

**JAPAN INTERNATIONAL COOPERATION AGENCY  
MINISTRY OF ECONOMY AND BUDGET PLANNING  
ASTANA CITY GOVERNMENT  
CAPITAL DEVELOPMENT CORPORATION**

**THE DETAILED DESIGN STUDY  
OF  
THE WATER SUPPLY AND SEWERAGE SYSTEM  
FOR  
ASTANA CITY  
IN  
THE REPUBLIC OF KAZAKHSTAN**

**ASTANA WATER SUPPLY AND SEWERAGE PROJECT**

**(DRAFT) TENDER DOCUMENTS**

**VOLUME 2-B**

**STANDARD SPECIFICATIONS**

**DECEMBER 2003**

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

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# **THE ASTANA WATER SUPPLY AND SEWERAGE PROJECT**

## **BIDDING DOCUMENTS FOR CONTRACT CP-1:**

### **CONSTRUCTION OF WATER SUPPLY AND SEWERAGE FACILITIES**

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## **DIVISION 1 GENERAL REQUIREMENTS**

### **SECTION 1.1 SCOPE OF WORK**

#### **1.1.1 LOCATION OF WORK**

The project area covers built-up area in the Astana city and water intake site at the Vyacheslavsky reservoir in the Republic of Kazakhstan.

#### **1.1.2 WORK TO BE DONE**

The extent of the work to be done is described in the relevant sections of the Particular Specifications. The drawings indicate the locations, type and extent of the work, generally, the work to be done, based on the drawings.

#### **1.1.3 INTENT OF CONTRACT DOCUMENTS**

It is the intent of the contract documents to provide for the execution and completion of all details of the work described herein, and it is understood that the Contractor, shall furnish all labor, material, equipment, tools, transportation and necessary supplies, such as may be required to execute the Contract in a satisfactory and workmanlike manner and in accordance with the contract documents.

The specifications and other parts of the contract documents are intended to supplement, but not necessarily duplicate, each other. Any work exhibited in the one and not in the others shall be executed as if it had been set forth in all, in order that the work be completed according to the complete design as determined by the Engineer.

Should anything be omitted from the specifications and other contract documents which is necessary for a clear understanding of the work, or should it appear that various instructions are in conflict, then the Contractor shall secure written instructions from the Engineer before proceeding with the work affected by such omissions or discrepancies. It is understood and agreed that the work shall be performed and completed according to the true spirit, meaning, and intent of the contract documents.

#### **1.1.4 PRECEDENCE OF CONTRACT DOCUMENTS**

If a conflict arises between contract documents, the document, highest in precedence, shall control. Unless directed otherwise by the Employer with the recommendation of the Engineer, the order of precedence shall be:

First : Particular Specifications

Second : Standard Specifications

Third : Drawings

Variation orders, supplemental agreements and approved revisions to drawings and specifications will

take precedence over documents listed above. Detailed plans shall have precedence over general plans.

### **1.1.5 INTERCHANGEABILITY OF STANDARDS**

Whenever reference standards appear in these specifications, they are intended to be the latest available and materials meeting other internationally accepted standards, which ensure an equal or higher quality than the reference standards, are acceptable. Decisions as to equal or higher quality will be made by the Engineer.

The following is a list of internationally accepted standards. The respective abbreviation is given for each standard for clarity.

AASHTO	: American Association of State Highway and Transportation Officials
ACI	: American Concrete Institute
ASTM	: American Society for Testing and Materials
AWWA	: American Water Works Association
BS	: British Standards
DIN	: Deutsche Industrie Normen
GOST	: National Standards (Kazakhstan and Russian)
IEC	: International Electrotechnical Commission
ISO	: International Organization for Standardization
JIS	: Japanese Industrial Standards
JWWA	: Japanese Water Works Association
SNiP	: Construction Codes and Regulations (Kazakhstan and Russian)

### **1.1.6 MINIMUM STANDARD**

The specifications and contract drawings define a minimum standard of workmanship. The Contractor shall include in his Bid the cost of any additional work or improvements in the quality of the work, that he may consider necessary to unconditionally guarantee the performance of the completed work in conformity with the Contract.

### **1.1.7 WORKMANSHIP**

The quality of the workmanship and materials shall be first class and the work shall present a neat and attractive appearance when finished.

If ordered by the Engineer, the Contractor shall make enough openings in the work and/or materials as are necessary to inspect the work.

Should the Engineer find the work and/or materials so opened up to be faulty in any respect, the

Contractor shall remove and make good all defective work and/or materials and shall bear the expense of all such openings, inspecting, and making good.

**1.1.8 REQUIREMENTS OF AGENCIES**

The Contractor shall be responsible for complying fully with the requirements of all agencies which govern any or all of the work under this Contract. These requirements may affect installation and construction methods and may include a written notice to an agency prior to the commencement of construction. In response to the written notice by the Contractor, an agency shall notify the Contractor in writing with respect to his decision within two weeks. When a written notice to an agency is required, a copy of the notice shall be submitted to the Engineer by the Contractor.

**1.1.9 SPECIFICATIONS**

The Contractor shall have a copy of these Standard Specifications and Particular Specifications or parts of specifications referred to herein on the site at all times. All specifications shall be producible upon demand of the Engineer. Failure to have copies of all specifications on the site will be considered an infraction to the Contract.

## **DIVISION 1 GENERAL REQUIREMENT**

### **SECTION 1.2 CONTROL OF WORK**

#### **1.2.1 CONTRACTOR'S EQUIPMENT**

The Contractor shall furnish his equipment which will be efficient, appropriate and large enough to secure a satisfactory quality of work and a rate of progress which will ensure the completion of the work within the time stipulated in the Bid. If at any time such equipment appears to the Engineer to be inefficient, inappropriate or insufficient for securing the quality of work required or for producing the rate of progress aforesaid, he may order the Contractor to increase the efficiency, change the character or increase the quantity of the Contractor's equipment, and the Contractor shall conform to such order at no additional cost to the Contract. Failure of the Engineer to give such order shall in no way relieve the Contractor of his obligations to secure the quality of the work and rate of progress required.

#### **1.2.2 LOCATIONS OF WORK**

Pipelines and structures will be located substantially as indicated on the drawings, but the Engineer reserves the right to make such modifications in locations as may be found desirable to avoid interference with existing structures and utilities or for other reasons. Where fittings, pipe, bends and curves are noted on the drawings, such notation is for the Contractor's convenience and does not relieve him from laying and jointing different or additional items where required.

#### **1.2.3 OPEN EXCAVATIONS**

The Contractor shall comply with all provisions of the Clauses of the Conditions of Contract related to the Safety, Security and Protection of the Environment and Third Party Insurance. The length of open trench will be controlled by the particular surrounding conditions, but shall always be confined to the limits prescribed by the authorities concerned. If the excavation becomes a hazard, the authorities concerned may require special construction procedures such as limiting the length of open trench, prohibiting stacking of excavated material on the trench side, and requiring that the trench shall not remain open overnight.

#### **1.2.4 TEST PITS**

Test pits for the purpose of locating underground pipelines or structures in advance of the construction shall be excavated and backfilled by the Contractor at the direction of the authorities concerned. Test pits shall be backfilled immediately after their purpose has been satisfied and the surface restored and maintained in a manner satisfactory to the authorities concerned. The above work will be executed at no additional cost to the Contract.

### **1.2.5 PROTECTION OF EXISTING STRUCTURES AND UTILITIES**

The Contractor shall assume full responsibility for the protection of all buildings, structures and utilities, public or private including poles, signs, services to buildings, utilities in the street, water pipes, hydrants, drains and electric and telephone ducts and conduits, whether or not they are shown on the drawings. The Contractor shall carefully support and protect all such structures and utilities from injury of any kind. Any damage resulting from the Contractor's operations shall be repaired at his expense. The Contractor should choose to relocate any existing structure or utility, for his own convenience. All costs shall be borne by the Contractor.

The Contractor shall bear full responsibility for obtaining all locations of underground structures and utilities. Services to buildings shall be maintained, and any costs or charges resulting from damage thereto shall be paid by the Contractor.

### **1.2.6 OBSTRUCTION OF UTILITY SERVICES**

The Contractor shall ensure that all existing hydrants, valve boxes, curb stop boxes, or other public utility controls shall remain unobstructed and accessible during the construction of the work.

### **1.2.7 OPERATION OF UTILITY SERVICES**

The Contractor shall obtain written approval from the authorities concerned before operating any valve, switch, or other control on existing utility services.

All consumers affected by such operation shall be notified by the Contractor, before the operation, of the date, time and probable length of time of service interruption.

### **1.2.8 MAINTENANCE OF FLOW**

The Contractor shall at his own cost, provide for the flow of drains and water courses interrupted during the progress of the work, and shall immediately remove all offensive matter. The entire procedure of maintaining existing flow shall be fully discussed with the authorities concerned well in advance of the interference of any flow.

### **1.2.9 PROVISIONS FOR TRAFFIC AND DETOURS**

All operations necessary for the execution of the works and for the construction of any temporary works shall, in so far as compliance with the requirements of the Contract permits, be carried on so as not to interfere unnecessarily or improperly with the public convenience or the access to use and occupation of public or private roads and footpaths or to properties whether in the possession of the Employer or of any other person.

The Contractor shall conduct his construction so that interference with the flow of traffic will be held to a minimum. He shall construct temporary bridging across his trenches where necessary for traffic

and pedestrians should the adjacent road be required by the Contractor for working or stockpiling area, he shall obtain prior written permission from the road Authority. Where detours are permitted, the Contractor shall provide all necessary barricades and signs as required to divert the flow of traffic. While traffic is detoured the Contractor shall expedite construction operations, and periods when traffic is being detoured will be strictly controlled.

All excavation in public ways and adjacent thereto, excavated material, equipment and any other obstacle which may in any way be a source of potential danger to the public shall be well lighted at night.

### **1.2.10 CLEAN-UP WORK TO BE DONE**

The Contractor shall bear full responsibility for the protection of all finished exterior and interior surfaces, fixtures and equipment from stains, marks, dirt or damage of any kind, from the time of their construction, finishing, or installation until the time of handing over the fully completed project to the Employer.

Before requesting an inspection of the completed works with the intent of final acceptance, the Contractor shall do all necessary cleaning, making good, and touching up that may be required to leave all finished surfaces, fixtures and equipment in acceptable condition, in accordance with the full intent and meaning of these specifications.

The following particular requirements shall be recognized as setting the standard for the final condition of the work.

#### **1. BUILDING SITES**

On or before the completion of the work, except as otherwise specially directed in writing, the Contractor shall remove all temporary buildings and structures built by him and all construction, machinery, plant, equipment, lumber and other construction materials and debris from the site of the Contract. The Contractor shall remove and acceptably disinfect all material containing organic matter, in, under and around buildings used by him and rubbish of all kinds from any ground which he shall have occupied within the limits of the property of the Employer and shall leave the site in a neat and satisfactory condition.

#### **2. ALL EXPOSED CONCRETE MASONRY AND SHEET METAL**

The Contractor shall thoroughly clean and eliminate mortar droppings, marks of concrete leakage, formwork marks, tar spatters and paint droppings.

#### **3. GLASS**

The Contractor shall repair, if necessary, wash thoroughly and polish glass on all faces and free it from

excess glazing compound, paint and scratches. Air spaces of double glazed sash shall be absolutely free from shavings, sawdust or dirt of any kind.

#### 4. PAINTED, ENAMELLED AND VARNISHED SURFACES

The Contractor shall clean all such surfaces of all marks, stains, scratches, fingerprints, graffiti or other damage.

#### 5. FLOOR SURFACES

The Contractor shall remove all temporary protective coverings and shall leave all surfaces clean, unmarked and free from stains, and where specified, properly waxed and polished.

#### 6. INTERIOR GLAZED WALLS

The Contractor shall clean all glazed wall surfaces of stains or spattered paint.

#### 7. FINISH HARDWARE, LIGHTING FIXTURES AND ELECTRICAL OUTLET PLATES

The Contractor shall clean and polish and leave free from paint, dirt or dust the above described surfaces. This particularly applies to all hinges.

#### 8. DUCT WORK

The Contractor shall remove dust and debris from all ductwork.

#### 9. ROOF SURFACES

The Contractor shall ensure that gravel topping is evenly spread and intact on all roofs and free from construction debris, carelessly dropped nails or any other foreign matter.

#### 10. PLUMBING AND PLUMBING FIXTURES

The Contractor shall free all pipes and fittings from dirt and debris, clean and polish all fixtures and ensure that facilities are in proper working order.

#### 11. ALL PIPE WORK

The Contractor shall check all pipe work for its proper support and water tightness, for cleanliness both on its exterior or interior, including the removal of interior rust.

### **1.2.11 PRIVATE LANDS**

The Contractor shall not enter private lands unless he has the Employer's written permission to do so and shall assume full responsibility for any and all claims which might arise as a result of such entry.



**1.2.12 FLOTATION, SETTLEMENT, INCLINATION AND STRAIN**

The Contractor shall take all necessary precautions against the flotation, settlement, inclination and strain of any structures during construction. The Contractor shall be responsible for any damage caused by the preceding and any expense incurred in making good such damage shall be borne by the Contractor.

**1.2.13 INCONVENIENCE AND RIGHT OF ACCESS**

The construction of the works shall be carried out in such a manner that a minimum of inconvenience is caused to the Employers and occupants of properties adjacent to the works.

**1.2.14 PREVENTIVE MEASURES**

The Contractor shall submit with his construction schedule, a list of procedures he intends to follow during construction, which shall include procedure and means to prevent interruption of service and contamination to the existing water supply system. The Engineer reserves the right to instruct the Contractor to re-submit any other proposed alteration or modification of the procedure.

**1.2.15 EXCESS FILL MATERIALS**

The Contractor shall be responsible for the disposal of all excess fill material from any excavation not considered in the grading and bear all costs associated with handling of this excess material.

**1.2.16 PUMPING AND DRAINAGE**

The cost of dewatering of excavations and of any other pumping and drainage necessary at the site for the proper construction, curing, boarding and inspection of the works, shall be borne by the Contractor. The Contractor shall dispose of all ground water and surface run-off in a manner approved by the Engineer and the authorities concerned.

**1.2.17 OVERHEAD CONSTRUCTION**

No machinery shall be employed which, in the opinion of the Engineer and the authority concerned, will unduly interfere with wires and other overhead construction.

