, every pipe supplying water to a cistern shall be fitted with a float operated valve or some other equally effective device to control the inflow of water and maintain it at the required level. The inlet control device shall be suitable for the particular application, taking into account the supply pressure and the temperature of the water in the cistern.

B When a float operated valve is used it shall either:
1 comply with BS 1212: Part 2 or 3 and be used with a float complying with BS 1968 or BS 2456 of the correct size corresponding to the length of the lever arm and the water supply pressure; or
2 where any other float operated valve or other level control device is used, it shall comply with the performance requirements of BS 1212 where applicable to the circumstances of its use and shall be clearly marked with the water pressure, temperature and other characteristics for which it is intended to be used.

C Every float operated valve shall be securely fixed to the cistern it supplies and where necessary braced to prevent the thrust of the float causing the valve to move and so alter the water level at which it shuts off. This water level shall at least 25mm below the lowest point of the warning pipe connection or, if no warning pipe is fitted at least 50 mm below the lowest point of the lowest over flow pipe connection

D Every ball float valve shall be so placed that it is readily accessibly for examination, maintenance and operation.

2.07 Servicing Valves

A Servicing valves shall comply with the relevant provisions of BS 6700. They shall be located in accessible positions so as to enable the flow of water to individual or groups of appliances to be controlled and to limit the inconvenience caused by interruption of supply during repairs.

B A servicing valve shall either comply with the requirements for stop valves specified in

Clause 2.4 of this Part or shall be capable of withstanding a static pressure 1.5 times the maximum pressure it will be subjected to in use, be leak tight when closed against the latter pressure and, when installed on any pipe pressurised from the mains or on any pipe under a static pressure exceeding 1 bar, shall be operable only by means of a key, screwdriver or coin inserted into a slot on the valve. Screw down servicing valves shall not be of loose jumper design.

C Pipes connecting feed cisterns to primary circuits shall not be fitted with servicing valves where the capacity of the cistern does not exceed 18 litres. A servicing valve shall be fitted upstream of, and as close as practicable to, every float operated valve connected to a supply pipe.

D Every pipe taking water from a cistern of capacity exceeding 18 litres shall be fitted with a servicing valve close to the storage cistern, tank or cylinder.

E Having regard to the hydraulic resistance of screw down type valves, it is permissible for copper alloy gate valves complying with BS 5154 to be used for this purpose. Specially designed spherical plug valves are available in the smaller sizes and are well suited for fitting near to single outlet fittings and appliances as servicing valves.

2.08 Backflow Protection Devices

A Pipe interrupters for backflow protection shall comply with the relevant provisions of BS 6281: Part 3.

B Vacuum breakers for backflow protection shall comply with the relevant provisions of BS 6282: Part 2 and 3.

C Check valves for backflow protection shall comply with the relevant provisions of BS 6282: Part 1. Any additional installation instruction issued by the manufacturer or supplier of the check valve shall also be complied with.

D Combined check valve and vacuum breaker for backflow protection shall comply with the relevant provisions of BS 6282: Part 4.

E Double check valve assembly for backflow protection shall comply with the relevant provisions of BS 6282: Part 1, with a draining tap complying with the relevant provisions of BS 2879 connected between them.

2.09 Cold Water Storage Tanks

A Cold water storage tanks shall impart no taste, colour, odour or toxicity to the water nor promote or foster microbial growth under the conditions where the cistern is going to be installed. Cold water storage tanks shall be constructed in accordance with the following:
1 galvanised mild steel complying with the relevant provisions of BS 417
2 polyethylene complying with the relevant provision of BS 4213.

B The tank shall be supported on a firm level base capable of withstanding the weight of the cistern when filled with water to the rim.

C Any tank with an effective capacity of up to 1000 litres shall be fitted with a warning type overflow pipe. Tanks with an effective capacity exceeding 1000 litres shall be fitted with one or more overflow pipes. For capacities up to 5000 litres the lowest overflow pipe shall be a warning pipe. For capacities exceeding 5000 litres, either the

lowest pipe will be a warning pipe, or a device shall be fitted that gives an audible or visual alarm when water in the tank reaches a level at least 50mm below the lowest point of the lowest overflow pipe. Overflow pipes shall be made of rigid corrosion resistant material. No overflow or warning pipe shall rise in level outside the cistern. Warning type overflow pipes shall discharge water immediately the water in the tank reaches the overflow level and shall discharge to a conspicuous position, outside the building where this is appropriate. The overflow pipe or pipes should be able to convey water away from the tank at a rate equal or greater than the rate of flow of water into the tank. Notwithstanding, warning type overflow pipes shall be not be less than 20mm in diameter.

2.10 Hot Water Storage Tanks

A Hot water storage tanks shall be constructed in accordance the relevant provisions of BS 843 and the following:
1 galvanised steel tanks shall comply with the relevant provisions of BS 417: Part 2 of BS 1565
2 copper tanks shall comply with the relevant provisions of BS 699, BS 1566: Part 1, BS 1566: Parts 2 or BS 3198.
3 cast iron tanks shall comply with the relevant provisions of BS 1563
4 pressed steel sectional tanks shall comply with the relevant provisions of BS 1564.

B A cistern type storage water heater incorporating a cold water feed cistern shall be so located that the water heater base is higher than the level of the highest outlet to be served and gives adequate flow at the outlets.

C Unless otherwise stated, the temperature of the stored water shall never exceed 65°C.

D Every vessel shall be fitted with a thermostat acting on the heat input and in addition, every hot water storage vessel of capacity greater than 150 litres shall be fitted with an automatic control capable of stopping and starting the heat input to the stored water at pre-set times. A pressure relief valve shall be incorporated into the system, be mounted on the top of the tank and be vented to a suitable position.

2.11 Central Hot Water Systems

A The following central hot water systems shall comply with the relevant provisions of BS 6700:
1 direct vented system
2 indirect vented system
3 direct un-vented system
4 indirect un-vented system.

B Pumped circulation shall be provided in all cases where the natural circulating pressure available is insufficient to circulate the water through the system. Immersed rotor (glandless) type circulating pumps shall be used on primary circuits only. Pumps for boosting or secondary circulation shall be adequately resistant to corrosion. Inlet and outlet connections to a circulating pump shall be fitted with fullway valves. Circulating pumps shall be quiet in operation. The circulating pump shall be installed in accordance with the manufacturer's recommendations and space shall be allowed for maintenance and removal. Circulating pumps shall comply with the relevant provisions of BS 1394.

2.12 Insulation

A General
1 Thermal insulating materials shall comply with BS 5422 and BS 3958 where applicable.
2 Thermal insulating materials shall be applied in accordance with the manufacturer's recommendations. They shall be kept dry before, during and after application, except for water which may be required for the purpose of mixing. Gaps shall not be left at the joints of the insulating materials.
3 Where necessary, insulating material shall be resistant to or shall be protected by suitable covering against mechanical damage, rain, moist atmosphere, subsoil water and vermin.
4 Examples of suitable materials of insulating purposes are:
a polyurethane foam
b foamed or expanded plastics
c corkboard
d amoliated vermiculite.

B Pipes
1 While insulating material shall be continuous over pipes and fittings, it shall be finished in such a manner as to allow access to valves for operation.
2 Where cold water pipes pass through areas of relatively high dew point, eg habitable areas, they shall be insulated to prevent condensation forming on them.
3 Pipes in hot water supply systems that exceed the maximum lengths given below, shall be thermally insulated in accordance with BS 5422.