## **DIVISION 1 GENERAL REQUIREMENTS**

### **SECTION 1.3 CONTROL OF MATERIALS**

#### **1.3.1 APPROVAL OF MATERIALS**

Only new materials and equipment shall be incorporated in the work. All materials and equipment furnished by the Contractor shall be subject to the inspection and approval of the Engineer. No material shall be incorporated into the work without approval of the Engineer.

As soon as possible after the Contract has been executed, the Contractor shall submit to the Engineer data relating to materials and equipment he proposes to furnish for the work. Such data shall be of sufficient detail to enable the Engineer to identify the particular product and to form an opinion as to its conformity to the specifications.

Facilities and labor for the handling and inspection of all materials and equipment shall be furnished by the Contractor.

The Contractor shall submit data and samples sufficiently early to permit consideration and approval before materials are necessary for incorporation in the work. Any delay of approval resulting from the Contractor's failure to submit samples or data promptly shall not be used as a basis of a claim against the Engineer.

In order to demonstrate the proficiency of workmen or to facilitate the choice among several textures, types, finishes, and surfaces, the Contractor shall provide such samples of workmanship of finish as may be required.

The materials and equipment used on the work shall correspond to the approved samples or other data.

Where name brands or specific suppliers are identified, and the intent is to provide a specific reference for quality and for functions, equivalent products will be considered acceptable. The Engineer will determine "the equivalent" of the substitute item.

#### **1.3.2 HANDLING AND STORAGE OF MATERIALS**

All materials and equipment to be incorporated in the work shall be handled and stored by the manufacturer, supplier, fabricator, and the Contractor before, during, and after shipment in a manner to prevent warping, twisting, bending, breaking, chipping, rusting, and any injury, theft or damage of any kind whatsoever to the material or equipment.

Cement and lime shall be stored, covered and off the ground, and shall be kept completely dry at all times. All structural steel, miscellaneous steel, and reinforcing steel shall be stored off the ground or otherwise to prevent accumulations of dirt or grease, and in a position to prevent accumulations of standing water and to

minimize rusting. Beams shall be stored with the webs vertical. Precast concrete elements shall be handled and stored in a manner to prevent accumulations of dirt, standing water, staining, chipping or cracking. Masonry products shall be handled and stored in a manner to reduce breakage, chipping or cracking.

All equipment subject to corrosive damage by the atmosphere if stored outdoors (even though covered) shall be stored in a building to prevent damage. The building may be a temporary structure on the site or elsewhere, but it must be satisfactory to the Engineer.

Any materials which, in the opinion of the Engineer, have become so damaged as to be unfit for the use intended or specified shall be promptly removed from the site of the work, and the Contractor shall receive no compensation for the replacement of the damaged material or its removal.

Manufactured materials shall be delivered and stored in their original containers, plainly marked, with identification of material and manufacturer.

### **1.3.3 TESTING**

When requested by the Engineer, and in his presence, the Contractor shall perform or make arrangements for all tests and analysis of materials, equipment, and structures in accordance with the relevant clauses of the specifications. All facilities, labor, and materials required for the satisfactory performance of these tests, analysis, and inspections, whether on the site, at the place of delivery, at the manufacturer's testing laboratory, or at an independent testing laboratory shall be supplied by the Contractor at his own expense.

The Contractor shall furnish, without cost to the Employer, samples of material to be used in the work. No material shall be used prior to approval by the Engineer.

The Engineer may require the Contractor to submit the material testing results for his approval before the material is used. The testing shall be performed at the independent laboratory approved by the Engineer. All the expenses incurred shall be borne by the Contractor.

The Contractor shall furnish the required samples at least three weeks before he anticipates ordering them to allow time to perform the tests.

## **DIVISION 1 GENERAL REQUIREMENTS**

### **SECTION 1.4 TEMPORARY FACILITIES**

#### **1.4.1 TEMPORARY OFFICE**

A temporary office shall be established in proximity to each job site and shall be adequately furnished, and maintained in a clean, orderly condition by the Contractor for the duration of construction. The Contractor or his authorized representative shall be present in the office at all time while work is in progress. Instructions received there from the Engineer shall be considered as delivered to the Contractor.

#### **1.4.2 TEMPORARY TELEPHONE**

Install in the temporary office a telephone for the Engineer and Contractor's use. The Contractor shall pay all bills charged against the telephone, including the installation charge and all monthly charges throughout the construction period.

#### **1.4.3 TEMPORARY WORKSHOP AND DWELLINGS FOR EMPLOYEE'S FAMILIES**

Prior to constructing workshop or dwellings at the job site, permission shall be obtained from the Engineer. Workshops shall be constructed in such a manner that they will not be an obstacle to public travel or an aesthetic and noisy nuisance and the area shall be kept clean at all times. If the Contractor provides living accommodation for those employed by him and their families, the dwellings shall be maintained in a clean and sanitary condition. Each dwelling unit shall be provided with lights, water supply and sanitary facilities and properly furnished.

#### **1.4.4 SANITARY ARRANGEMENTS**

The Contractor shall provide and maintain temporary sanitary facilities on the site for the use of all persons connected with the work. The Contractor shall keep the site in a clean and sanitary condition, and shall post notices and take such precautions as may be necessary to keep the site clean. The Contractor shall carry out any cleaning whatsoever as may be directed by the Engineer to maintain such sanitary condition.

#### **1.4.5 FIRST AID**

The Contractor shall provide all necessary first aid facilities, attendants and supplies for his labor force, regulations and all other statutory requirements, to the Employer and the Engineer.

#### **1.4.6 ENGINEER'S OFFICE**

The Contractor shall complete the installation and furnishing of an office for the exclusive use of the Engineer.

## **DIVISION 1 GENERAL REQUIREMENTS**

### **SECTION 1.5 SPECIAL PROVISIONS**

#### **1.5.1 WATER**

The responsibility shall be upon the Contractor to provide and maintain at his own expense an adequate supply of potable water for his use and his subcontractors' work for construction and domestic consumption and to install and maintain necessary supply connections and piping for the same, but only at such locations and in such a manner as may be approved by the Engineer. Before final acceptance, temporary connections and piping, installed by the Contractor, shall be removed to the satisfaction of the Engineer, unless requested by the Engineer to be left, upon agreement on price.

#### **1.5.2 ELECTRICITY**

All electrical current required by the Contractor shall be furnished at his own expense. All temporary connections for electricity shall be subject to the approval of the Engineer. All temporary lines shall be furnished, installed, connected and maintained by the Contractor in a workmanlike manner satisfactory to the Engineer, and shall be removed by the Contractor in like manner, at his expense, prior to final acceptance of the works, unless requested by the Engineer to be left, upon agreement on price.

#### **1.5.3 WORK IN PUBLIC WAYS**

The Contractor shall observe all applicable traffic regulations. The responsibility of conformance is that of the Contractor.

#### **1.5.4 PRESSURE AND LEAKAGE TESTS**

##### **1. GENERAL**

Before acceptance, liquid and gas conveying and containing units shall be tested by the Contractor in the presence of a representative of the Engineer. These tests consist of pressure and leakage tests on all conduits, pipelines, tanks and channels. The pressure tests are for the purpose of ensuring that the system, as constructed, is structurally adequate for the anticipated pressures and the leakage tests are to ensure that leakage either out of or into the units is within the requirements of these specifications. Liquid carrying units shall be tested with water and gas carrying units with air, or other approved gas.

Water for testing shall be obtained by the Contractor at his own expense. The Contractor will be required to transport the water to site not adjoining the water distribution system. The Contractor shall furnish all labor, fuel, oil, grease and power required for testing purposes. This shall be for the time necessary to indicate to the satisfaction of the Engineer that the work is in conformance with the specifications.

Concrete tanks and conduits open to the atmosphere will not be pressure tested, but will be tested for leakage under high water level conditions.

The Contractor shall furnish suitable temporary service connections, testing plugs or caps, pressure pumps, pipe connections, air compressors, meters, pressure and vacuum gauges, thrust supports and other equipment required to carry out tests. No water may be pumped into tanks or pipes, or tests commenced in any way, without the Engineer's approval and all testing shall be conducted in the presence of the Engineer or his authorized representative.

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

## 2. PRESSURE TESTS

Pressure tests, unless otherwise specified in the Particular Specifications, shall be applied for a one-hour period at a pressure 1.5 times the normal operating pressure of the system. Vacuum systems shall be tested at a vacuum of 1.5 times the normal operating vacuum of the system. All exposed joints may be checked during this test for leakage with a soap solution.

If any pressure test opens a joint, cracks a pipe or otherwise ruptures part of the system, the Contractor shall make the necessary repairs and repeat the pressure test. Pressure or vacuum gauges shall be installed at a low point in the system and the required pressure maintained continuously during the test period.

## 3. LEAKAGE TESTS

Leakage tests, unless otherwise specified in the Particular Specifications, shall be conducted for a continuous two (2) hour period at the maximum operating pressure of the system. If any test shows the leakage of any tank, channel or conduit to exceed that specified, the structure shall be emptied, carefully examined and all defects repaired by grouting, cutting out or re-making joints, as directed, or by any other approved method. Such tests shall be repeated until the leakage is less than the stipulated amount. When leakage is allowed as infiltration, it will be measured by means of v-notch weirs, pipe spigot or by plugs in the end of the pipe to be provided and installed by the Contractor in an approved manner and at such times and locations as may be directed by the Engineer.

Where leakage is allowed as exfiltration it will be measured either through a calibrated meter, by pumping from an open tank suitably calibrated and recording times and quantities or by other approved methods.

For leakage tests by exfiltration of exposed piping systems, the lower end of the piping shall be suitably plugged and the system filled with water to the maximum possible water head taking care to exceed the working pressure of the pipe. Tests will be continued for one hour and there shall be no

visible or measurable leaks.

#### 4. TANKS AND CONCRETE STRUCTURES

Concrete tanks and conduits shall be tested for leakage. Where possible, tests shall be done before the structure is backfilled and before any water-proofing material, if required, is installed.

Concrete tanks, reservoirs and concrete conduits shall be tested individually by filling to normal operating level after all visible leaks have been stopped. The total leakage for any unit for a period of twenty four hours shall not exceed 0.5% of the volume of water contained in the unit.

Steel tanks shall be pressure tested by the manufacturer to a pressure of 0.04 MPa unless otherwise specified, and this shall be so noted on the tank. Tanks will be tested, after installation, for leakage and any leaks shall be repaired.

#### 5. PIPELINES

All pipes, to be buried or otherwise covered up, must remain uncovered until approved by the Engineer.

Buried water pressure pipelines shall be tested in accordance with AWWA C600 titled, "Installation of Cast Iron Water Mains".

Exposed pressure pipelines shall be tested for infiltration after the backfill has been placed, and the groundwater has returned to its normal elevation. Infiltration tests shall be made under the supervision of the Engineer, and the length of line to be tested shall not be less than the length between adjacent manholes and not more than the total length of each size of pipe.

For buried gravity pipelines, the allowable infiltration or leakage shall not exceed 34 liters per day per centimetre of diameter per 100 meters of pipe. Leakage between two adjacent manholes may be up to twice the amount above stated, provided the average leakage for the total length of any size does not exceed the amount first stated and provided there are no gushing or spurting leaks.

If an inspection of a completed section shows any manholes, pipes, or joints which allow the infiltration of water in a noticeable stream or jet, the defective pipes or joints are discovered at this time, they shall be repaired by the Contractor.

The air blower and compressed air systems including instrument air system shall be pressure and leakage tested. A 10 % loss or less in pressure over the test period will be acceptable.

The vacuum systems shall be tested as hereinbefore specified. A 10 % increase in pressure over the test period will be acceptable.

**1.5.5 DISINFECTION**

Before being placed in service all works including water pipelines, concrete conduits, concrete tanks, connections to existing water pipelines and all other appurtenances which are to be in contact with, contain or convey potable water will be disinfected by the Contractor. Disinfection shall be done after completion and acceptance of the specified leakage and pressure tests.

After completion of the specified tests, tanks, conduits and appurtenances to be disinfected shall be thoroughly cleaned out. Cleaning may be by flushing, hose stream, brush or other proper means as may be required for successful removal of all foreign material. All oil, grease and foreign material, not removed with water shall be removed with appropriate solvents in such a manner as not to injure the concrete or other materials, or impart a harmful residue to the potable water system after completion.

Disinfection shall be the responsibility of the Contractor, but the Contractor shall be responsible for all cleaning and flushing of pipelines, structures and appurtenances in preparation for disinfection in a manner acceptable to the Engineer.



## **DIVISION 2 SITE WORKS**

### **SECTION 2.1 SITE PREPARATION AND MISCELLANEOUS WORK**

#### **2.1.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals necessary to do all clearing, grubbing and stripping of top soil, and the demolition of all existing structures and foundations, as shown on the drawings and as specified herein.

#### **2.1.2 CLEARING AND GRUBBING**

Except as otherwise directed by the Engineer, the Contractor shall cut, grub, remove and dispose of all trees, stumps, brush, shrubs, roots, rubbish, organic matter and any other objectionable material within the limits of the work of the Contract, including areas to be occupied by buildings, structures, roads and any area where excavation or backfilling is required.

Any trees or group of trees designated on the drawings or by the Engineer to remain shall be protected from damage during any construction operation by erecting suitable barriers or by other approved means. Trees that are designated to remain and are damaged by the Contractor shall be repaired or replaced as directed by the Engineer without cost to the Employer. Clearing operations shall be conducted in a manner to prevent falling trees from damaging trees designated to remain.

#### **2.1.3 STRIPPING**

Topsoil may be stripped from all areas to be occupied by buildings, structures and all areas to be excavated except areas to be filled or paved. Avoid mixing topsoil with subsoil and stockpile it in areas on the site as approved by the Engineer. Topsoil shall be stockpiled free from brush, trash, stones, other extraneous material and protected until it is placed. Any topsoil stockpile remaining after all work is in place shall be disposed of by the Contractor, if the Engineer so directs.

#### **2.1.4 DISPOSAL OF MATERIALS**

All tree trunks, limbs, roots, stumps, brush, foliage and other vegetation shall become the property of the Contractor and removed and disposed of by him off the project site. Burning of debris may be allowed on the project site, under the supervision of the Contractor, provided that burning arrangements are approved by the Engineer. Notice of burning shall be given by the Contractor to the local fire department before burning. The remaining burnt materials after burning shall be disposed of by the Contractor.