Outside diameter of pipes (mm)	**Maximum length (m)**
12	20
Over 12 up to and including 22	12
Over 22 up to and including 28	8
Over 28	3

C All hot water storage vessels shall be thermally insulated so that heat loss under normal operating conditions shall at no time exceeds 90 W/m^2 surface area.

2.13 Electrical Immersion Heater and Storage Vessel

A Storage type electric water heaters incorporating one or more thermostatically controlled immersion heaters shall use suitable storage vessels provided with adequate feed and expansion arrangements.

B The storage vessel shall be constructed so that water delivered is not liable to become contaminated to the extent that it is hazardous to health or is unfit for its intended use.

C The storage vessel shall be corrosion resistant.

D The immersion heater or heaters shall comply with the relevant provisions of BS 3456.

E All electrical controls, including thermostats, cut-outs and switches, shall comply with the relevant provisions of BS 3955.

2.14 Filters

A Filters shall be able to remove the following:
1 harmful bacteria
2 giardia cysts
3 chlorine tastes and odours

4 sediment to 1 micron.

B Filters shall have the following characteristics:
1 inhibit the growth of bacteria and other micro-organisms
2 easy to inspect, clean and maintain.

C Filters shall not unduly affect distribution rates.

Part 3 Execution

3.01 Pipe Installations

A Pipe runs within buildings should not be laid exactly horizontal but to a slight fall to reduce the risk of air locks forming.

B In installations that do not have limited straight runs and many bends and offsets, allowance for expansion and contraction of the pipes shall be made by forming expansion loops, by introducing changes of direction to avoid long straight runs or by fitting proprietary expansion joints. This is particularly important where temperature changes are considerable and where the pipe material has a relatively large coefficient of expansion.

C In installations with limited straight runs and many bends and offsets, thermal movement is accommodated automatically.

D Where a pipe enters a building it shall be accommodated in a sleeve that has previously been solidly built-in and the space between the pipe and the sleeve shall be filled with non-hardening, non-cracking, water-resistant material for a minimum length, of 150 mm at both ends to prevent the passage of water, gas or insects.

3.02 Concealed Pipework

A Concealed pipework shall be housed in properly constructed builders work ducts or wall chases and have access for maintenance and inspection. Ducts and chases should be constructed as the building structure is erected and should be finished smooth to receive pipe fixings. No pipe or joint in or under a building shall be embedded in any wall or solid floor or in any material below a solid floor at ground level except for the following:
1 the enclosing of any pipe and associated pipe joints in a purpose made duct or chase in a solid floor in such a way that the pipe and pipe joints can be exposed for purposes of examination, repair or replacement without endangering the structural integrity of the building
2 the enclosing of any pipe and associated pipe joints in a purpose made chase in a solid wall (but not within the cavity of a hollow wall) in such a way that the pipe and pipe joints can either be capped off and isolated or be exposed for purposes of examination, repair or replacement without endangering the integrity of the building
3 the enclosing of any pipe and associated pipe joints in any internal wall that is not a solid wall
4 the enclosing of any pipe but not joints within a purpose made pipe sleeve or duct in or under any solid floor in such a way that the pipe may be removed and replaced, and the provision of an inspection access point at each joint.

B No pipe or pipe joint shall be located under floorboards or a suspended floor, at ground floor level unless every pipe and pipe joint is accessible for examination. Where access panels are formed in floor panels of structural chipboard or plywood, the structural

stability of the building shall not be affected.

C All pipe laid in ducts shall be adequately supported by clipping as specified in Table 1

3.03 Pipe Fixings

A Iron pipe shall be secured by heavy weight holder bats of iron or low carbon steel either built in or bolted to the structure.

B Copper and stainless steel piping shall be secured by copper, copper-alloy, plastics clips or brackets.

C Steel piping shall be secured by steel copper alloy, suitable plastic clips or brackets. Copper clips or brackets shall not be used for fixing steel piping.

D Plastic piping shall be secured by suitable metal, plastic clips or brackets. Allowance shall be made for free lateral movement within the clips and brackets.

E Piping that is insulated shall be secured on clips or brackets that allow sufficient space behind the back of the pipe and the batten or wall to which the pipe is fixed for the insulation to be properly installed.

F The spacings for fixings for internally located piping shall be in accordance with:

Type of Piping	Nominal Size of Pipe[1]	Spacing on horizontal run (m)	Spacing on vertical run (m)
Copper (light gauge and stainless steel complying with ISS 2871: Part 1 or BS 4127: Part 2)	15	1.200	1.800
	22	1.800	2.400
	28	1.800	2.400
	35	2.400	3.000
	42	2.400	3.000
	54	2.700	3.000
	76	3.000	3.600
	108	3.000	3.600
	133	3.0000	3.600
	159	3.6000	4.200
Copper (heavy gauge) complying with BS 2871: Part 2	15	1.800	2.400
	22	2.400	3.000
	28	2.400	3.000
	35	2.700	3.000
	42	3.000	3.600
	54	3.000	3.600
	76	3.600	4.500
	108	3.900	4.500
	133	3.900	4.500
	159	4.500	5.400

Type of Piping	Nominal Size of Pipe[1]	Spacing on horizontal run (m)	Spacing on vertical run (m)
Unplasticized PVC [2] complying with BS 3505	3/8	0.530	1.060
	1/2	0.610	1.220
	3/4	0.685	1.370
	1	0.760	1.520
	1 1/4	0.840	1.680
	1 1/2	0.915	1.830
	2	1.065	2.130
	3	1.370	2.740
	4	1.525	3.050
	6	1.830	3.660
Polyethylene	3/8	0.300	0.500
	1/2	0.400	0.800
	3/4	0.400	0.800
	1	0.400	0.800
	1 1/4	0.450	0.900
	1 1/2	0.550	0.900
	2	0.550	1.100
	2 1/2	0.600	1.100
	3	0.700	1.200
	4	0.700	1.400

1. Nominal size of pipe for copper and stainless steel is in millimetres. Nominal size of pipe for uPVC and polyethylene is in inches.
2. These figures are based on an ambient temperature of 20°C. For other temperature ranges the pipe manufacturer should be consulted.

3.04 Pipework Jointing

A Jointing of pipes shall be in accordance with the relevant provisions of BS 6700

B All proprietary joints shall be made in accordance with the manufacturer's instructions.

C Care shall be taken to establish satisfactory jointing techniques for all water service pipework. All burrs shall be removed from the ends of the pipes and any jointing materials used shall be prevented from entering the water system

D All piping and fittings shall be cleaned internally and be free from particles of sand, soil metal filings and chips etc.

E Jointing systems using elastomeric sealing rings shall be Type W, complying with the relevant provisions of BS 2494, and shall be obtained from the pipe manufacturer.

3.05 Installation of Stop Valves, Gate Valves & Draining Taps

An adequate number of valves and draining taps shall be provided so as to permit the various sections of the installation to be isolated and drained down. The following rules shall apply to all installations:

1 A stop valve shall be fitted to the main at a height of 1 metre above the point of entry into the building
2 a draining tap shall be fitted to the main immediately above the stopvalve.
3 a stop valve shall be provided to the main as close as possible to the storage cistern
4 a gate valve shall be provided to the down supply pipes from all cold water storage cistern, as close as possible to each cistern

5 a stop valve shall be provided to the branch supply pipe for each range of sanitary fittings at the junction with the main down supply.
6 a draining tap shall be provided at the lowest point of each branch supply pipe to enable the whole of the installation to be drained.

3.06 Installation of Water Storage Tanks

A Where possible and practicable, tanks shall be positioned in locations where they can be easily accessed for inspection, cleaning and maintenance.

B Tanks positioned outside buildings shall be provided with covers and a suitable shade.

C Each tank shall be fitted with a 25 mm diameter outlet for connection to a drain pipe. The outlet shall be flush with the bottom of the tank. The floor of tank shall be laid at a slight fall towards the outlet. A drain pipe and a stop-tap shall be fitted to the outlet. The drain pipe shall be run to a point as detailed in the Project Specification or shown on the Project Drawings.

D Every pipe supplying water to a cistern shall be fitted with a float operated valve or some other equally effective device to control the inflow of water and maintain it at the required level.

E Distribution pipes from tanks shall be connected so that the lowest point of the outlet is not less than 50 mm above the bottom of the tank.

F Connections to distribution pipes feeding hot water apparatus shall be set at a level of at least 25mm above connectors to pipes feeding cold water outlets.

3.07 Testing

A The Contractor shall notify the Engineer at least one working day before of his intention to test a section of pipeline. Unless otherwise stated by the Engineer, both interim and final tests shall be undertaken on each section of the Works. The Contractor is responsible for providing water for testing purposes and for its disposal on completion of testing.

B The timing of tests shall be arranged as follows:
1 interim test: as soon as practicable after completion at a particular section, with particular attention to all work which will be concealed
2 final test: to be carried at a completion of all work on the water services and prior to handing over
3 re-tests: items failing any test shall be corrected immediately and re-tested before further work proceeds.

C The Contractor shall note that satisfactory completion at an interim test does not constitute a final test.

D Visual inspection shall be carried out at both interim and final testing in order to detect faults in construction or material not shown up under test but which could lead to premature failure. A careful record shall be kept of such inspections. All internal pipework shall be inspected to ensure that it has been securely fixed. All cisterns, tanks, hot water cylinders and water heaters shall be inspected to ensure that they are properly supported and secured, that they are clean and that cisterns are provided with correctly fitting covers before testing takes place.

E When the installation is complete and visual inspection has been satisfactorily completed, it shall be slowly filled with water, with the highest draw-off point open to allow air to be expelled from the system. The installation, including all cisterns, tanks cylinders and water heaters, shall then be inspected for leaks.

F The system shall be hydraulically tested in the following way:
1 subject the pipes, pipe fittings and connected appliances to a test pressure at least 1.5 times the maximum working pressure for a period of at least 1 hour
2 check the installation for leaks; including all cisterns, tanks, cylinders and water heaters.

G Each draw-off tap, shower fitting and float-operated value shall be checked for flow against specified requirements. Performance tests shall also be carried out on any specialist items to show that they meet the requirements detailed.

3.08 Disinfection

A All hot water systems and cold water systems installed shall be disinfected before being taken into use. For installation with more than one cistern, all cisterns shall be cleaned and chlorinated simultaneously as described below.

B All visible dirt and debris shall be removed from the cistern. Then the cistern and distributing pipework shall be filled with clean water and then drained until empty of all water. The cistern shall be filled again and the supply closed.

C A measured quantity of sodium hypochlorite solution of known strength shall be added to the water in the cistern to give a free residual chlorine concentration of 50 mg/l in the water.

D The cistern shall be left to stand for 1 hour. Then each draw-off fitting shall be successively opened working progressively away from the cistern. Each tap or draw-off fitting shall be closed when the water discharged begins to smell of chlorine. The cistern shall not be allowed to become empty during the operation; if necessary it shall be refilled and chlorinated as detailed above. Should refilling be necessary, the cistern and pipes shall be left for a further hour before continuing the disinfection procedure.

E The tap furthest from the cistern shall be opened and the level of free residual chlorine in the water discharged from the tap shall be measured. If the concentration of free residual chlorine is less than 30 mg/l the disinfecting process shall be repeated.

F Finally, the cistern and pipes shall remain charged with chlorinated water for at least 16 hours and then thoroughly flushed out with clean water until the chlorine concentration at the taps is no greater than that present in the clean water from the supply main.

End of Section 15410

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Section 15780

Split System Air Conditioning Units

Part 1 General

1.01 Description

A. The extent of air conditioning work required by this Section is indicated by the requirements of this Section and in the Particular Specifications.

B. Regulatory Requirements
   1. Provide capacity ratings for air conditioning equipment in accordance with international standard necessary for the Engineer's approval.
   2. ASHRAE Compliance. Construct refrigerating system of condensing units in accordance with American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard ANSI/ASHRAE 15 "Safety Code for Mechanical Refrigeration".

1.02 Submittals

A. Product Data.
   1. Comply with Section 01300
   2. Clearly indicate rated capacities of selected model
   3. Weights (shipping, installed, and operating)
   4. Furnish specialties and accessories
   5. Installation and start-up instructions.

B. Shop Drawings
   1. Submit manufacturer's assembly-type shop drawings
   2. Indicate dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams.
   1. Submit ladder-type wiring diagrams for power and control wiring required for final installation of air conditioning units and controls.
   2. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Maintenance Data.
   1. Submit maintenance data and parts list for each air conditioning unit, control, and accessory; including "trouble-shooting" maintenance guide.
   2. Include this data and product data in maintenance manual; in accordance with requirements of Section 01730.

1.03 Quality Assurance

A. All products shall be new.

B. Products shall be of an experienced manufacturer.
   1. Manufacturer must have similar equipment installed and successfully operating in a similar climate for a minimum of five years.
   2. Must demonstrate equal or larger capacity operating installations using similar

equipment.

3. Provide names and phone numbers of contacts at referenced installation to verify performance.
4. Demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.

Part 2 Products

2.01 General

A. Provide factory-assembled and tested air-cooled condensing units as indicated. Include the following:
   1. Compressors
   2. Condensers
   3. Evaporator Coil
   4. Condenser and Evaporator Fans
   5. Refrigeration and Temperature controls
   6. Filters
   7. Dryers

B. Provide capacity and electrical characteristics as scheduled.

C. Provide necessary compressor oil, refrigerant, refrigerant and condensate pipes, filter drier, moisture indicator sight glass, high pressure switch (manual reset) low pressure switch (automatic reset), pressure relief device, liquid line shut off valve, suction and discharge shutoff valves and line service gauge ports, suction line accumulator, check valve, and room thermostat assembly as a complete package.

D. Factory wire all controls, and place in a readily accessible location.

E. Testing
   1. Test and rate units according to manufacturer's standard
   2. Units to carry manufacturer's related industrial standard certification seal.

2.02 Casing

A. Provide 18 gauge galvanized steel casing, bonderized and finished with baked enamel.
   1. Insulate with minimum 12mm insulation
   2. Provide knockout for electrical and piping connections.
   3. Provide condensate drain connection.
   4. Include lifting provisions to facilitate rigging.

B. Provide removable panel for inspection and access to internal parts and controls

C. Provide base with mounting holes. Provide brass service valves, fittings and gage ports on exterior of casing.

2.03 Compressor

A. Provide welded hermetic compressors with built-in overloads and vibration isolation and crankcase heater.

B. Provide for compressor motor, thermal and current-sensitive overload device, internal high-pressure protection, high and low pressure cutout switches, start capacitor and relay,

2-pole contactor, and temperature actuated switch and timer to prevent compressor rapid cycle.