## **DIVISION 2 SITE WORKS**

### **SECTION 2.2 EXCAVATION, DEWATERING, BACKFILL, FILL AND GRADING**

#### **2.2.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals necessary to perform all excavation, dewatering, disposal, backfill, fill and grading required to complete the work indicated on the drawings and specified herein. The work shall include but not necessarily be limited to excavation for structures, manholes, vaults, ducts, pipelines and appurtenances, and paving; all backfilling and filling for embankments and grading, disposal of waste and surplus materials, and all related work such as sheeting, bracing and dewatering. Topsoil and sod excavated under this section may be stored by the Contractor for use as specified under Section 2.1 "Site Preparation and Miscellaneous Works."

Sodding and loaming, related to landscaping, is specified in Section 2.4, "Landscaping".

It shall be the responsibility of the Contractor to inspect all trucks and vehicles that are used in transporting excavated soils, organic spoil, and other items from and to the construction sites. The truck beds shall be sufficiently tight, and shall be loaded in such a manner that objectionable materials will not be spilled onto the soil, streets, or highways. The Contractor shall observe all applicable traffic regulations.

The Contractor shall conduct his operations in such a fashion that trucks and other vehicles do not create a dirt nuisance in the streets. Any dirt, mud, or other materials that are spilled into the streets by the tires of vehicles or their tires shall be promptly cleared away by the Contractor.

#### **2.2.2 CONSTRUCTION PROCEDURES TO STABILIZE EXCAVATIONS FOR STRUCTURES AND PIPELINES**

The stability of excavations will be affected by factors such as the soil characteristics, the depth of the excavation, ground water elevation, surcharge loading (including building and traffic loads) rain and/or flooding, pile driving, construction activities including stockpiling of materials and equipment, traffic and rate of excavation. The following items form the minimum criteria which shall be observed by the Contractor unless otherwise specified when planning an excavation, sheeting and bracing and a pile driving schedule:

##### **1. STRUCTURES**

- a. Open excavation will be permitted to a maximum depth of 4.0 m.
- b. A maximum slope of two horizontal to one vertical may be used.
- c. Any excavation carried to a depth greater than 4.0 m measured from existing ground level shall be a stepped excavation. Steps shall be prepared for every 4.0 m depth of excavation with a minimum 1.0 m width.

- d. The excavation where required or ordered by the Engineer shall be sheeted to avoid collapsing of the excavation and to prevent structures located close to excavations from being damaged.
- e. The stockpiling of excavated clay, backfill or construction materials within a minimum distance of 5 meters from the top of slope is prohibited.

**2. PIPELINES**

- a. Excavations shall be completed in accordance with the limiting trench widths shown on the drawings.
- b. Excavations less than 1.5 m in depth may at the Contractor's option and after approval by the Engineer be accomplished without sheeting.
- c. Excavation to depths greater than 1.5 m shall be sheeted and braced.
- d. The stockpiling of excavated clay, backfill or construction materials within a minimum distance of 5 m from the top of slope of unsheeted trenches is prohibited.

Pile driving activities, if applicable, can affect the stability of excavations in soft clay by remolding the soil and generating excess pore water pressure in the clay. These factors will be most important when excavations are completed prior to pile driving or when excavations are made immediately after pile driving.

The Contractor shall submit to the Engineer for approval his proposed methods of excavation, dewatering and bracing. Included shall be a schedule indicating the rate and depth of excavations, a plan for disposal of excavated material, and details of proposed lateral supports and bracing.

Excavations, and the protection of side slopes and backfill are to be rigidly controlled by the Contractor to the approved schedule. If the Contractor fails to protect side slopes, any resulting damage from a slope failure shall be repaired at the Contractor's expense.

The Contractor shall take all necessary precautions against the subsidence, displacement, inclination, etc. of any existing structures during dewatering. The Contractor shall be responsible for any damage caused by the preceding and any expense incurred in making good such damage shall be borne by the Contractor.

**2.2.3 SUBSURFACE CONDITIONS**

Not applicable.

**2.2.4 MATERIALS**

**1. SELECTED MATERIAL (MATERIAL NO. 1)**

Selected fill material shall be soft, dark gray clay soil or other materials normally removed from excavations including clay or sand as approved by the Engineer. The material shall consist of mineral soil substantially free from organic materials, top soil, wood and trash, and other objectionable material which can not be compacted properly. No boulders or stones larger than 50 mm in any

dimension shall be contained in the selected fill material.

## 2. GRANULAR MATERIALS (MATERIAL NO.2 AND 3)

### 2.1 GENERAL

Granular materials specified herein mean sand, gravel or crusher run stone which may be used for fill.

### 2.2 SAND (MATERIAL NO. 2)

Sand shall be natural, of hard durable particles of mineral aggregate, and free from vegetable matter, soft particles and excess loam and clay. Sand shall not contain a total of more than 30 percent by weight of loam and clay. Gradation shall be from fine to coarse, adequate for good compaction. Sea sand may be allowed for use if approved by the Engineer, but salt content shall not exceed more than 0.1 percent of NaCl.

### 2.3 GRAVEL AND CRUSHED STONE (MATERIAL NO. 3)

Gravel shall be natural, consisting of hard durable particles graded fine to coarse in a reasonably uniform combination with no boulders or stones larger than 50 mm in size.

It shall be free from slag, cinders, ashes, refuse, or other deleterious or objectionable materials, and excess loam and clay.

Crushed stone of similar size range and quality as the gravel may be allowed to use as a fill material.

## 2.2.5 SHEETING AND BRACING

### 1. GENERAL

The terms sheeting and bracing shall cover all necessary methods of lateral support of excavations and vertical support of existing facilities including wood and steel sheeting, piling, poles and shoring or such other materials as may be approved by the Engineer.

### 2. SHEETING AND BRACING DRAWINGS

The Contractor shall submit to the Engineer for approval, drawings of the sheeting and bracing indicating that the following minimum list of criteria has been incorporated:

- (1) The Contractor shall execute test boring and laboratory soil test to obtain soil parameters such as unit weights, water contents, Atterberg limits, and unconfined compressive strength.
- (2) Heavy rain and/or high ground water levels can cause flooding of the excavation or the ground outside the excavation.
- (3) Surcharge loading of the sheeting and bracing systems caused by adjacent structures, roadways, walkways, stockpiles of earth fill or construction materials or equipment or any other reason shall be considered.
- (4) The overall stability of the excavation and the stability of the bottom of the excavation shall be analyzed.

- (5) The sheeting and bracing systems shall be designed to resist lateral earth pressure where appropriate which will ensure that the sheeting and bracing will support the side of the excavation in accordance with the requirements of these specifications.

### 3. INFORMATION FOR SHEETING AND BRACING

The Contractor shall submit to the Engineer, for approval, a complete set of working drawings for any proposed sheeting and bracing. The following information shall be included on the drawings:

- (1) The sequence of driving individual sheets and/or master piles and logging.
- (2) The use of falsework bracing to maintain alignment of sheeting during installation.
- (3) The sequence of excavation in relation to placement of bracing anticipated elapsed time between excavation and placement of braces.
- (4) The use of temporary earth beams to provide support during the installation of bracing.
- (5) The dimensions of the sheeting and bracing materials, including section modulus, yield strength, design stresses and composition of materials.
- (6) The depth of embedment of the sheeting and/or master piles below the bottom of the excavation.
- (7) The proposed methods for dewatering of the excavation during normal and high water (flood) conditions.
- (8) Precise details showing the method of shimming or prestressing of braces.

### 4. SHEETING AND BRACING PROCEDURES

The Engineer will require that the drawings for the sheeting and bracing system be submitted for approval at least one month prior to the anticipated date of installation. Approval of the drawings by the Engineer is for approval only insofar as it affects the finished work, and such approval will not relieve the Contractor of the responsibility in any manner for the adequacy of the design for strength and for the safety of the laborers and inspectors working therein. If at any time during the course of the work the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports to be put in at the expense of the Contractor, and compliance with such an order shall not relieve or release the Contractor from his responsibility for the sufficiency of such supports.

The Contractor shall furnish, put in place, and maintain such wood and/or steel sheeting and bracing as may be required to support the sides of excavation necessary for proper construction, and to protect adjacent structures, utilities, roadways and bridges from undermining or other damage.

When any open excavation is carried out near or under any existing buildings, canal walls, utilities, service mains, cables and paved surfaces such as roads liable to be damaged by settlement, the Contractor shall provide the necessary shoring to prevent damage, whether such existing facilities are indicated on the drawings or not.

The Contractor shall leave in place to be embedded in the backfill all steel and wood sheeting and

bracing which the Engineer may direct him in writing to leave in place at any time during the progress of the work for the purpose of preventing injury to structures, utilities, or property, whether public or private. The Engineer may direct that timber used for sheeting and bracing be cut off at any specified elevation.

The right of the Engineer to order sheeting and bracing left in place shall not be construed as creating any obligation on his part to issue such orders, and his failure to exercise his right to do so shall not relieve the Contractor from liability for damages to persons or property occurring from or upon the work occasioned by negligence or otherwise, growing out of a failure on the part of the Contractor to leave in place sufficient sheeting and bracing to prevent any caving or moving of the ground.

No wood sheeting or bracing is to be completely withdrawn if driven below the centerline of any pipe, and under no circumstances shall any sheeting or bracing be cut off at a level lower than 30 cm above the top of any pipe.

Wood for bracing and sheeting shall be of adequate section and quality and shall be sound, and free from knots, twists or other weakening effects. The sheeting shall be braced at all times to prevent slips and cave-in of walls or subsidence of adjacent areas. The system of bracing shall allow for the temporary removal of cross struts. The removal of bracing that allows the sheeting to take lateral loads acting as a cantilever will not be permitted.

#### **2.2.6 PUMPING, DRAINAGE, FLOTATION AND COFFERDAM**

Before commencing work the Contractor shall submit to the Engineer for approval his proposed program for dewatering, excavations and keeping them from being flooded. This shall include a detailed description of all pumping arrangements, equipment he proposes to employ and plans and sections of any proposed dikes around the excavation. Earth dikes shall not be constructed within 5 m of the top of slope of an open excavation. The area enclosed by the dike shall be sloped to drain to prevent ponding of water.

Only equipment, methods and a program which has been approved by the Engineer shall be used. This approval, however, shall not relieve the Contractor of the responsibility for the satisfactory performance of the drainage system.

The Contractor shall construct all concrete work, pipelines, and fills in the dry. The Contractor shall at all times during construction provide and maintain proper equipment and facilities to remove promptly and dispose of properly all water entering excavations, including ground water, surface water and rainfall, and keep such excavations dry so as to obtain a satisfactory undisturbed subgrade foundation condition until structures, pipes or fills to be built thereon have been completed to such extent that they will not be floated or otherwise damaged, by allowing water levels to return to natural elevation.

Dewatering shall be such as to prevent boiling or detrimental underseepage at the base of excavation

or the movement of water through or alongside any concrete being placed.

Pumping water from excavations onto pavement in such a manner as to cause dirt to settle out on pavement or in existing drains shall not be permitted.

If it is necessary to interrupt existing drainage, the Contractor shall provide temporary drainage facilities that will prevent damage to public and private interests and to the work in progress and shall restore the original drainage system as soon as the work permits.

The Contractor shall submit for approval drawings showing the proposed layouts of cofferdam construction in canals and rivers. Drawings shall indicate location, size, materials and representative cross sections of any proposed cofferdam. Approvals of the cofferdam drawings will only be insofar as it affects the finished work and boat, vehicle and pedestrian travel in the area. Approval will not relieve the Contractor of responsibility for the adequacy of the construction for strength and for the safety of those working within or adjacent to the cofferdam.

### **2.2.7 EXCAVATION**

#### **1. GENERAL**

Excavations shall be made of such widths and depths as will give suitable room for building and structures, pipelines and ducts, for bracing, supporting, pumping and drainage; and the bottom of the excavation shall be rendered dry and in all respects acceptable to the Engineer. Soils below normal grade, which become soft, loose, "quick", or otherwise unsatisfactory for support of the new work as a result of inadequate excavation, dewatering or other construction methods, shall be removed and replaced as hereinafter specified in Section 2.2.8 Subgrade Protection at the Contractor's expense.

Excavating equipment shall be satisfactory for carrying out the work in accordance with the specifications. Machine excavation in clay shall be done with a bucket with a smooth cutting edge. Excavated material, not required to be removed from the site, shall be so placed as to inconvenience as little as possible the work and vehicular and pedestrian traffic. The Contractor shall observe the requirements of Section 2.2.2 relating to the stability of excavations.

When excavations have reached the depth indicated on the drawings, the Engineer shall be notified and he may inspect conditions. If materials and conditions are not satisfactory to the Engineer, the Engineer will issue instructions as to the procedures. Existing structures, pipes and conduits which are to remain or have been installed under this Contract or by others shall be protected from damage during all phases of construction and shall be kept in full operation during the work of this Contract. Trees and root structures to remain, must be protected during excavation to the satisfaction of the Engineers

#### **2. STRUCTURES**

Excavation for structures shall be carried out in conformance to an approved schedule. In general

excavations up to 4.0 m deep may be done without sheeting. Excavations shall not be made below 3.0 m depth until pile driving has been completed. Excavations below 4.0 m shall be carried out in a manner to protect side slopes. Piles shall be protected from damage by earth removing equipment. Excavation shall be made to the depths required for placing the required working mat. All voids between the limits of excavation and neat lines of undersides of structures shall be filled with compacted granular Material No. 3 except where otherwise specified or shown on the drawings.

Any excavation and filling outside and below neat lines of structures necessitated by the Contractor's failure to protect side slopes from failure shall be at the expense of the Contractor.

### 3. TRENCH

#### 3.1 General

Excavation methods and equipment for trenches shall be suitable for the work.

#### 3.2 Removal of Pavement

Pavement to be removed during excavations shall be cut along straight parallel lines before excavating to provide a uniform edge and minimize the amount of pavement disturbed.

Asphaltic pavement shall be cut with side slopes vertical. For reinforced concrete pavement lateral reinforcing bars shall be cut at the center of the trench and bent up vertically. When possible a minimum length of 60 cm shall be left on each side of the excavation for splicing of reinforcing required for restoration of the pavements. If a full slab is removed, existing tie bars shall not be cut. Should voids occur under existing pavement during construction, the pavement above shall be removed. Settlement and cracks in bituminous macadam pavement are to be restored to the approval of the Engineer.

When cracks develop in concrete pavements during construction the concrete pavement shall be removed and replaced or where deemed necessary the entire section bound by joints may be replaced as specified above. For excavations in tile side walks, tiles shall be removed and reused where possible. In general, tiles are not to be cut. Excavations for pipes under existing curbs and walls may be tunneled. If existing curbs or walls outside pavement limits are removed or damaged by the Contractor's operations, they shall be replaced at his expense and shall conform to the existing conditions.

#### 3.3 Excavation

In all cases the earth shall be dug with machinery or by hand to a depth as required to provide the specified thickness of working mat below the pipe or structure. Granular Material No. 2 shall then be placed immediately to the grade of the excavation, to provide a working mat. Excavations for ducts shall be adequate to provide concrete encasement. Subgrade shall be protected as hereinafter specified.

Excavation for pipelines, ducts, and appurtenances shall be to straight lines and grades as required.



**4. EXCAVATION BELOW NORMAL GRADE.**

If, in the opinion of the Engineer, the material, in its undisturbed natural condition, at or below the normal grade of the excavation as indicated on the drawings is unsuitable for foundations, it shall be removed to such depth and width as he may direct and be replaced with suitable material as directed by the Engineer. The amount of payment for this authorized excavation below grade to be made to the Contractor for this variation order shall be as specified in the Conditions of Contract.

If, in the opinion of the Engineer, a thicker working mat is required, the Contractor shall excavate material below normal grade to a depth as directed by the Engineer and replace it with the required working mat material. The amount of payment to be made to the Contractor for this variation order shall be as specified in the Conditions of Contract.

**5. EXCAVATION OF ABANDONED FOUNDATIONS**

The Contractor shall remove from excavations all concrete, brick masonry foundations and wood including piles that interfere with the construction of the work. This material shall be removed to a distance of 30 cm from the sides and 15 cm below work or as directed by the Engineer.

This work shall be understood to include all masonry walls, slabs, piles, old surface pavements, etc, which in the opinion of the Engineer require their removal to allow the new work to be constructed as proposed. Any piles removed by pulling shall have the voids filled with sand. Concrete and brick masonry may be used as backfill in locations approved by the Engineer.

**2.2.8 SUBGRADE PROTECTION**

**1. GENERAL**

Where excavations are to be made in the native clay that will be subject to foot traffic a working mat is required. Such excavations, dewatering operations, pile driving, reinforcing steel setting, concrete placement and/or pipe installation shall be performed in a manner which will preserve the undisturbed condition of the natural material underlying the structure.

Unless otherwise indicated on the drawings working mats as specified hereinafter are required in all cases.

If through failure of the Contractor to properly care for water, failure to postpone final excavation immediately above the subgrade until shortly before placing of the new work thereon, or other failure or neglect to conduct this excavation work properly so that the natural subgrade soil becomes soft, wet or otherwise disturbed in the opinion of the Engineer so that it is not in proper condition for construction thereon, the Contractor shall excavate the disturbed material and shall backfill with lean concrete or granular Material No. 2 or No. 3 placed in compacted layers of no greater than 15 cm each. If the disturbance extends to an excessive depth, the Contractor will be required to drive piles to support the structure. All material and labor costs related to over excavation, backfill, piles, additional

concrete and steel, engineering costs for redesign and other work and materials which may be required shall be borne by the Contractor.

## 2. STRUCTURES AND CONDUITS WITH PILE FOUNDATIONS

Where structures and conduits are bearing on pile foundations the excavation shall be made to the required subgrade level (bottom of working mat) by power machinery or by hand. Before cutting off pile, or constructing footing or slab, the subgrade shall be leveled by smoothing out the existing material, removing humps and filling depressions to the required subgrade level.

A working mat shall then be placed consisting of a minimum thickness of 20 cm of compacted granular material No. 3 and a minimum thickness of 5 cm of lean concrete.

In conjunction with the placing of the working mat, granular Material No. 2 or No. 3 shall be added to replace existing material removed below or beyond the limits required either due to stepped excavation or because of the Contractor's operations or as otherwise required by the Engineer. This granular material shall be compacted to the extent required by the Engineer.

## 3. STRUCTURES WITHOUT PILE FOUNDATIONS

Where structures and conduits are to be constructed without a pile foundation, the bottom 10 cm of native material shall be removed by hand in a manner which will provide a flat bottom of undisturbed soil. Power machinery shall not be used for this final excavation to subgrade level unless it can be demonstrated to the satisfaction of the Engineer that a smooth undisturbed surface will result. The bottom of the excavation shall not be subjected to equipment loads or vibrations.

Immediately after excavation to the required subgrade elevation, a working mat of granular material No. 3 having a minimum thickness of 20 cm shall be placed and compacted on the undisturbed clay. This layer shall be compacted by a minimum of two passes of hand operated compaction equipment approved by the Engineer. A second layer consisting of 5 cm of lean concrete shall be placed. This working mat is required to protect the bottom of the excavation from disturbance during subsequent placement of pipes, reinforcement, forms and concrete. No water shall be allowed to enter the excavation during the time that final excavation is performed and until the working mat has been placed.

## 4. PIPE STRUCTURES, CONDUITS AND DUCTS WITHOUT PILE FOUNDATIONS

Where structures and conduits are to be constructed without a pile foundation, the bottom 10 cm of native material shall be removed by hand in a manner which will provide a flat bottom of undisturbed soil. Power machinery shall not be used for this final excavation to subgrade level unless it can be demonstrated to the satisfaction of the Engineer that a smooth undisturbed surface will result. The bottom of the excavation shall not be subjected to equipment loads, vibrations or foot traffic.

Immediately after excavation to the required subgrade elevation, a working mat of granular material

No. 3 having a minimum thickness of 10 cm as shown on the drawings shall be placed and compacted on the undisturbed clay. This working mat is required to protect the bottom of the excavation from disturbance during subsequent placement of pipes, reinforcement, forms and concrete. No water shall be allowed to enter the excavation during the time that final excavation is performed and until the working mat has been placed. A working mat greater than the required minimum thickness specified herein and on the drawings, may be used at the convenience of the Contractor at no additional cost to the Employer.

### **2.2.9 TRENCH BACKFILL AND COMPACTION**

#### **1. BEDDING**

All buried pipelines and appurtenances are to be constructed to the lines and grades indicated on the drawings. Pipe shall be bedded as specified hereinafter and as specified in Section 2.3 "Installation of Underground Piping and Fittings" in the Standard Specifications and as indicated on the drawings. Bedding shall be granular Material No. 2 placed as a working mat on the undisturbed bottom of the trench to the depths required and then carried up the sides of the pipe to the required depth as shown on the drawings. The materials shall be compacted by hand tools under and around the pipe and brought up evenly on both sides of the pipe using suitable equipment. The bedding material shall be compacted against undisturbed earth or sheeting at the sides of the trench.

The bedding shall be placed in layers not exceeding 15 cm in thickness measured prior to compaction. Each layer shall be compacted by a minimum of four passes with a hand operated plate tamper approved by the Engineer. When in the opinion of the Engineer, compaction of the bedding may adversely affect the undisturbed condition of the bottom of the trench, the compaction requirement may be reduced.

#### **2. BACKFILL**

Under pavement and shoulders and sidewalks, backfill shall be compacted by a minimum of 2 passes of flat-faced mechanical tampers or vibrating soil compactors of a type approved by the Engineer, and by wetting when necessary. The filling shall be continued evenly in 20 cm layers with at least one mechanical tamper for two men shoveling granular Material No. 2 into the trench.

Where the trench will not be constructed beneath pavements, shoulders and sidewalks, the following methods of compaction may be approved. The backfill may consist of Materials No. 1 or No. 2 and shall be placed in 30 cm layers and may be compacted by ramming out or rolling or by methods satisfactory to the Engineer. After backfilling is completed, the Contractor shall restore the ground surface to its original grade and condition.

Puddling or water jetting to achieve compaction will not be allowed.

Under sidewalk areas the top 10 cm layer of trench backfill shall consist of compacted granular

Material No. 2. The layer shall be compacted by a minimum of three passes of a mechanical tamper or other equipment approved by the Engineer.

The surface of all driveways, sidewalks and other areas which are disturbed by the trench excavation and which are not a part of the paved highway shall be restored by the Contractor to a condition at least equal to that existing before work began. If settlement takes place, he shall immediately deposit additional fill to restore the grade of the ground.

### **2.2.10 GENERAL FILL AREAS**

Fill material shall consist of Material No. 1 and may include the material excavated in connection with the construction of the work, if approved by the Engineer. Material, conforming to this requirement, shall be placed in layers having a maximum thickness of 40 cm, measured before compaction. The layers shall be compacted using hand tampers or other equipment approved by the Engineer.

Materials, placed in fill areas, shall be deposited to the lines and grades shown on the drawings, making due allowance for settlement of the material and for the placing of loam thereon.

If the drawings specify other than Material No. 1, for surfaces of fill areas, the indicated granular material shall be placed and compacted as shown.

### **2.2.11 BACKFILL AND FILL**

#### **1. GENERAL**

This section relates to furnishing and placing of material to replace excavated material, fills for embankments, roads and pipe bedding.

The Contractor's attention is directed to the previous section titled "Subgrade Protection" which relates to the installation of a working mat prior to construction of structures and pipelines.

No backfilling or filling shall be done without the approval of the Engineer. The Engineer may require the removal of any backfill or fill placed without his authorization. This may be for reasons of checking compacted work, type of material used or the degree of compaction.

Backfilling and filling over pipes shall begin as soon as practicable after the pipe has been laid, jointed and inspected. Backfilling shall be carried up evenly around the perimeter walls of any structure.

There will be consolidation (settlement) of the undisturbed material under the fill required at the sites. The Engineer will require that areas to be filled in the finished work shall be filled early in the construction period. The Engineer will require that the placing of final pavement be delayed to the end of the Contract period.

All references hereinafter to percent compaction shall be understood to refer to the maximum dry density determined by ASTM D698 Method D or other internationally accepted standards or

### **SCHEDULE OF BACKFILL AND FILL MATERIALS**

<b><u>Typical Location</u></b>	<b><u>Backfill and Fill Material</u></b>
Dikes and embankments	Material No. 1
New Paved areas	Material No. 2
Common backfill and fill around and under structures and for grading	Material No. 1
Structural Fill	Material No. 3
Pipe bedding	Material No. 2
Trenches, backfill and fill	Material No. 1 or No. 2
Refill of authorized excavation below normal grade	Material No. 2 or No. 3
Topsoil or loam	See Section 2.4.2, "LANDSCAPING"

#### **2. DIKES AND EMBANKMENTS**

Dikes and embankments shall be constructed of Material No. 1 placed on the native material, unless otherwise indicated on the drawings. The site shall be cleared of brush, stumps, wood, trash or other debris. Stripping of the grass and root mat is not required. The fill material shall be placed in layers with a maximum thickness of 40 cm using chunks of Material No. 1 formed by mechanical excavating equipment (e.g., backhoe, clamshell), packed with Material No. 1. Each layer shall be dried sufficiently to permit compaction by a minimum, of two passes of compaction equipment approved by the Engineer. When, in the opinion of the Engineer, drying of the clay is not required, each layer shall be thoroughly compacted using hand tampers or other hand operated mechanical equipment approved by the Engineer.

#### **3. NEW PAVED AREAS**

Roads, parking areas and sidewalks will require the furnishing and placing of backfill and fill as required to construct them to the cross sections and elevations indicated on the drawings. Prior to placement of fill the site shall be cleared of brush, stumps, wood, trash or other debris, to the satisfaction of the Engineer. Stripping of grass and root mat is not required. However, standing grass shall be cut or burned off.

In areas where pavements will be placed over and/ or adjacent to structures, or trenches, backfill shall be granular Material No. 2. The backfill shall be placed in layers not exceeding 20 cm in thickness measured before compaction and shall be compacted to 93 percent of the maximum dry unit weight.

Where existing grade is below the level of the bottom of the subbase, granular Material No. 2 shall be placed in layers not exceeding 20 cm in thickness measured before compaction and shall be compacted to 93 percent of the maximum dry unit weight.

Where existing grade is above the required subbase elevation, the material shall be excavated to allow placement of the required thickness of subbase.

The thickness of the first layer of fill to be placed may be increased to 30 cm and shall be compacted to a minimum of 90 percent of the maximum dry unit weight by rollers or tampers which will prevent disturbance of the existing subgrade.

#### 4. COMMON BACKFILL AND FILL

Backfill and fill required against exterior walls and under structures for grading and not under pavement and pipelines shall be Material No. 1 placed and compacted to finished grades indicated on the drawings. (Refer to Section 2.2.11.3 for backfill under pavements). The material shall be small chunks of Material No. 1 placed in layers having a maximum thickness of 30 cm before compaction, and shall be compacted sufficiently to prevent settlement by rollers or ramming and wet down as required. Any voids between chunks shall be filled and packed with Material No. 1.

No backfill shall be placed against walls until they and their supporting slabs, if applicable have attained sufficient strength.

Fill required for site grading shall be Material No. 1, deposited within the lines and to the grades shown on the drawings or as directed by the Engineer, making due allowance for settlement of fill and existing subgrade.

Fill shall be placed only on surfaces which have been inspected and approved by the Engineer.

Fill shall be placed in layers measuring not more than 0.40 m in thickness prior to compaction. Each layer shall be compacted by a minimum of two passes of a tractor dozer weighing not less than a sheepsfoot roller or other excavating or compaction equipment approved by the Engineer. Any voids in each layer shall be filled with Material No. 1 and compacted. Fill shall be brought up in substantially level lifts through the site, starting in the deepest portion of the fill.

During the filling operation all roots, debris and organic matter shall be removed from the fill areas and the Contractor shall assign a sufficient number of men to this work to ensure satisfactory compliance with these requirements.

#### 5. STRUCTURAL FILL

The Contractor shall strip the area to be occupied by compacted fills of all topsoil, old fill or unsuitable foundation soils, brush, stumps, wood, trash or other debris.

Stripping of grass and root mat is not required, however, standing grass shall be cut or burned off. The Contractor shall grade the area as required to provide a relatively smooth and level surface to permit drainage of surface runoff and compaction of the subgrade prior to placement of compacted fills. The subgrade shall be compacted by a minimum of two passes of approved compaction equipment. Where

in the opinion of the Engineer, compaction of the subgrade is not desirable, the above compaction requirement will be waived.