2.04 Condenser

A. Construct coil of seamless copper or aluminum tubes with mechanically bonded aluminum plate fins. Coat all coils to prevent corrosion, Technicoat 10-1 phenolic coating, ACRA - CLAD, or approved equal.
   1. Use brazed tubing joints.
   2. Provide with liquid accumulator and liquid subcooler.
   3. Provide weatherproof fused disconnect at the unit.
   4. Leak test coils at 1034 kPa and pressure test unit at 3310 kPa.

B. Provide aluminum propeller fan, direct driven, with permanently lubricated fan motor with thermal overload protection. Include suitable safety guards.

2.05 Evaporator Fans

A. Use forward curved centrifugal evaporator fans

B. Provide either belt driven fans with adjustable sheaves or direct driven fans. Use permanently lubricated motor bearings.

C. Include fused disconnect.

2.06 Filters

A. Provide cleanable filters, washable or vacuum cleanable.

B. Polyurethane construction or approved equal.

2.07 Refrigerant Piping

A. Use seamless refrigeration copper tubing.
   1. Sized by equipment manufacturer.
   2. Match unit connection sizes.

B. Provide continuous thermal insulation.
   1. Closed cell type.
   2. Minimum 15 mm thickness.
   3. Design temperature range: -20°C to +100°C.

2.08 Condensate Drain Piping

Use PVC piping.

2.09 Spare Parts

Furnish five set of filters to the Employer for each split cooling unit.

Part 3 - Execution

3.01 Inspection

Examine areas and conditions under which the air conditioning equipment is to be installed and do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 Installation of Split Cooling Units

A. Install split cooling air conditioning equipment in accordance with manufacture's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturers recommended clearances.

B. Electrical
   1. Install electrical devices furnished by manufacturer but not factory mounted.
   2. Furnish electrical field-wiring diagrams to Electrical Installer for power wiring to air conditioning equipment, and control wiring for field-mounted controls.
   3. Provide positive equipment ground for components.
   4. Verify that electrical wiring installation is in accordance with manufacturer's submittal and the installation requirements of the Division 16 specifications.
   5. Do not proceed with equipment start up until wiring installation is acceptable to equipment installer and engineer.

C. Condensing and Fan Coil Units.
   1. Connect pre-charged refrigerant tubing to unit's quick-connect fitting.
   2. Run tubing so as not to interfere with access to unit.
   3. Collect condensate and pipe to nearest plant drain or the location shown on the drawings.

D. Install furnished accessories.

3.03 Start Up of Split Cooling Units

A. Start-up air conditioning equipment, in accordance with manufacturers start-up instructions, and in presence of manufacturer's representative.

B. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

End of Section 15780

Section 15870

Power Ventilators

Part 1 General

1.01 Description

A. The extent of the power ventilation equipment is indicated by the requirements of this section and the Particular Specifications The equipment shall include all appurtenances necessary for a fully operational installation.

B. Power ventilators include but are not necessarily limited to the following:
   1. Roof exhausters.
   2. Propeller exhaust and supply fans
   3. Cabinet Supply fans.
   4. Wall Exhausters

C. References
   1. AMCA 99 - Standards Handbook.
   2. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
   3. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
   4. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.
   5. SMACNA - Low Pressure Duct Construction Standard.
   6. ANSI/AFMB 9 - Load Ratings and Fatigue life for Ball Bearings.
   7. ANSI/AFMB II - Load Ratings and Fatigue life For Roller Bearings.

1.02 Submittals

A. Provide fan curves with specified operating point clearly plotted.
   1. Contractor shall calculate static pressure and motor power requirement for each fan.
   2. Submit calculations to Engineer for approval before ordering the fans.
   3. Provide fan and motor required to meet specified operating conditions without additional cost to the employer.

B. Submit sound power levels for both fan inlet and outlet at rated capacity.

C Submit manufacturer's installation instructions.

1.03 Quality Assurance

A. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300.

C. Fabrication: Conform to AMCA 99.

Part 2 Products

2.01 General

A. Select fan to meet the operating criteria scheduled.

1. Do not decrease motor size, increase noise levels, or increase tip speed by more than 10 percent from scheduled values.
2. Do not increase inlet air velocity by more than 20 percent from scheduled criteria.
3. Accommodate variations in static pressure of plus or minus 10 percent.

B. Base performance on operation at sea level.

C. Statically and dynamically balance fans to eliminate vibration and noise transmission to occupied areas.

D. Fans for outside installation shall be weather protected and suitable for operation in a similar climate with similar ambient temperatures and high relative humidity which approaches 100 percent.

E. Provide safety screen where inlet or outlet are exposed.

2.02 Roof Exhausters

A. Use vertical discharge centrifugal type fans of heavy gauge carbon steel or non-corrodable construction, a square base, and continuous curb gaskets to suit roof curb provided.
1. Totally enclose the inner housing to protect the fan bearings and belts.
2. Support the inner housing from the outer housing by means of air straightening guide vanes.
3. Continuously weld the housing and the fan wheels.
4. Use phosphatized surface preparation with an industrial air dry enamel paint as the standard Surface Coating System on steel units.

B. Mount the motor on a continuously welded base that is perpendicular to the fan housing and supported by four adjustable riser bolt assemblies.

C. Use industrial quality fan wheels with backward curved blades and non-overloading power characteristics. Mount the fan wheels to the fan shaft with a split taper bushing.

D. Use heavy duty, self-aligning ball or roller type fan bearings conforming to ANSI/AFMB 9 L-10 life at 50,000 hours(ball bearings) or ANSI/AFMB11 L-10 life at 120,000 hours (roller bearings).

E. Provide non-static, oil resistant belts with minimum life expectancy of 24,000 hours.

F. Roof Curb
1 300mm high
2 Sound attenuating type
3 Self-flashing with continuously welded seams
4 25mm insulation
5 Curb bottom
6 Factory installed nailer strip.

G. Provide Factory wired, non-fusible safety disconnect switch in NEMA 4 enclosures.

H. Sheaves
1. Cast iron or steel
2. Dynamically balanced
3. Bored to fit shafts and keyed

4. Variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position
5. Fan shaft with self-aligning, pre-lubricated ball bearings.

I. Ratings: provide air flow and static pressure rating per AMCA 210.

2.03 Propeller Exhaust And Supply Fans

A. Wall Mounted Fan Unit
1. Direct driven with deep spun venturi orifice housing
2. Resiliently mounted motor
3. Construct fan of durable heavy gauge steel panel or non-corrodable material with pre-drilled holes for quick surface or recessed mounting.

B. Provide Factory Wired, non-fusible safety disconnect switch in NEMA 4 enclosures.

C. Backdraft Damper
1. Gravity activated
2. Aluminum or non-corrodable multiple blade construction
3. Felt edged with nylon bearings on propeller exhaust fans only.

D. Provide heavy gauge plated steel wire guard for motor conforming to OSHA requirements.

E. Finish: baked enamel paint.

F. Ratings: provide air flow and static pressure rating per AMCA 210.

2.04 Cabinet Supply Fans

A. Centrifugal Fan Unit
1. Horizontal Discharge
2. Forward curved blades
3. Direct driven
4. Galvanized steel housing lined with 13 mm thick acoustic insulation
5. Resilient mounted motor.

B. Provide factory wired, non-fusible safety disconnect switch in NEMA 4 enclosures.

2.05 Wall Exhauster

A. Centrifugal side wall mounted Fan Units
1. Direct driven with spun aluminum housing and resiliently mounted motor
2. Include 12mm mesh and 16 gauge aluminum bird screen secured with cadmium plated bolts and screws.

B. Provide factory pre-wired, non-fusible safety disconnect switch in NEMA 4 enclosure.

C. Provide gravity activated, aluminum multiple blade backdraft damper, felt edged with nylon bearings.

D. Ratings: provide air flow and static pressure rating per AMCA 210.

Part 3 Execution

3.01 Installation

A. Install in accordance with manufacturer's instructions. Secure roof exhausters with lag screws to roof curb.

B. Do not operate fans for any purpose until ductwork is clean, filters are in place, and bearings have been lubricated.

C. Install fans with vibration isolation mountings and flexible connections as specified.

D. Pipe scroll drains to nearest floor drain.

E. Provide backdraft damper on discharge of exhaust fans and where indicated on the drawings.

End of Section 15870

Section 15895

Galvanised Steel Ventilation Ductwork

Part 1 General

1.01 Description

Provide and install low and medium pressure ductwork as shown on the drawings and specified herein.

1.02 Reference Standards:

ASHRAE - Handbook 1981 Fundamentals; Chapter 33 - Duct Design.
ASHRAE - Handbook 1983 Equipment; Chapter 1 - Duct Construction.
ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
SMACNA - Low Pressure Duct Construction Standards.
SMACNA - Medium Pressure Duct Construction Standards.

1.03 Submittals

A. Submit shop drawings and product data under provisions of Section 01300.

B. Indicate duct fittings, as well as particulars such as gages, sizes, welds, and configuration, prior to start of work for each system.

C. Submit Samples

D. Submit two copies of SMACNA HVAC Duct Construction Standards, Metal and Flexible, latest edition.

1.04 Quality Assurance

A The ductwork be the product of a single current manufacturer having five years or more experience in the manufacture of similar sized ductwork as required in the specifications.

B Comply with local laws and regulations.

1.05 Definitions

A. Duct Sizes: Inside clear dimensions. For lined duct, maintain sizes inside lining and increase sheet metal sixes accordingly.

B. Low Pressure: 50.8 kg/m^2 WG positive or negative static pressure and velocities less than 12 m/s.

C. Medium Pressure: 76.2 kg/m^2 WG positive or negative static pressure and velocities less than 20 m/s.

Part 2 - Products

2.01 Materials

A. General: Non-combustible conforming to requirements for Class 1 air duct materials or UL 181.

B. Steel Ducts: ASTM A525 or ASTM A527 galvanized steel sheet, lock-forming quality, having zinc coating of 0.4 kg/m^2 for each side in conformance with ASTM A90.

C. Flexible Ducts: Interlocking spiral of galvanized steel or aluminum construction or fabric supported by helically wound spring steel wire or flat steel bands; rated to 500 Pa positive and 375 Pa negative for low pressure ducts.

D. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic.

E. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.02 Fabrication

A. Fabricate and support in accordance with SMACNA Low or High Pressure Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by written permission of the Engineer.

C. Construct tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centreline.
   1. Where not possible and where rectangular elbows are used, provide air foil turning vanes.
   2. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream and downstream of equipment shall not exceed 30 degrees.

E. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.

F. Use double nuts and lock washers on threaded rod supports.

G. Fabricate continuously welded medium pressure round duct fittings two gages heavier than duct gages indicated in SMACNA Standard.
   1. Use minimum 100 mm cemented slip joint, brazed or electric welded.
   2. Prime coat welded joints.

H. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated that 90 degree conical tee connections should be used.

I. Provide access doors for dampers, coils and similar items. Include operable latches.

Part 3 Execution

3.01 Installation

A. Assemble and install ductwork in accordance with recognized industry practices which will achieve airtight and noiseless operation while performing as specified.
   1. Install each run within maximum misalignment tolerance of 3 mm and internal surfaces smooth.
   2. Rigidly support ducts in accordance with SMACNA recommendations using suitable ties, braces, hangers and anchors of the type which will hold ducts true to shape and prevent buckling. Provide concrete inserts as required to avoid delays in the work.
   3. Perform field fabrication work to match shop fabrication and to accommodate installation requirements.
   4. Seal ductwork after installation in accordance with SMACNA recommendations.

B. Provide openings in ductwork where required to accommodate thermometers and controllers.
   1. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to prevent air leakage.
   2. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

C. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

D. Arrange ductwork runs vertically and horizontally except as indicated otherwise on the drawings.
   1. Avoid diagonal runs wherever possible.
   2. Run ductwork along the shortest route which does not obstruct usable space or block access for servicing building and equipment.
   3. Keep ducts close to walls, overhead construction, columns, and other structural and permanent building elements.
   4 Limit clearance to 12 mm where furring is required for enclosure or concealment of ducts.
   5. Allow for insulation thickness.
   6. Wherever possible, provide 25 mm clearance around outside of insulated ductwork.
   7. In finished or occupied areas, conceal ductwork from view by locating in mechanical shafts, hollow wall construction or above suspended ceilings.
   8. Do not encase horizontal runs in solid partitions except as specifically shown on the drawings.
   9. Coordinate work with suspended ceiling and lighting layouts and similar finished work.

E. Where ducts pass through interior partitions and exterior walls, conceal space between construction opening and duct or duct plus insulation using sheet metal flanges of same gauge as the duct. Overlap opening on all four sides by at least 40mm.

F. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of the ductwork system.

G. Set plenum doors 150 mm to 300 mm above the floor. Arrange door swings so that fan static pressure holds door in the closed position.

H. Connect terminal units to ducts directly or with a maximum of 300 mm of flexible duct. Do not use flexible duct to change direction.

I. Provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering the system.

3.02 Adjusting and Cleaning

A. Clean ductwork internal of dust and debris as it is installed, unit by unit. Clean external surfaces of foreign substances which might cause corrosive deterioration or which might interfere with painting or the application of adhesives.

B. Clean system by forcing air at high velocity through ducts to remove accumulated dust.
   1. Clean a portion of the system at a time to obtain sufficient air.
   2. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

C. Clean duct systems with high power vacuum machines.
   1. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning.
   2. Provide adequate access into ductwork for cleaning purposes.

D. Test and balance the air handling system as specified in Section 15990. Seal any leaks in ductwork that become apparent during balancing.

End of Section 15895

Section 15910

Ventilation Ductwork Accessories

Part 1 General

1.01 Description

A. Provide ductwork accessories as indicated on the drawings and as required by these specifications.

B. Types of ductwork accessories required include but are not necessarily limited to the following:
   1. Low Pressure manual dampers.
   2. Fire and smoke dampers.
   3. Turning vanes.
   4. Duct hardware.
   5. Duct access doors.
   6. Flexible connections.
   7. Diffusers, grilles and registers
   8. Louvers
   9. Blast gates.

C. References, Codes and Standards
   1. SMACNA Compliance. Comply with applicable portions of SMACNA "HVAC Duct Construction Standards, Metal and Flexible".
   2. Industry Standards. Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.

1.02 Submittals

A. Product Data. Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions. Comply with Section 01300
   1. Schedule air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
   2. Provide data sheet for each type of air outlet and inlet, and each accessory furnished; indicating construction, finish, and mounting details.
   3. Provide performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.

B. Shop Drawings. Submit assembly-type shop drawings for each type of ductwork accessory. Show interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components.

C. Maintenance Data. Submit maintenance data, including parts lists, for each type of duct accessory. Include this data as well as product data, and shop drawings in maintenance manual.