Structural fill shall be granular Material No. 3

Structural fill shall then be placed in layers not to exceed 15 cm measured before compaction where hand-guided compaction is used and not to exceed 20 cm where heavy equipment or rollers are used. Structural fill shall be compacted to a minimum of 95% of the maximum dry unit weight.

If fill material is too wet or dry to meet the compaction requirement, the Contractor will be required to alter the water content such that uniform acceptable compaction can be obtained. All fill materials shall be placed and compacted in the dry.

The Contractor shall dewater areas to be filled and shall perform the work in such a manner which will preserve the undisturbed state of the subgrade material.

#### 6. PIPE BEDDING

All buried pipelines and appurtenances are to be constructed to the lines and grades indicated on the drawings. Pipe shall be bedded as specified hereinafter and as specified in Section 2.3 "Installation of Underground Piping and Fittings" in the Standard Specifications and as indicated on the drawings. Bedding shall be granular material No.2 placed as a working mat on the undisturbed bottom of the trench to the depths required and then carried up the sides of the pipe to the required depth. The material shall be compacted under and around the pipe and brought up evenly on both sides of the pipe using suitable equipment. The bedding material shall be compacted against undisturbed earth or sheeting at the sides of the trench.

#### 7. TRENCH BACKFILL AND FILL

Trenches for pipelines shall be backfilled from the working mat or bedding to the required elevation with granular Material No. 2.

Backfill under areas to be paved shall be granular Material No.2, thoroughly compacted to the satisfaction of the Engineer by tamping in 20 cm layers using mechanical rammers.

#### 8. BACKFILLING OF EXCAVATION BELOW NORMAL GRADE

The backfilling of authorized excavations below grade shall be completed with compacted granular Material No. 2 unless otherwise required. Payment for the furnishing and placing of this additional material, shall be by a variation order as specified in the Conditions of Contract.

If the Contractor excavates below or beyond the limits shown on the drawings or specified or directed, such over excavation shall be refilled at the Contractor's expense with lean concrete to a minimum thickness of 15 cm or a layer of compacted granular Material No. 2 or other material satisfactory to the Engineer. The type of material to be used shall be approved by the Engineer.

### **2.2.12 COMPACTION EQUIPMENT**

The Contractor shall provide compaction equipment suited for compaction of the various materials specified. In all cases, the efficiency and acceptability of compaction equipment shall be subject to approval of the Engineer.

Compaction against foundation walls, footings, and piers, in trenches, and in other confined areas, shall be accomplished by manually operated mechanical tampers.

### **2.2.13 GRADING**

The surfaces of filled areas shall be graded to smooth true lines, strictly conforming to grades indicated on the drawings, and no soft spots or uncompacted areas will be allowed in the work. No grading shall be done when the material is too wet, either from rain or from excess application of water.

At such times, work shall be suspended until the previously placed and new materials have dried sufficiently to permit proper compaction or grading, or the Contractor shall mechanically aerate and air dry the material as directed.

### **2.2.14 DISPOSAL OF EXCAVATED MATERIAL**

All excavated materials are to be removed from the site of the work by the Contractor, unless otherwise specified. Excavated material may be used for common fill as indicated by the Engineer.

The Contractor shall provide sufficient transportation, equipment and labor for pipeline installations so that excavated material shall be immediately hauled away.

When the Engineer approves the stockpiling of excavated material at the site, the material shall be neatly piled so as to inconvenience, as little as possible, the work and the public and adjoining property Employers. In no case shall it be stockpiled at the edge of excavations and along canal walls or building foundations where it can introduce a surcharge load to a side slope or lateral load on a structure.

### **2.2.15 PIPE CONNECTIONS AT STRUCTURES**

Pipelines which are not supported on a pile foundation that are laid into a structure from a trench must be capable of withstanding some deflection due to the differential settlement that can not be avoided between a structure on piles and pipe in the native soil, or in fill.

The following methods have been indicated on the drawings or may be required for withstanding this deflection:

- (1) To minimize this settlement, unless otherwise indicated on the drawings, the backfill and fill



materials under the pipe and against the structure wall shall be granular Material No. 2. At the centerline elevation of the pipe, the fill shall extend laterally a minimum of 0.30 m from the outside of the pipe. The fill shall then be sloped downward at two horizontal to one vertical to intersect the native material. This material and compaction shall extend 3 m (measured along the axis of the trench) beyond the structure or to the native trench bottom, whichever is the closer.

- (2) Short lengths of pipe shall be used so that there are a number of joints for flexibility in the pipeline in proximity to the structure.
- (3) The use of right angles and joints may be required to add flexibility in the pipeline in proximity to the structure.

#### **2.2.16 FILL UNDER CONCRETE SLABS**

A minimum of 0.30 m of structural fill shall be placed as required below the slab. Structural fill shall be placed in accordance with Section 2.2.11.5.

A 20 cm leveling course of granular material No. 3 shall be placed in accordance with Section 2.2.11. A five (5) cm course of lean concrete shall then be placed to the elevation of the underside of the slab.

## **DIVISION 2 SITE WORKS**

### **SECTION 2.3 INSTALLATION OF UNDERGROUND PIPING AND FITTINGS**

#### **2.3.1 SCOPE OF WORK**

This section covers the installation of all pipe and fittings in the ground. All installation shall be in strict conformance with the respective manufacturer's instructions and applicable standards other than exceptions as described herein. Wherever the Engineer deems it practical to do so, the installed pipe shall be backfilled with all joints exposed until successful hydrostatic testing has been done.

The intention of these specifications is to cover all types of pipe. Any pipe of a material not specifically mentioned in this section shall be installed in the same manner as the closest listed pipe. For example, should it become necessary to use polyethylene pipe, it shall be installed in the manner outlined for PVC in this specification but in accordance with the manufacturer's recommendations.

At all fittings and valves not in valve chambers, concrete anchorages shall be installed as shown on the drawings.

All clamps, rods, bands, special couplings, nuts, bolts, etc., used to restrain pipe or for other purposes shall be given a heavy coat of a bituminous paint approved by the Engineer before installation. All faces of the material shall be coated. After these items have been installed and tightened a second coat of the bituminous paint shall be given to the exposed items. The bolts and nuts of mechanical joints and flanged joints and blind flanges shall also be given a coat of bituminous paint after the joint has been made up. Care shall be taken to prevent the concrete used for anchorages from coming in contact with joint bolts and nuts.

All trenches shall be free of water and suitable for the requirements of the appropriate joining methods.

At nighttime and lunchtime when pipe laying is not in progress, the end of the pipe shall be covered or has a watertight plug inserted.

The drawings indicate fittings for the convenience of the Contractor. Field conditions may dictate a change in location or additional fittings to be installed.

No pipe shall be installed where any old masonry or concrete encountered in the excavation is closer than 30 centimeters to any part of the pipe or fittings.

The installation of valves, hydrants, and air releases shall be as shown on the drawings.

At locations where the new pipe is to be connected to existing pipes or pipes of a different material, special couplings, fittings or pipe sections shall be used. At connections to existing pipelines extreme care must be exercised to prevent any damage to the existing pipe. The pipe to be connected shall be

exposed and cleaned. A plan of action shall be established with all necessary fittings and specials on hand prior to commencement of the tie in.

### **2.3.2 WORK SPECIFIED ELSEWHERE**

Piping	: Section 15.2
Excavation, Dewatering, Backfill, Fill and Grading	: Section 2.2
Disinfection	: Section 1.5.5
Concrete	: Division 3
Testing	: Section 1.3.3

### **2.3.3 INSTALLATION OF METAL PIPE AND FITTINGS**

#### **1. CAST IRON/DUCTILE IRON**

The pipe shall be handled in such a way to prevent any damage to the cement lining or exterior coating and any damage shall be repaired promptly before installation. For large diameter ductile iron pipes (greater than 600 mm), the ends of the pipe shall have wooden stiffeners at quarter points of the spigot end to prevent any distortion of the pipe at its end. This blocking shall remain in the pipe until it is ready for installation. The pipe shall be stored on site without any stacking unless blocking is provided between layers of pipes.

Any cutting of pipe shall be made by use of acceptable cutting tools and/or machines as required. Cutting of ductile iron pipe shall be by saws operated electrically or pneumatically.

Cutters utilizing compression will not be allowed for cutting ductile iron pipe. All cuts shall be clean and perpendicular to the axis of the pipe. Any damage to the linings shall be repaired.

The pipe shall be bedded in a layer of granular Material No. 2, except where designated on the drawings. Granular Material No. 2 shall be placed in 15 centimeter layers on both sides of the pipe and compacted by hand tools. This filling shall be carried up to the level as specified. Backfilling above the crown is specified elsewhere. No blocking will be allowed under the pipe. The entire length of the pipe shall be firmly and evenly bearing on the sand bedding. Bedding details shall be in accordance with the details shown on the drawings.

Joints for cast iron-ductile iron will be rubber gasket mechanical or flanged. Joints shall be harnessed where specified.

No deflections shall be allowed in excess of that allowed by the manufacturer's recommendations.

Mechanical joints shall be in accordance with the manufacturer's recommendations. The joint surfaces and rubber gasket shall be thoroughly cleaned with soapy water before fit-up. After fit-up the bolts shall be tightened alternately on opposite ends of joints diameters and in rotation around the pipe.

When properly assembled, the gland shall be equidistant from the bell face at all points. Bolts shall be tightened to the following standard torques:

<u>Bolt Size (mm)</u>	<u>Range of Torque (N• m)</u>	<u>Pipe Size (mm)</u>
16	60	
20	100	100-600
24	140	700-800
30	200	900-2600

If effective sealing is not attained at the maximum torque indicated above, the joint shall be disassembled, cleaned and reassembled. No overstressing of the bolts shall be allowed.

Flanged joints shall be made up with a rubber gasket of 3 mm thickness. After cleaning all flanged surfaces, jointing materials shall be tightened with a suitable wrench to proper torque. Nuts spaced at an angle of 180 degrees apart shall be well smeared with grease. All nuts shall be confirmed to be tightened at the designated torque as shown below using a torque wrench.

<u>Bolt Size (mm)</u>	<u>Standard Torque (N• m)</u>	<u>Pipe Size (mm)</u>
16	60	75-200
20	90	250-300
22	120	350-400
24	180	450-600
30	330	700-1200
36	500	1350-1800
42	580	2000-2400
45	700	2600

## 2. STEEL

The ends of the pipe shall have wooden stiffeners installed inside the pipe at quarter points at both ends of the pipe. This blocking shall remain inside the pipe until the pipe has been installed. The Contractor shall prevent any fires being made inside or adjacent to the pipe. While the pipe is stored on site the pipe sections shall be kept free of any objects being stored inside and the larger diameter pipe will be allowed only if blocking is provided between pipes.

The pipe shall be evenly bedded throughout its entire length on a bed of granular Material No. 2. Modifications to this bedding shall only be as indicated on the drawings. Granular Material No. 2 shall be placed on both sides of the pipe and compacted with hand tools in 15 centimeter layers up to the level as specified. No blocking shall be allowed under the pipe. Bedding shall be in accordance with the details shown on the drawings.

Joints for steel pipe and fittings shall be either welded, couplings (restrained or unrestrained) or flanged. The type of joint to be used is listed in the pipe schedule and/or on the drawings.

Welded joints shall be butt weld and in conformance with AWWA C206, "Field Welding of Steel Water Pipe Joints" unless otherwise specified. After the welds have been inspected and approved by the Engineer the lining and exterior coating shall be repaired as specified.

Joints using couplings with restraints shall be installed in compliance with the manufacturer's recommendations. Schedules and details of restraining lugs and rods are shown on the drawings. The lugs shall be welded in compliance with the requirements outlined above for welded joints. Wherever possible the lugs shall be welded on, in the factory prior to lining. If field welding of lugs is done the coating and linings shall be repaired as described above for welded joints.

While the work is in progress and there is need for passage through the pipe, a layer of heavy tar paper shall be laid and maintained in the bottom of the pipe through the entire length. This paper shall be removed at the completion of the work.

All field cutting and mitering of the pipe should be minimized. When such cutting is required it shall be done by a suitable cutting machine, leaving a smooth cut at right angles to the axis of the pipe.

### 3. COPPER PIPE

Copper pipe shall be installed in a trench 30 cm wide and shall have a minimum cover of 50 cm. The pipe shall have 10 cm of bedding. The entire trench backfill and bedding shall be granular Material No. 2. Unions shall be installed in the pipe at intervals not to exceed 10 meters and at least one between each pair of bends. The pipe shall be left exposed until a successful pressure test has been performed.

Pipes shall be installed side by side with a 5 cm space provided between the edges of the pipes. Pipe joints shall be soldered except for unions which shall be screwed. Solder shall be 25-5 for all pipes.

### 4. CAST IRON SOIL PIPE

Cast iron soil pipe shall be the hub and spigot type. Pipe shall be bedded in a 15 cm bed of granular Material No. 2 and installed in a trench adequate in width for installation but not to exceed 60 cm. The entire trench shall be backfilled with granular Material No. 2 compacted in 30 cm layers. The joints shall be jute and poured lead. The lead shall be properly tamped to insure tight joints. The minimum depth of the lead shall be 2 cm. The joint shall be made with a single pour. Any defective joints shall be burned out or cut out and replaced as outlined above.

## **2.3.4 INSTALLATION OF CEMENT MATERIAL PIPE**

### **1. REINFORCED CONCRETE GRAVITY PIPE**

#### **1.1 GENERAL**

The pipe shall be stored and handled in such a way to prevent any damage to the ends. Any pipe with a broken spigot or tongue shall not be used in the work. Rubber gaskets shall be of the proper circumference and fit tightly on the spigot.

All concrete pipe delivered to the site shall be inspected by the Engineer and any pieces rejected shall promptly be removed from the site. Pipe not inspected by the Engineer shall not be accepted in the work. The Contractor shall make ample allowance for time to allow such inspection.

Pipe shall be installed as soon as the excavation is completed to the normal grade of the bottom of the trench. The Contractor shall immediately place granular Material No. 2 in the trench and the pipe shall be firmly bedded in this material to conform accurately to the line and grade shown. No blocking under pipe will be permitted.

A depression shall be left in the bedding at the joint to prevent contamination of the rubber gasket immediately before being forced home. Before the pipe is lowered into the trench, the tongue and groove must be cleaned and free from dirt.