1.03 Quality Assurance

Manufacturer's Qualifications. Use firms regularly engaged in manufacture of ductwork

accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

Part 2 Products

2.01 Dampers

Low Pressure Manual Dampers.

1. Provide dampers of single blade type or multiblade type, constructed in accordance with SMACNA "HVAC Duct Construction Standards."
2. Provide volume dampers with recommended size quadrants per SMACNA standard.
3. Where ductwork are insured provide quadrants on a stand off so that they are accessible.
4. Motorize dampers where shown on the drawings.

2.02 Fire Dampers

Provide fire dampers, of types and sizes indicated. Construct casings of 10-gauge galvanized steel with bonded red acrylic enamel finish. Provide fusible link rated at 70 to 75 Degrees C unless otherwise indicated. Provide damper with positive lock in closed position, and with the following additional features:

1. Damper Blade Assembly. Curtain type.
2. Blade Material. Steel, match casing.

2.03 Turning Vanes

A. Fabricated Turning Vanes. Provide fabricated turning vanes and vane runners constructed in accordance with SMACNA "HVAC Duct Construction Standards."

B. Manufactured Turning Vanes. Provide turning vanes constructed of 38 mm wide curved blades set at 19mm o.c., supported with bars perpendicular to blades set at 50 mm o.c., and set into side strips suitable for mounting in ductwork.

2.04 Duct Hardware

Quadrant Locks.

1. For each damper with lengths over 300 mm, provide quadrant lock device on one end and an end bearing plate on the other end of the shaft.
2. Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

2.05 Duct Access Doors

A. Provide access doors where fire dampers or motorized dampers are installed in ductwork.

B. Construct of same or greater gauge as ductwork served.
   1. Provide insulated doors for insulated ductwork.
   2. Provide flush frames for uninsulated ductwork and extended frames for externally insulated duct.
   3. Provide one size hinged, other side with one handle-type latch for doors 300 mm high and smaller, 2 handle-type latches for larger doors.

2.06 Flexible Connections

Provide flexible duct connections wherever ductwork connects to vibration isolated equipment.

1. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment.
2. Make airtight joint.
3. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment.

2.07 Diffusers, Grilles and Registers

A. Except as otherwise indicated, provide manufacturer's standard diffusers, grilles and registers where shown; of size, shape, capacity and type indicated. Construct of materials and components as indicated and as required for complete installation.

B. Use diffusers, grilles and registers that provide minimum throw, pressure drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Provide diffusers, grilles and registers with border styles that are compatible with adjacent ceiling, wall and duct systems.
   1. Where necessary, specifically manufacture items to fit into ceiling module with accurate fit and adequate support.
   2. Refer to drawings and specifications for types of ceiling, wall and duct systems which will contain each type of diffuser, grille or register.

D. Ceiling Air Diffusers, Return Air Grilles, and Exhaust Air Grilles
   1. Use manufacturer's standard steel frame and panel.
   2. Provide square housing covered with removable perforated panel in frame. Conceal air pattern devices above panel.
   3. Size diffuser housing to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.
   4. Provide manually adjustable core with concentric rings or louvers, fully adjustable for horizontal to vertical air flow.
   5. Use adjustable opposed blade damper assembly, key operated from face of diffuser.
   6. Provide tools designed to fit through diffuser face and operate volume control device and/or pattern adjustment.
   7. White Enamel. Semi-gloss white enamel prime finish.

E. Supply Air Register
   1. Use manufacturer's standard extruded aluminum frame and adjustable blades.
   2. Use individually adjustable horizontal and vertical straight at manufacturer's standard spacing.
   3. Provide 2-sets of blades in face. Make rear set at 90 degrees to face set.
   4. Use adjustable opposed blade damper assembly, key operated from face of register.
   5. Provide curved blades mounted on adjustable frame to produce air scooping action in duct at register or grille take-off.
   6. Provide tools designed to fit through diffuser face and operate volume control device and/or pattern adjustment.
   7. White Enamel. Semi-gloss white enamel prime finish.

2.08 Louvres

See Section 10210 for requirements.

2.09 Blast Gates

A. Except as otherwise indicated, provide manufacturer's standard blast gates where shown on the drawings.
   1. Use size, shape, capacity and type indicated.
   2. Construct of materials and components as indicated and as required for complete installation.

B. Construct of fiberglass material with stainless steel hardware or non-corrosive material.

Part 3 Execution

3.01 Inspection

A. Examine areas and conditions under which ductwork accessories will be installed.

B. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 Installation of Ductwork Accessories

A. Install ductwork accessories in accordance with manufacturer's installation instructions including applicable portions of SMACNA standards.
   1. Comply with recognized industry practices.
   2. Ensure that products serve intended function.

B. Install turning vanes in square or rectangular 45 and 90 degree elbows located in supply and exhaust air systems, and elsewhere as indicated.

C. Install access doors with operable latches.

D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

E. Locate diffusers, registers, and grilles, as indicated drawings. Unless otherwise indicated, locate units in center of acoustical ceiling modules.

3.03 Spare Parts

Furnish to Employer, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

3.04 Field Quality Control

A. Operate installed ductwork accessories to demonstrate compliance with requirements.

B. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

3.05 Adjusting and Cleaning

A. Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action. Final positioning of manual dampers is specified in Section 15990 - Testing, Adjusting, and Balancing of HVAC Systems.

B. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

End of Section 15910

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Section 15990

Testing, Adjusting and Balancing of HVAC Systems

Part 1 General

1.01 Description

Testing, adjusting, and balancing of HVAC system:

1. Heat recovery units.
2. All supply and exhaust fans.
3. Deodorization systems

1.02 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation:

1. ASHRAE system and application handbook, 1987 Edition, Chapter 57.
2. ASHRAE Fundamentals Handbook, 1989 Edition, Chapter 13.
3. SMACNA Standards for Testing and Balancing.

Part 2 Products

Not used

Part 3 Execution

3.01 Procedure

A. General:

1. Adjust all HVAC systems to deliver the specified air quantities within the following tolerances.
   a. equipment (fans, heat transfer equipment, air terminal units, hydronic terminal equipment, etc.). ± 5 percent.
   b. air outlets. ± 10 percent.

B. Final Tests, Inspection and Acceptance.

1. Contractor to correct punch list work and complete prior to submission of the final report.
2. Submit the final report for Engineer's review prior to system commissioning.
3. The final report shall include, but not be limited to the following:
   a instrument list form.
   b design and operating motor power.
   c manufacturer's fan curve with design and operating points plotted.
   d operating voltage and amperage.
   e motor starter heater element sizes.
   f static pressure profile form.
   g air terminal tests.
   h rectangular duct traverse report.
   i round duct traverse report.
4. System Commissioning Tests:
   a. tests shall demonstrate that capacities and general performance of air and water

systems comply with contract requirements.

b. at the time of system commissioning, recheck, in the presence of the Engineer, random selections of data (air quantities) recorded in the report.

5. Random selection of points and areas for checking by the Engineer.
6. Provide same measurement and test procedure as approved for work forming basis of final report.
7. Selections for checks in general will not exceed 25 percent of the total number tabulated in the final report.

C. Retests:

1. If random tests elicit a measured flow deviation exceeding the specified tolerances at ten percent or more of the checked selections, the final report will automatically be rejected. In the event the report is rejected; readjust and test all systems, record new data, submit new final report, and perform new rechecks, all at no additional cost to the Employer.
2. Marking of Settings. Following final acceptance of the final report by the Engineer, permanently mark the settings of all dampers and other adjustment devices so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

End of Section 15990

Section 16010

General Provisions for Electrical Installations

Part 1 General

1.01 Description

A The Electrical Installation Contractor, herein referred to as the '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 Scope of Work

1 The 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.

C 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 laid down by the following :

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 MEW 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 centers 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 catalog 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 conduit, 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 any 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 centers 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 centers 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 center and panel board in addition to color 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 at a height of 300 mm, wall mounted telephone 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 Labeling

A For switchgear, switchboards, motor control centers 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 stenciled "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 NWSDB.

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 centers, 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 percent 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 percent 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 percent 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 percent 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 percent 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 percent spare lamps of each wattage of different type.
4 5 percent 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

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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

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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 wire way.

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) IEC 60614-2-5)	Flexible steel conduits and adapters for the protection of electric 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 shal 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, plant rooms, 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. Adapters 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 JISC 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 centers 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

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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 Armoring 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 manufacturers 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 nonmetallic 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 armor with overall PVC sheath and shall include an overall screen of copper braid or aluminium foil.
3 Shielded Twisted Pair. Cables shall be color coded individually screened twisted pair, multicore, 0.9 mm^2 copper conductor, PVC insulated, galvanized steel wire armored 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 armored 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 thyey 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 similaiar 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 Weatherproof 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 weatherproof 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

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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

A 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.

B 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.

C 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 230 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, 230 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

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 power 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, hermetically sealed, naturally cooled, double wound, core type suitable for indoor 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/IEC 76.

B. Transformer oil shall be to BS 148/ IEC 296.

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.

C. The impedance voltage of the transformer shall be 6.3 percent.

2.02 Transformer Duty

The transformers shall be capable of supplying predominantly motorized loads with ratings up to 400 kW on soft starting. 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. 33000/420 volts between phases at no load, 400 V at full load.

B. Changeover between HV voltage ranges shall be effected by an externally operated off-circuit switch located below the cold oil level.

2.04 Winding Connections

A. The windings shall be connected HV delta, LV star in accordance with vector group reference Dyn 11 of IEC 76.

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 tappings 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 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 weatherproof 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 open 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, grimp 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 weatherproof housing for the restricted earth fault current transformer.
8. Earthing terminal for tank.
9. Marshaling 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, spacings 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 with stand test
8. Induced over voltage with stand test
9. External construction inspection
10. Check of oil leakage.

C All the above tests shall be carried out at the transformer manufacturers 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

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Section 16375

High Voltage Switchgear

Part 1 General

1.01 Description

This Section shall include all labour, materials and accessories for the complete performance of all high voltage switchgear in accordance with the Specifications and Drawings.

1.02 Standards

A. The switchboard cubicles shall be manufactured and tested in accordance with IEC 298/BS 5227.

B. The Contractor shall submit with his offer the Type Test Certificate for the type of switchgear offered, issued by a recognized independent testing laboratory.

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 Ratings

The transformer feeder cubicles shall be rated as described in the Particular Specifications.

2.02 Busbars

The busbar system shall be flat air insulated copper busbars, designed to withstand the high dynamic stresses pass through an epoxy resin flange plate between adjoining cubicles. Flat tie-off connections join the busbars to the lower disconnect contacts.

2.03 Circuit Breakers

A. The circuit breakers shall be maintenance-free sealed-for-life, vacuum, horizontal draw-out, motorized, truck-mounted type complying with BS 5311/IEC 56 and shall have ratings as indicated in the Particular Specifications.

B The circuit breakers shall incorporate motor-charged spring stored-energy mechanisms.

C The circuit breakers shall incorporate an emergency stop push-button.

D The circuit breakers shall be capable of being positioned in either “IN SERVICE” or “TEST” positions within the breaker compartment. On withdrawal of the truck from service to test position, automatic shutters shall cover the contact orifices. Busbar and cable shutters shall be individually padlocked.

2.04 Isolation and Interlocks

A. Mechanical interlocking shall be used within the feeder cubicles to prevent faulty operation of circuit breakers, switch trucks and earthing switches.

B. Circuit breaker - Truck - Cubicle
   1. Truck in test position
      a. Live parts are covered by earthed shutters
      b. The circuit breaker can be operated on the auxiliary voltage if the low-voltage plug is connected to the socket.
   2. Truck between test and service position
      a. Truck can only be moved if the circuit breaker is open
      b. the circuit breaker cannot be closed
   3. Truck in service position
      a. Circuit breaker can be closed if the low-voltage plug is connected to the socket.
      b. The truck can only be withdrawn from service position if the circuit breaker is open.

C. Truck - Earthing switch (Cable incoming feeders)
   1. Truck removed; earthing switch can be closed
   2. Truck in service position; earthing switch cannot be closed
   3. Earthing switch OFF; Truck can be moved into service position
   4. Earthing switch ON; Truck cannot be moved into service position.

D. Each mechanical interlock arrangement must be capable of being padlocked.

2.05 Surge Arresters

A. Main power surge arresters shall have a surge capacity of 25 kA and an energy protection level greater than 1700 Joules for three phase circuits, and greater than 1200 Joules for single phase circuits. They shall provide visual status indication and have a natural quiescent current of less than 3 mA. The unit shall be of modular construction and allow easy replacement of surge diverter boards.

B. The surge diverter shall be mounted so as to allow safe observation of status and replacement of components without isolation of the supply being protected.

2.06 Transformer Over-temperature Protection

A. The distribution transformers shall be equipped with temperature monitoring devices which, when operated, shall send a signal to the respective HV feeder, causing the relevant circuit breaker to trip.

B. Interconnecting cabling shall be provided between the feeder cubicles and the relevant transformers to effect this facility.

2.07 Control of Circuit Breakers

Local control of the circuit breakers shall be provided on the switchgear. The commands for circuit breaker closing and opening shall be given locally by the control switch S1 (OFF/ON COMMAND) mounted in the cubicle door.

2.08 Protection Relays

A. Solid-state IDMT relays shall be provided to give short-circuit and earth-fault protection for transformer and feeder cables.

B. In the event of a fault condition, the type of fault shall be indicated by the respective indication unit and in detail by the protection relay.

2.09 Indication Units

A. Fault/alarm indication units shall be provided on the low voltage compartment doors.

B. The indication units shall indicate the following conditions:
1. Tripped on fault
2. Short-circuit overcurrent
3. Earth fault overcurrent
4. Overtemperature warning
5. MCB fault
6. Disturbance (one or more alarms in the same cubicle have activated)

2.10 Bar-Type Position Indicators/Mimic Diagram

The switching positions of circuit breakers and earthing switches shall be signaled by means of bar-type switch position indicators on a mimic diagram on the low-voltage compartment doors.

2.11 Switchboard Construction

A Switchboards cubicles shall be of robust construction and shall be unaffected in part or whole by the forces imposed by short circuit or other fault currents, operation, vibration or temperature changes.

B Switchboards cubicles shall be metal-clad in accordance with IEC 298, divided into separate compartments. The circuit breaker, busbars, HV cable connection and LV devices shall be arranged in different compartments. For the safety of the operating personnel, it is essential that should an “arc” develop if any of the compartments for any reason whatsoever, it shall be confined to the compartment without affecting other compartments.