#### **1.2 "O" RING JOINTS**

The "O-Ring" gasket and bell shall be lubricated by a vegetable lubricant furnished by the pipe manufacturer and harmless to the rubber gasket. The pipe shall be properly aligned in the trench to avoid any possibility of contact with the side of the trench and fouling the gasket. As soon as the tongue is centered in the groove of the previously laid pipe, it shall be forced home with jacks or come-alongs. After the gasket is compressed and before the pipe is brought fully home, each gasket shall be carefully checked for proper position around the full circumference of the joint. The jacks or come-alongs shall be anchored sufficiently back along the pipeline so that the pulling force shall not dislodge the piece of pipe already in place. Only a jack or come-along shall be employed to force home the pipe smoothly and evenly and to hold the pipe while backfilling is in progress. Under no circumstances shall crow-bars alone be used nor shall any of the motor-driven equipment be used.

As soon as the pipe is in place and before the come-along is released, backfill shall be placed to the mid-diameter for at least one-half the length of the pipe. Not until this backfill is placed shall the come-along be released. If any motion at joints can be detected, a greater amount of backfill shall be placed before pressure is released.

All pipe is to be laid in an upstream direction unless otherwise approved by the Engineer for each specific instance.

### 1.3 CEMENT MORTAR JOINTS

If used for drainage pipe, cement mortar joints shall be made by caulking all around with twisted jute of proper size to give good alignment to the pipe. Inner surfaces of abutting sections shall be flush and in a smooth grade. The jointing surfaces shall be saturated with water and the annular opening filled with mortar. A 45 degree fillet bead of mortar shall be formed all around from the spigot to the top of the vertical face of bell.

Mortar for jointing shall consist of one part portland cement and three parts sand, using a minimum amount of water sufficient to make a workable mortar.

All joints regardless of type shall be grouted in the following manner:

For 600 mm diameter and larger pipe, the interior joints shall be filled with mortar after the backfilling is completed. The mortar shall consist of one part by volume of cement and 2 parts by volume of well graded coarse concrete sand, meeting the requirements of ASTM C33. The mixture shall have a dry, crumbly consistency and shall be pounded into place and trowelled to make a smooth joint.

Field cutting of reinforced concrete pipe ends shall be done with a carborundum saw or similar device approved by the Engineer. Cutting of special pipe lengths using only a chisel or similar tool is prohibited.

### 2. NON REINFORCED CONCRETE PIPE

Non reinforced concrete pipe shall be installed as described for reinforced concrete. The joints shall be cement mortar and jute. Cutting of pipe will be allowed provided the cut is made in a workmanlike manner and only for locations approved by the Engineer.

### 3. ASBESTOS CEMENT PIPE

Not applicable.

### 4. PRESTRESSED CONCRETE PIPE

All work shall be in full conformance with the manufacturer's recommendations.

Fittings shall be cast iron, ductile iron, or steel and shall have either restrained mechanical joints or flanged joints. Mechanical joints shall be made up as outlined above in Section 2.3.3.

At crossings over canals and ditches, the pipe shall be steel with welded joints where specified. At the junction of the steel to the concrete pipe an adaptor coupling or special pipe section shall be installed. The joints shall be fully restrained and assembled in conformance with the pipe manufacturer's recommendations.

The pipe shall be bedded as shown on the drawings. The bed shall be provided with a continuous even bearing for the entire length of the pipe.

The joints of the pipe and fittings shall be restrained or flanged and installation shall be in full compliance with the manufacturer's recommendations and these specifications.

A depression shall be left in the bedding material at the joint to prevent contamination of the rubber gasket immediately before being forced home. Before the pipe is lowered into the trench, the tongue and groove must be cleaned and free from dirt. Gasket and bell shall be lubricated by a vegetable lubricant. The pipe shall be properly aligned in the trench to avoid any possibility to contact with the side of the trench and fouling the gasket. As soon as the tongue is centered in the groove of the previously laid pipe, it shall be forced home with jacks or come-alongs. After the gasket is compressed and before the pipe is brought fully home, each gasket shall be carefully checked for proper position around the full circumference of the joints. Steel inserts shall be used to prevent the pipe from going home until the feeler gage is used to check the final position of the gasket. The jacks or come-alongs shall be anchored sufficiently back along the pipeline so that the pulling force will not dislodge the pieces of pipe already in place. Only a jack or come-along shall be employed to force the pipe home smoothly and evenly and hold the pipe while back-filling is in progress. Under no circumstances shall bars alone be used nor shall any of the motor driven equipment be used.

As soon as the pipe is in place and before the come-along is released, sand backfill shall be placed to the middiameter for at least one half the length of the pipe. Not until this backfill is placed shall the come-along be released. If any motion at joints can be detected, a greater amount of backfill shall be placed before pressure is released.

When each section of pipe is in final position, the interior joints shall be filled with mortar to the inside flush surfaces completely around the pipe circumference. See Division 3 for mortar requirements.

All pipes shall be sound and clean before laying. When laying is not in progress, including lunchtime, the open ends of the pipe shall be closed by a water tight plug or other approved means.

The pipe shall be protected from flotation. Good alignment shall be preserved in laying. Fittings, in addition to those shown on the drawings, shall be installed as required.

All metal portions, including nuts and bolts, of the joints shall be given a heavy coat of coal tar paint which has been approved by the Engineer. This paint shall be applied after the joint has been made up except for parts which will not be able to be painted when the joint has been made up.

Joints shall not be backfilled until the pipeline has successfully passed leakage and pressure tests. The Engineer may elect to waive this requirement if in his opinion traffic conditions warrant him to do so. The Contractor shall be fully responsible for protection of exposed joints.

At connections to valve chambers the concrete pipe shall be joined to the steel pipe by special adaptor pieces and the joint shall be fully restrained. No field cutting of concrete pipe will be allowed. Minor



changes in alignment shall be made by using bevel adaptors manufactured by the same company as the pipe. Bevel adaptors shall have restrained joints or flanges.

### **2.3.5 INSTALLATION OF PLASTIC MATERIAL PIPES**

#### **1. POLYVINYL CHLORIDE**

Careful consideration must be given to the handling and storage of polyvinyl chloride pipe and fittings. The pipe must be stored to avoid contact with any direct sunlight. Extreme care must be made to prevent any scarring or nicking of the pipe from bearing on sharp objects. Any pipe which has any cut or bruised deeper than 10% of the wall thickness will be rejected and shall not be used in the work. The section of pipe with such a cut shall be rejected in its entirety. The pipe shall be stored in such a manner that no direct sunlight is on the pipe but ventilation is provided. Covering the pipe with a tarpaulin shall not be allowed. Stacking shall not exceed 60 centimeters in height.

The pipe shall be bedded as shown in the drawing. The same material shall be placed alongside the pipe and compacted in 20 cm layers up to the crown of the pipe.

The joints shall be rubber gasket type. The socket and spigot of the pipe shall be carefully cleaned before the rubber ring is set in place. The spigot shall then be covered with an approved lubricant and the pipe pushed into the socket. Pushing the pipe into the socket shall be done by barring against the opposite end of the pipe being installed. A wooden block or other suitable device shall be used to prevent any damage to the socket against which the bar is being pressed. No blocking will be allowed under the pipe and it shall bear evenly along its entire length on the bedding material.

Cutting of the pipe shall be kept to a minimum. When cuts are necessary they shall be perpendicular to the axis of the pipe and smooth. Cuts shall be made with tools in conformance with the pipe manufacturer's recommendations. Cut ends shall then be tapered and beveled with a special tool made for that purpose and the beveled end shall be exactly the same as the spigot end of the pipe as manufactured at the factory.

If any solvent weld joints are allowed by the Engineer they shall be made in strict accordance with the manufacturer's recommendations and utilize only solvents furnished by the manufacturer. In addition it will be necessary to snake the pipe so that an offset from true horizontal alignment of 30 cm in 30 m of laying length will be provided. Care shall be taken to insure that the temperature of both sections of pipe being jointed are the same.

Solvent joints shall be used only after written approval by the Engineer.

### **2.3.6 CONNECTIONS TO EXISTING PIPES**

Existing mains shall be exposed and cleaned. Before any cutting and shutdown of the main is begun the details and schedule for making the connection shall be worked out between the Contractor and the

Engineer.

The existing pipe shall be carefully measured in particular the outside diameter. The couplings to be used to join the new nipple piece to the existing pipe shall be compatible with the diameter so measured. Details of these connections are shown on the drawings. No modifications to the coupling or its gasket shall be allowed. The schedule of shutdown shall be worked out and kept to a minimum by use of prefabrication of pipe and fittings to be installed. The shutdown shall be made by water supply enterprise crews operating the valves. In some instances these shutdowns will be required to be made at night or on Sundays or holidays.

Once the shutdown has been made the cut shall be made as quickly as possible but in a workmanlike manner using cutting tools which will insure a clean even cut without any damage to the pipe. As soon as the installation of the new fittings, pipe and valve has been completed, the Contractor shall brace the pipe and fittings to the satisfaction of the Engineer. This bracing shall not be removed until permanent anchorage of size and detail shown on the drawings has been installed.

During the time the cut pipe is exposed the Contractor shall protect the cut ends by covering with plastic or other suitable means. The inside of new fittings, pipes and valve shall be cleaned thoroughly before installation. Calcium hypochlorite shall be deposited in the branch pipe prior to final fit up. As soon as the assembly has been installed and braced, water supply enterprise shall reopen the valves on the existing pipe.

Any observed minor leaks shall be immediately corrected. Major leakage or failure shall be repaired immediately by installation of new fittings or a repair sleeve. In any case the work on "cut-ins" shall be a continuous operations until a successful leakless installation has been made.

When the existing mains are not removed, as soon as the connection to the existing pipe with the new pipe has been completed, the cut ends of the existing pipe in the ground shall be plugged by a wooden plate and encased with concrete to avoid cave-in of the road.

### **2.3.7 PIPE INSTALLATION IN A JACKED CASING**

#### **1. GENERAL**

The Contractor shall install pipelines in underground sleeves where indicated on the drawings. These specifications shall also apply to locations where the Contractor elects to install pipe in a sleeve to avoid open excavation and where required by the Engineer.

Where jacked sleeves are indicated on the drawings the cost of this work shall be understood to be included with the lump sum bid price. Where the Contractor elects to use a sleeve for installation this shall be done at no increase in cost to the Employer. Where the Engineer requires a sleeve installation that is not indicated on the drawings this additional work shall be done under variation order as described in the Conditions of Contract.

The Contractor shall be fully responsible for inspecting the location and shall familiarize himself with the conditions under which the work will be performed and with all necessary details as to the orderly prosecution of the work. The omission of any details for the satisfactory installation of the work in its entirety which may not appear herein, shall not relieve the Contractor of full responsibility.

Before starting work, the Contractor shall submit for approval a detailed schedule of the entire jacking operation, details of the sleeve to be used and the intended methods of jacking, and installation of the pipe. Approval of such a schedule shall not relieve the Contractor of his responsibility to provide a fully satisfactory installation.

Shop drawings of the sleeve and all fabrication and erection details of the jacking equipment shall be submitted for approval prior to fabrication and delivery.

## 2. INSTALLATION

The equipment shall be suitable for jacking the required sleeve length designated on the drawings or as required.

The Contractor shall install, maintain, and remove all sheeting, underpinning, cribbing and appurtenances required to support any existing structure or facility.

If any movement or settlement occurs which causes or might cause damage to structures, over, along or adjacent to the work, the Contractor shall immediately stop any or all work except that which assists in making the work secure and in preventing further movement, settlement or damage.

The Contractor shall resume jacking, after obtaining approval of the Engineer, at the place where such movement, settlement or damage, and shall repair the damage, at his own cost, to the satisfaction of the Engineer.

The jacking pits shall be provided with a sufficient number of engine driven dewatering pumps and sump drainage to maintain a firm dry working surface in the shaft area and over the entire working face of the sleeve at all times until the jacking operation is complete and approved.

The Contractor shall be fully responsible for the removal of the jacking pit. All work required in conjunction with such removal shall be included in the work of this section including the breaking up, removing, and disposing of concrete, if so required, or cutting off of sheeting and furnishing and placing fill.

## 3. SLEEVE

Unless otherwise specified on the drawings, the size and wall thickness of the casing (sleeve) to be jacked to accommodate the contract pipeline shall be at the Contractor's option, except that the casing thickness shall be not less than 9.5 mm, and the Contractor shall be fully responsible for sufficiency of the casing provided.

The sleeves shall have both the interior and exterior coating with coal tar enamel prior to jacking. After the sleeve has been jacked into position the entire interior surface of the sleeve shall be cleaned and given a second coat of coal tar enamel.

#### 4. EXCAVATION

Earth shall be excavated from within the jacked sleeve as required to install the pipe in the required location. Earth may be removed as the sleeve is jacked so that any corrections in alignment can be made. Earth shall not be removed too close to the cutting edge in order to prevent voids from forming outside the sleeve. In the event of encountering obstructions which will not allow driving in safely or to the correct line the work shall be discontinued until agreement is reached on how to proceed.

The pipe shall be installed in the sleeve to the line and grade required and after having been satisfactorily placed and approved by the Engineer, the space between the outside of the pipe and the sleeve shall be completely filled with granular Material No. 2 pumped in one continuous uninterrupted operation in a manner to prevent occurrence of voids between the pipe and the sleeve. The pipe shall be braced at the sides and top of sleeve to prevent motion during the placing of the sand. A brick bulkhead shall be placed at the ends of the sleeve. Details of bulkheads shall be such as to prevent rigid connection between pipe and sleeve.

#### 5. TESTING

If the Engineer deems it necessary he may call for pressure and leakage testing of the section of the main in the sleeve separately from the rest of the system. The Contractor shall be fully responsible for providing taps, pipe, fittings, etc. and all necessary equipment and anchorage to perform the tests in accordance with the testing procedures outlined elsewhere in these specifications. At the time of testing the remainder of the system, the section of main in the sleeve will again be tested as part of the entire system.

**DIVISION 2 SITE WORKS**

**SECTION 2.4 LANDSCAPING**

**2.4.1 SCOPE OF WORK**

Furnish all labor, materials, equipment and incidentals necessary to loam, grass, plant and maintain all new planted areas as indicated on the drawings and/or specified herein. Existing grassed and planted areas which are disturbed by the new work and/or the Contractor's operations shall be restored to a condition equal to that at the start of the work or as shown on the drawings under the applicable subsections of this specification.