2.12 Earthing

A. The requirements of BS 7430 shall be complied with.

B. The cubicles shall be interconnected with a copper earth bar running along the switchboard, with individual connections being made to each circuit breaker enclosure and removable gland plate.

C. The earth bar size shall be sufficient to accommodate cable sheaths, cable glands and switchroom earth connectors.

D. All hinged doors must be bonded across the hinges, and on no account should the earth connection limit the door movement.

2.13 Instrumentation

Three dial type, switchboard pattern, flush mounting type ammeters shall be provided for each feeder cubicle.

2.14 Anti-Condensation Heaters

Each panel shall be provided with suitably rated heater for operation from 230 V AC supply, thermostatically controlled.

2.15 Test Terminal Blocks

A. Current transformer secondary wiring shall be connected through terminal blocks with change-over links to permit easy ratio change and testing. It shall be possible to change the CT's ratio without the need for switching off the breaker.

B. A test block shall be provided on the front of the panel to enable the incoming CT circuits to be short circuited and to permit currents to be injected into the phase and neutral connections of the relays and meters.

2.16 Small Wiring

A. All wiring shall be 2.5 mm^2 copper conductor, 600 V, tropical-grade, PVC insulated. All small wiring shall be suitably terminated with circuit numbers.

B. Trip circuits shall have an additional ferrule coloured red and marked "TRIP". Each circuit identification number shall be suffixed with the panel identification letter.

2.17 Cable Compartments

A. The cable compartment shall be suitable for two HV, 3 core, cross linked, polyethylene, double steel tape, armoured PVC served cable, cable size 70 mm^2 copper.

B. The cable compartment shall be complete with suitable gland and jointing material. The compartment shall be designed for air insulated termination.

C. Cable compartments shall be separated from other compartments such as circuit breakers, busbar compartment etc.

2.18 Labels

Each panel of each switchboard shall have a circuit label approximately 300 x 80 mm mounted on the front of the panel in a prominent position. These labels shall be made of suitable engraving material approximately 2 mm thick, white surface with black engraving. Small black labels of similar material shall be mounted on the rear of the panels.

2.19 Secondary MCBs and ACBs

A. LV control circuits shall be protected by MCBs and ACBs.

B. All necessary MCBs shall be supplied and they shall be fitted with clearly legible labels indicating the circuit and shall grouped according to their functions.

2.20 Current Transformers

Current transformers must be provided in accordance with BS 7626/IEC 185 with quantity, ratios, burden and accuracy class to suit the intended circuit operation. Separate current transformers should be provided for protection and metering circuits.

2.21 Voltage Transformers

Voltage transformers for use with measuring and protective devices shall be provided in accordance with IEC 186.

Part 3 Execution

3.01 Installation

A. The cubicles shall be installed level and securely attached to the concrete foundations with expansion anchors. The sections shall be joined together with bolts, nuts and washers to form a complete unit assembly.

B. Equipment shall be installed level and securely attached to the concrete foundations with expansion anchors. The sections shall be joined together with bolts, nuts and washers to form a complete unit assembly.

3.02 Testing

A. Works Tests:
   1. Type tests must be performed where the manufacturer cannot provide full type-test certificates in accordance with the governing British Standards and IEC publications.
   2. Other works tests should comprise:
      a. Routine tests in accordance with BS 5227, BS 5311, BS 142 and IEC 694.
      b. Any special test specified.
      c. Primary injection testing of metering and protection circuits.

B. Site Tests:
   1. Circuit breakers shall be HV pressure tested, plus mechanically tested.
   2. The HV assemblies shall be both primary and secondary injection tested and inspected.

3.03 Documentation

A. The following documents and drawing shall be provided:
   1. General arrangement of the switchboard showing elevations, plans, dimensions, floor fixings etc.
   2. AC Power System diagram(s) showing the schematic arrangement of circuit-breakers, switch-disconnectors, including circuit ratings.
   3. Installation drawing showing assembly data and cable routes.
   4. Control circuit diagram(s) showing metering, protection and control and interlocking systems.

B. Certificates of Type Testing including fault withstand, temperature rise, etc., in accordance with IEC 694 must be provided.

C. Certificates of Routine testing in accordance with IEC 694 must be provided.

3.04 Tools

The following tools must be provided on the basis of one set for each switchboard:

1. Tool rack
2. Erection and maintenance tools - special or proprietary items racking handle.
3. Racking handle
4. Manual spring charge handle
5. Slow close equipment - where appropriate
6. Control test plus, sockets and flexible leads

End of Section 16375

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 metalised 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	Cartridge Fuses.
BS 142	Electrical Protective Relays.
BS 159	Busbar & Connection.
BS 162	Electrical Power Switchgear.
BS 3938/IEC 185	Current Transformers.
BS 4794, Pt.2 /IEC 337-2	Control Devices.
BS 37 Pt.1	Electricity Meters General.
BS 89, IEC 51	Direct Acting Indicating Elect. Measuring Instruments.
BS 5685/IEC 521	Electric Meters.
BS 5420/IEC 144	Degree of Protection of Enclosures.
BS 4752/IEC 157-1	Switchgear and control-gear.
BS 5419/IEC 408	Air Break Switches.
BS 5424, Pt.1/IEC-1 & 1A	Contactors.
BS 5472	Low Voltage Switchgear and Control-gear.
BS 6231	PVC Insulated Cables for Switchgear.
BS 5486/IEC 439	Factory Built Assemblies LV
IEC 947-3	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 equipments and remote devices.
f) Connection wiring diagrams, for each control unit, showing numbered terminal points, numbered wires and numbered interconnections to other equipments and remote devices.
g) Complete catalog 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, verminproof 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 439.

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 both Arabic and 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 947-3 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, drawout 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 position 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. 157 - 1A, 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 A 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 specified.
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 moistureproof 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 verminproof, 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 spedcified.
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 nonilluminating 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 color 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 molded 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 shutdown. 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 equippped 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 a overcurrent 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

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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 centers 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 centers 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 Centers 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 centers 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 color 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 Schedules.

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 to 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 Devices

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 centers, 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 position 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-center 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 inverters 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 146.

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 regarding harmonic distortion. The level of harmonic distortion shall not exceed 5 percent.

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 = 400 V $\pm$ 10 percent, 3 phase, 50 Hz $\pm$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 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 an RS 485 serial 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 inverter 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 color, 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 color: 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 Color: 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 vapor 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, sealed lead acid batteries (MSE) 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 undervoltage trip circuit to electronically trip the UPS output in order to protect the batteries.

C The noise level of the unit shall not exceed 60dB(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 shut down 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. 400V automatic start on mains failure, standby diesel generator set as indicated on the drawings. The set shall be complete with diesel engine, generator, control panel, batteries, starting motor, built-in 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 an 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/cm^2:
   - 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, 230/400 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 under these conditions at the rated speed without undue heating of the engine or alternator 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 sealed lead acid batteries 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.

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 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 weatherproof 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 not more than 100 m/min when engine is running. Filters 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	:	400 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.

2.02 Control Board

A Cabinet
1 Sheet steel construction, totally enclosed, dust protected and verminproof.
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 an 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 signaling.
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 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 tropicalised 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 provide 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 signaling without any hardware changes. The exchange shall be capable of meeting all the requirements of the local telecommunication authority requirements in signaling, 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, bothway 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 dBmop.

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 dialing response 5 to 15 secs.
2 Failure to dial successive digit following dialing 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 signaling 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 dialing 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 An 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 analog 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

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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 centers, 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 energising 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 recognised 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

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