**2.4.2 MATERIALS**

**1. LOAM**

Loam shall be fertile, natural soil, typical of the locality free from large stones, roots, sticks, clay, weeds and shall be obtained from an approved source. It shall not be excessively acid or alkaline nor contain toxic material harmful to plant growth. Topsoil stockpiled under Section 2.2, "Excavation, Dewatering, Backfill, Fill and Grading" may be used, but the Contractor shall furnish any additional loam at his own expense.

**2. FERTILIZER**

Fertilizer shall be a complete commercial fertilizer, 10-10-10 grade, delivered to the site in the original unopened container each showing the manufacturer's guaranteed analysis. It shall be stored so that when used it shall be dry and free flowing.

**3. TREES AND PLANTS**

Trees and plants shall be of selected stock and shall be obtained from a nursery that can demonstrate that it has furnished satisfactory trees and plants in the plant site area in the past. Trees shall be about 1 meter in height as measured from the burial line to the top of tree. The types and number of trees indicated on the drawings shall be planted. Plants shall be an average among 15 and 30 cm high and shall be of the types and numbers indicated on the drawings.

**4. SOD**

Sod shall be obtained from the local area and be free from noxious weeds and coarse, burned or bare spots. Sods shall be cut into rectangular sections or strips which may vary in length but which shall be uniform width. Sod may be removed in individual flat slabs, in folds, or in rolls, provided that the sizes of the sections of strips shall be such as to permit handling without breaking. The form in which the sods are to be removed shall be approved by the Engineer. Generally, longer sections will be permitted in removing sod from clay topsoils than from soil containing a high percentage of sand.

The sections shall be severed below the root line with an approved sod cutter or sharp, flat spade and placed in temporary storage piles or transported directly to the proposed final locations.

Sod shall be about 4 cm thick and shall be of acceptable variety.

### **2.4.3 INSTALLATION**

#### **1. SODDING**

The subgrade of areas to be sodded shall be raked and all rubbish, sticks and lumps of soil shall be removed. Topsoil (loam) shall be spread and lightly compacted to a depth of 10 cm. Over areas to be grassed, apply fertilizer as recommended. Sods shall be placed in a solid strip laid edge to edge with staggered joints. All sods shall be very carefully handled to prevent loosening and separation of the topsoil from the roots. The combined thickness of the sod and topsoil shall be at least 13 cm. The sod shall be settled by watering and by tamping a board laid over it.

Thereafter, the sodded areas shall be watered by sprinkling, during the early morning or late afternoon of each day until good growth has been established.

#### **2. PLANTING**

Tree pits shall be excavated with vertical sides. Tree pits shall be 60 cm greater in diameter than the ball of earth or spread of roots of the tree and sufficiently deep to allow for a 13 cm thick layer of loam (topsoil) beneath the ball or roots.

The depth of planting beds and pits shall be adjusted as necessary to permit a minimum of 10 cm of topsoil under balls or roots of all plants. Depth of planting soil shall be at least 30 cm over entire planting area.

Plant pits shall not be backfilled with topsoil until they have been approved by the Engineer. If pits are prepared and backfilled with topsoil on grade prior to planting, their location shall be marked and recorded on the drawings so that when planting proceeds they can readily be found. Plants shall be planted to the densities noted in the schedule.

Plants shall be set in center of pits plumb and straight and at such a level that after settlement, the crown of the plant will be at or not more than 5 cm lower than the surrounding finished grade.

- (1) When balled and burlapped trees are set, topsoil shall be compacted around bases of balls to fill all voids. All burlap, ropes or wires shall be removed from the tops of balls.
- (2) Roots of bare root plants shall be properly spread out and top soil carefully worked in and any broken or frayed roots shall be cut off clean.
- (3) Topsoil around roots or balls shall be thoroughly compacted and watered. Immediately after the plant pit is backfilled, a shallow basin slightly larger than pit shall be formed with a ridge of soil to facilitate and contain watering. After planting, the soil in the shrub beds shall be cultivated between shrub pits, raked smooth and neatly outlined.

#### **2.4.4 MAINTENANCE DURING PLANTING OPERATIONS**

Maintenance shall begin immediately after each plant is planted and shall continue until the Contract is completed. Plants shall be watered, mulched, weeded, pruned, sprayed, fertilized, cultivated and otherwise maintained and protected until acceptance. Settled plants shall be reset to proper grade and position, planting saucer restored and dead material removed. Defective work shall be corrected as soon as possible after it becomes apparent and weather and seasons permit. Upon completion of planting, the Contractor shall remove from the site excess soil and debris and repair any damage to structures etc., resulting from planting operation.

#### **2.4.5 MAINTENANCE FOLLOWING PLANTING**

Any additional maintenance required following the completion of the Contract shall be done by the Contractor at no expense to the Employer. The plantings shall be watered in a satisfactory manner during and immediately after planting, twice per week, for a period of three weeks and as required to ensure proper care and growth until completion of the Contract.

#### **2.4.6 INSTRUCTIONS TO EMPLOYER**

Full and complete written instructions for maintenance and proper care and development of the landscaping are to be furnished by the Contractor to the Employer at least 10 days prior to the completion of the work.

#### **2.4.7 FINAL INSPECTION**

The Engineer will inspect the conditions of the planting and seeding done under this Contract within two months after acceptance of the works. Any planting, seeding, sodding, etc. required that is dead or not satisfactory in growth as determined by the Engineer shall be removed and replaced with plants of the same kind and size as required.

## **DIVISION 2 SITE WORKS**

### **SECTION 2.5 PAVING**

#### **2.5.1 SCOPE OF WORK**

Furnish all labor, materials, equipment and incidentals for restoration of existing pavements, sidewalks and curbs which are disturbed by the work and for the construction of new pavement and curbs as shown on the drawings and as herein specified.

Granular materials where required for pavement subbase or paving are specified in Section 2.2 "Excavation, Dewatering, Backfill, Fill and Grading".

Concrete, reinforcing steel, joints, finishes and other related work to concrete pavement are specified in Division 3 and hereinafter.

The Contractor's attention is directed to the fact that the placing of fill for roads and dewatering operations will cause consolidation (settlement) of the native subsoil. No permanent pavements are to be placed until authorized by the Engineer. The Contractor will be required to construct temporary access roads in the same location as the permanent roads are to be constructed so that the existing subgrade will be subject to surcharge loads well in advance of the placing of the permanent pavement.

#### **2.5.2 PREPARATION OF DISTURBED SUBGRADE**

No subbase material for new or restored pavements shall be placed until the Engineer has inspected and approved the subgrade.

Backfilling of excavations and fill is specified in Section 2.2 "Excavation, Dewatering, Backfill, Fill and Grading". The required subbase material may be placed in conjunction with backfilling or at a later time. Exceptions to this are in sidewalks and soils subject to traffic, where the specified backfill material shall be placed to the top of the excavation at the time of backfill. Prior to placing permanent pavement the temporary paving, if any, shall be removed and the subbase reshaped and rolled. If the subbase has not been placed, the backfill material shall be excavated to the depth required to place the specified subbase.

#### **2.5.3 PREPARATION OF EXISTING SUBGRADE**

##### **1. GENERAL**

New pavements are to be constructed with the subbase materials required on compacted subgrade. Where the existing material has been disturbed it shall be removed to the depth required to reach undisturbed material and the first layer of new subgrade placed thereon.

Where new or restored pavements are to be constructed across or parallel to trenches and other



disturbed or filled areas, the backfilling and compaction are specified in Section 2.2 "Excavation, Dewatering, Backfill, Fill and Grading."

## 2. PREPARATION OF SUBGRADE

The subgrade shall be shaped and compacted in accordance with the drawings and specifications and completed for at least 150 meters ahead of the placing of the subbase course material. Clay subgrade beneath pavements shall be compacted to a minimum of ninety percent (90%) of the maximum density determined from ASTM D698 Method A. Where, in the opinion of the Engineer compaction of the subgrade is not desirable, the compaction requirement will be waived.

### 2.5.4 SUBBASE MATERIALS AND INSTALLATION

Granular materials required for the subbase of pavements shall be placed in layers and compacted as shown on the drawings and as required in the following schedule:

Granular Material <u>No.</u>	Max. Layer* <u>Thickness (cm)</u>	Required ** <u>Compaction</u>
2	20	93 %
12	20	95 %

\* Thickness as measured before compaction

\*\* Maximum Dry Density, determined of ASTM D1557 Method D

Compaction equipment used in compacting subbase materials and asphalt wearing surfaces shall be the power rammer or frog-jump type compactor weighing a minimum of 50 kg or a roller of not less than 8,000 kg.

Subbase material containing excess moisture shall be dried prior to or during compaction at the Contractor's expense, by methods approved by the Engineer.

The finished subbase shall not vary more than 1.5 centimeters above or below the planned grade or any point. Subbase which does not conform to the above requirement shall be reworked, watered and thoroughly recompact to conform.

## 2. SPREADING GRANULAR MATERIAL

The subbase course shall be constructed in layers not exceeding 20 cm in thickness measured before compaction.

Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with pneumatic tired rollers, three-wheel or tandem rollers, or other equipment approved by the Engineer. Rolling operations shall begin from the outer edge of the roadbed toward the center, parallel to the centerline of the road; except on superelevated curves, where rolling shall begin at the

low side and progress toward the high side.

## **2.5.5 BASE COURSE MATERIALS AND INSTALLATION FOR PAVEMENT AND SIDEWALK**

### **1. GENERAL**

Granular materials required for the base course of pavements shall be placed in layers and compacted in accordance with the following schedule:

Granular Material <u>No.</u>	Max. Layer * <u>Thickness (cm)</u>	Required ** <u>Compaction</u>
7	20	95

\* Thickness as measured before compaction

\*\* Maximum Dry Density, ASTM D 1557 Method D

All new and restored concrete sidewalks are to be constructed on a compacted base consisting of 10 cm of granular material No.2. The base shall be compacted by two passes of hand operated mechanical compaction equipment approved by the Engineer.

### **2. CONSTRUCTION PROCEDURE FOR PAVEMENT BASE**

The base shall be granular material for pavement base placed and compacted to the depth indicated on the drawings.

Base shall be spread in layers with uncompacted thickness up to 20 centimeters subject to the approval of the Engineer and the layers shall be as nearly equal in thickness as possible. Care shall be taken to prevent segregation of the material into coarse and fine parts.

Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment approved by the Engineer.

Rolling operations shall begin along the edges and overlap the shoulder at least 75 centimeters, or as close to the outer edge of the shoulder as practicable where a full width roadbed base course is specified on the drawings, and progress toward the center, gradually in a longitudinal direction. On superelevated curves, rolling shall begin at the low side and progress toward the high side. The rolling operation shall continue until all roller marks are eliminated, and the course is thoroughly compacted.

Each layer shall be compacted to at least 95% of the maximum dry density as determined by ASTM D1557 Method D. Density of the compacted base course shall be determined by ASTM D1556.

Base course material which does not contain sufficient moisture to be compacted in accordance with the requirements of this section shall be sprinkled with water. The Contractor shall supply the necessary water at his own expense.

Base course material containing excess moisture shall be dried prior to or during compaction. Drying of wet material shall be performed by methods approved by the Engineer, at the expense of the Contractor.

Any irregularities which may develop in the surface during or after construction shall be corrected by removing or loosening the surface, and adding further material as required.

The finished surface of base course on which pavement is to be placed shall not have any deviation in excess of one centimeter from a straight edge 3 meters long applied to the surface paralleled to the centerline of the road and 1.25 centimeters from a template laid transversely, and shall be corrected by loosening, adding or removing material, reshaping and recompacting.

### **2.5.6 BITUMINOUS PAVEMENT**

#### **1. GENERAL**

All new bituminous pavement shall be asphalt concrete as hereinafter specified. Bituminous surface treatment is specified where required to match existing pavement or where specifically called for.

#### **2. BITUMINOUS PRIME (TACK) COAT**

Prime (tack) coat shall be applied on the finished surface of base course or existing pavement before laying permanent bituminous pavement. Rapid setting emulsified asphalt shall be used for prime (tack) coat. It shall be homogeneous and show no separation of asphalt of the thorough mixing within 30 days after delivery. Before applying the prime (tack) coat, all loose dirt and other objectionable materials shall be removed from the surface by means of the power broom or blower supplemented with hand brooms. Asphaltic material shall be applied by means of a distributor at the rate or 0.5-1.5 liters per square meter.

#### **3. BITUMINOUS SURFACE TREATMENT**

The base or subbase surface shall be graded as shown on the drawings or as determined by the Engineer, and shall receive the following bituminous surface treatment. Materials shall be granular material and rapid setting emulsified asphalt as herein before specified, placed in two applications.

On the surface already treated with bituminous prime coat, prior to the application of binder, loose dirt and other objectionable material shall be removed from the surface by means of power broom or other approved methods.

The first application of emulsified asphalt shall be made uniformly at a rate of 0.8 - 1.5 liters per square meter by means of the distributor, except in small areas the Engineer may approve the application by means of hand spray equipment attached to the distributor. Application temperature shall be within the range of 24 - 55 deg. C. Immediately following the first application of asphaltic material, the granular material No. 9 shall be spread uniformly within the limits of 18 - 28 kilograms

per square meter. Immediately after spreading to the satisfaction of the Engineer, the surface shall be compacted adding granular material No. 9, as required, to produce a dense even surface. All surplus granular material shall be swept off the surface and removed prior to the second application.

The second application of emulsified asphalt shall promptly follow. It shall be applied at a rate of 0.7 - 1.2 liters per square meter. Granular material No. 10 shall then be spread uniformly within the limits of 8 - 14 kilograms per square meter.

The granular material shall then be rolled and broomed until a smooth even textured surface is produced. The completed surface shall not be subjected to traffic for at least 24 hours.

#### 4. HOT MIX ASPHALT PAVEMENT (ASPHALTIC CONCRETE)

Materials for hot mix asphaltic concrete shall consist of a mixture of asphalt cement, granular material No. 8 and granular material No. 13 as mineral filler. Asphalt cement shall conform to AASHTO M20, penetration grade 85 - 100. Asphalt cement is to be added at 4.5 to 6.5% by weight of total mix.

Laboratory test specimens of paving mixes, combined in the proportions of the job-mix formula, shall be prepared and tested in accordance with the design procedures set forth for the Marshall Method of mix design and shall satisfy the requirements given below when tested in accordance with ASTM D1559, "Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus".

Marshall Stability, lbs	1000 minimum
Flow, 0.01 inch.	8 - 18
Percent voids in total mix	3 - 5

Use 50 blows on each end compaction effort for this mix design.

The job-mix formula shall be submitted for the Engineer's approval and he may change the grading as well as the bitumen content to obtain optimum quality of the completed mix.

- 4.1. Heating of Asphalt Materials: Asphalt cement shall be heated to a temperature between 121 deg. C and 163 deg. C. The Engineer will approve the exact temperature.
- 4.2. Heating of Mineral Aggregates: The mineral aggregates shall be heated to a temperature between 135 deg. C and 177 deg. C.
- 4.3. Heating of Mixture: The mixture when emptied from the mixer shall be at a temperature within the absolute limits of 135 deg. C even allowing for tolerances.
- 4.4. Delivery of mixture: The mixture shall be delivered on the road at a temperature within the absolute limits of 107 deg. C and 163 deg. C even allowing for tolerances.
- 4.5. Compaction: The mixture shall be compacted at a temperature within the absolute limits of 107 deg. C and 135 deg. C. The density of all samples taken from the compacted surface course shall be not less than 98% of the Marshall Density obtained in a laboratory specimen of the same mixture when subjected to 50 blows per side in the Marshall mold Pavement sections of the newly finished work shall be protected from traffic of any kind until the mixture has cooled to approximately ambient air temperature. Traffic shall not normally be permitted on

the newly laid surface less than 24 hours after completion of the pavement, except with the approval of the Engineer.

### **2.5.7 CONCRETE PAVEMENT**

Concrete for restoring existing street surface shall be Class A and shall be reinforced as required to match the existing pavement. New concrete pavements unless otherwise specified herein or indicated on the drawings shall conform to the construction methods for placing concrete, forms, reinforcement, joints, finishing and curing specified by the local codes insofar as they are applicable.

New concrete pavement for roadways and sidewalks shall be class A. It shall be placed to the limits and thicknesses indicated on the drawings.

Concrete pavement shall be placed in one course to the limits indicated on the drawings. Slabs shall be constructed in checker board order. Concrete curbs shall be constructed as indicated. All exposed concrete edges shall be finished with an edging tool having a radius of 1 cm. All paved areas are to be constructed so as to slope to drain. Extreme care shall be exercised to prevent low spots where ponding could occur.

Concrete pavement shall be placed to the thicknesses indicated on the drawings. Where existing reinforcing steel is removed it shall be replaced with equivalent steel.

The details of expansion, construction and longitudinal, transverse joints and their location are indicated on the drawings. Joints shall be filled with a mixture of asphalt and granular material No. 4 in proportion of 1 to 6. Longitudinal joints shall have dowels across the joint with the rods on one side of the joint wrapped in asphalt sheeting.

### **2.5.8 TEMPORARY PAVEMENT**

Where directed by the Engineer the Contractor shall furnish and place temporary bituminous pavement. It is the intention that temporary pavement be placed where existing paved surfaces are disturbed by the work. The Contractor shall furnish, maintain and remove temporary pavement as hereinafter specified.

Temporary pavement shall be cold-mix asphalt as required in the special specifications consisting of granular material No. 11 and 3 - 7% of rapid curing or rapid setting liquid asphalt mixed at recommended temperatures. Liquid asphalt shall be free from water and shall show no separation or curdling prior to use. It shall conform to Grade RC-250 as specified in AASHTO M81.

Temporary pavement is to be placed on the required subbase material for the permanent pavement and shall never be placed on material No. 1. Temporary pavement should be placed to the limits, required to restore paved surface, so as to be suitable surface for traffic. The temporary pavement shall be repaired as necessary to maintain the surface of the pavement until replaced by the permanent pavement. If points of settlements or holes appear in the temporary pavement the Contractor shall

repair the same within three days, after notification by the Engineer. Temporary pavement shall be placed to a minimum compacted thickness of 5 cm. The center of the temporary pavement shall be approximately 3 cm higher than the existing pavement.

### **2.5.9 SIDEWALKS**

New sidewalks are to be constructed using precast reinforced concrete slabs to the limits and details indicated on the drawings.

Existing sidewalks to be restored following excavation for the work shall be replaced to their original condition using similar materials and in equal thickness and appearance. Existing concrete tiles for sidewalks shall be of the types similar in their configurations and qualities to the existing ones. Sidewalks constructed of cast in place concrete with and without reinforcing steel shall be restored to their original condition. New sidewalks are to be constructed in conformance with the drawings.

### **2.5.10 PAINTING LINES**

Areas of new pavement indicated for parking shall be provided with white lines as detailed on the drawings. Lines and arrows shall also be painted on new pavement to direct the flow of vehicular traffic. No painting is required to restore existing street lines disturbed by construction.

White paint for concrete or asphalt paving stripes shall be a type specifically manufactured for this application containing reflective glass beads. It shall be highly abrasive and wear resistant. Samples must be submitted to the Engineer for final approval.

### **2.5.11 MAINTENANCE**

The Contractor shall maintain pavement placed under this Contract during the specified maintenance period and shall promptly refill and repave areas which have settled or are otherwise unsatisfactory for traffic.

## **DIVISION 2 SITE WORKS**

### **SECTION 2.6 FENCING**

#### **2.6.1 SCOPE OF WORK**

Provide all labor, materials, equipment and incidentals necessary to furnish and install all fences, as required by the drawings and as specified herein.

The work specified herein includes various types of security fences, walls, chain link fences, gates and appurtenances.

#### **2.6.2 WORK DESCRIBED UNDER OTHER SECTIONS**

Excavation, Dewatering, Backfill, Fill and Grading	: Section 2.2
Concrete	: Section 3.1
Concrete Reinforcement	: Section 3.2
Masonry Work	: Section 4.1
Structural Steel Work	: Section 5.1
Miscellaneous Metals	: Section 5.2
Painting	: Section 9.1
Concrete Finishes	: Section 3.3

#### **2.6.3 SECURITY FENCES**

The Contractor shall furnish and install security fences of the various types to the limits indicated on the drawings. Included are pedestrian gates and double gates for vehicular traffic. These fences are constructed on a mat foundation or a wood pile foundation with a reinforced concrete frame and either a masonry wall or metal grill and topped by 3 barbed wires. The vehicular gate includes roller bearing casters with a roll on metal surface which will ride on a metal surface set in a concrete beam in the pavement.

The metal grill for the fence and the gates will be of the sections indicated on the drawings and of welded construction. Fabrication of this grill and the gates will conform to Division 5, "Metals".

Barbed wire shall consist of 2 wire strand of No. 12 gauge galvanized wire with 4 point barbs spaced approximately 10 cm apart and the weight of zinc coating shall be in accordance with JIS G 3535 Class 1 or other internationally accepted standards or manufacturer's standards as approved by the Engineer. The barbed wires shall be installed on hooks embedded in the reinforced concrete extensions to the fence posts and steel extensions on the gates all as indicated on the drawings.

Shop and field painting of the grill and gates shall conform to Section 9.1.

## **2.6.4 CHAIN LINK FENCE**

### **1. GENERAL**

The chain link fence and chain link gates are to be completely galvanized. Ornamental iron gates are to be painted. It is the intent that the erection of the fence and gates will require very little welding. Where welding is required the surface shall be cleaned and painted as specified in Section 9.1.

### **2. MATERIALS**

Fabric shall be 2.10 meters high unless otherwise shown and shall be woven in a 5 cm mesh of No. 9 British Standard (BS) wire. The wire shall be zinc coated before weaving and the weight of zinc coating shall conform to local applicable Standard.

Top salvage shall have a twisted and barbed finish; bottom salvage shall have a knuckled finish.

Pipe for posts, frames and bracing shall be conformed to BS 1387 medium class and shall be galvanized. Fittings shall be hot dip galvanized pressed steel, conforming to BS 1740.

Tension wire shall be No. 6 BS gauge single strand. Extension arms shall be 5/16 inch thick steel plate. Barbed wire of 2-wire stand No. 12 gauge with 4-point barbs spaced approximately 10 cm apart. Concrete for fence posts shall be Class B unless noted otherwise.

### **3. FENCE CONSTRUCTION**

Pipes for the following purposes shall be the sizes noted.

	<u>O.D. Millimeters</u>	<u>Length (Meters)</u>
Line Posts	60	3.0
Terminal Posts*	89	3.0
Top Rail	43	as required
Bracing	43	as required
Gate Frames (pedestrian)	43	as required
Gate Frames (vehicular)	60	as required
Gate Posts	89	as required

\*End, corner and straining posts

Galvanized couplings of the outside sleeve type at least 18 cm in length shall be used to joint top rails. The top rail shall extend through all line posts to form a continuous brace from end to end of each stretch of fence and secured to each terminal post with a receptacle fitting.

Braces shall be installed horizontally midway between top rail and the bottom of the fence and shall extend from the terminal post to the first adjacent line post. End and gate posts shall have one brace;



corner and straining posts shall have two braces (one each side).

Gate frames shall include galvanized malleable iron hinges, latch and latch catch. Gate latches shall be suitable for a padlock which can be attached and operated from either side of gate. Gates shall be furnished with suitable hinges permitting 90° swing both in and out and suitable hardware to hold the gates open. Double gates shall be furnished with drop bar locking device.

Tension wire shall be stretched taut along the bottom of the fabric and shall be securely attached to all terminal and line posts and to the bottom of the fabric at 45 cm intervals. Spacing between tension wire and finished grade shall not be less than 5 cm and not more than 16 cm.

Fabric shall be fastened to the top rails, posts, braces with suitable tie wires at approximately 45 cm intervals.

#### 4. SETTING FENCE POSTS

Fence posts shall be set in cast in place concrete footings (Concrete Class B). Footings for line posts shall be 30 cm square by 90 cm deep and for terminal posts 35 cm square by 1 meter deep. Steel posts shall extend to within 10 cm of bottom of concrete, and shall be exactly in line, plumb and even across the tops. Concrete footings shall be allowed to set for at least 72 hours before fabric erection is started. Line posts shall be installed with a maximum spacing of 3.0 meters and at points where there is a change in grade.

The tops of concrete footings shall be sloped to drain.

## **DIVISION 3 CONCRETE**

### **SECTION 3.1 - CONCRETE**

#### **3.1.1 SCOPE OF WORK**

Provide all labor, equipment, materials and incidentals required to furnish mix, transport, and place all concrete work and install miscellaneous related items including forms, sleeves, anchor bolts, inserts and embedded items.

#### **3.1.2 GENERAL PROVISIONS**

Concrete shall be composed of portland cement, fine aggregate, coarse aggregate, water and admixtures, as specified, and shall be made at the site of the work, except as otherwise authorized in writing by the Engineer. Central mix or transit concrete may be permitted, provided it can be placed within the time requirements specified, and complies with all of the provisions herein specified.

Reinforced concrete and workmanship unless otherwise specified, shall conform to the standards set forth in the relevant sections of the Particular Specifications. Where the local codes listed do not have applicable provisions, construction shall be in accordance with internationally accepted standards and those acceptable to the Engineer.

All testing and inspection services required, will be done at the cost of the Contractor unless otherwise specified herein. Methods of testing will comply in detail with the applicable JIS Methods of Test.

#### **3.1.3 SUBMITTALS**

Samples of constituents and of concrete as placed will be subjected to laboratory tests. The Contractor shall submit samples as directed by the Engineer. All materials incorporated in the work shall conform to the approved samples.

The Contractor shall design the concrete proportion for all classes of concrete and submit his proposal together with the test results of the concrete strength of all classes of the concrete proportion design for the approval of the Engineer. The design of the concrete proportion and the concrete strength test shall be made in an independent laboratory approved by the Engineer. The Contractor is responsible for all expenses incurred in this process.

#### **3.1.4 QUALITY**

The Contractor shall furnish and place concrete as required by these specifications. The concrete to be produced and placed shall be of highest quality and uniformity. The Contractor, in all phases of his operations, will be subject to strict inspection to provide concrete construction of excellent quality.

Emphasis will be placed on the uniformity of the concrete aggregate, water-cement ratio, consistency,

air content, curing and temperature control of the concrete at the time of placement in the forms.

The consistency of the concrete in successive batches shall be determined by JIS A 1101 “Method of test for slump of concrete”. Concrete shall be of such consistency and mix composition that it can be readily worked into the corners and angles of the forms and around the reinforcement, inserts, embedded items and wall castings without permitting materials to segregate or free water to collect on the surface, due consideration being given to the methods of placing and compacting.

No excessively wet concrete will be permitted and, if at any time, concrete of consistency beyond the limits specified in the Particular Specifications is delivered to the job, the Engineer may direct the Contractor to reject the concrete or to add extra cement for which no additional payment will be made. A supply of cement shall be kept available at the site for this purpose. No additional water shall be added by drivers of transit-mix trucks except that established for the design. Failure to comply with this requirement shall be justification for rejecting the concrete.

The actual acceptance of aggregates and development of mix proportions to produce concrete conforming to the specific requirements shall be determined by means of prior laboratory tests made with the constituents to be used on the work.

Well in advance of placing concrete, the Contractor shall discuss with the Engineer the proposed sources of materials and concrete proportion which he proposes to use. He shall furnish samples of aggregate and cement for testing, deliver them at his own cost, to the organization designated by the Engineer and shall permit ample time for the laboratory to develop a proposed design proportion or to modify the design of the proportion within the limits of these specifications.

Concrete proportions, including water-cement ratio, shall be established on the basis of field experience and/or trial mixtures with materials to be employed, except permitted or required in these specifications. The Contractor shall establish proportions of material for concrete to meet the requirements as specified in the Particular Specifications. Proposed concrete proportions will produce an average compressive strength equal to or greater than required average compressive strength.

Required average compressive strength used as the basis for selection of concrete proportions shall be the following equation using standard deviation.

$$f_{cr} = f_c + 1.64 s$$

where  $f_{cr}$  : required average compressive strength

$f_c$  : specified compressive strength

$s$  : standard deviation

When an acceptable record of field test result to the Engineer is not available, concrete proportions may be established based on the trial mixtures meeting the following restrictions:

- a. Combination of materials shall be those for proposed work.
- b. Trial mixtures having proportions and consistencies required for proposed work shall be made using at least three different water-cement ratios or cement contents that will produce a range of strengths encompassing the required average strength.
- c. Trial mixtures shall be designed to produce a slump within  $\pm 2$  cm of maximum permitted.
- d. For each water-cement ratio or cement content, at least three test cylinder specimens for each test age shall be made and cured. Specimens shall be tested at 28 days.
- e. From results of the tests a curve shall be plotted showing relationship between water-cement ratio or cement content and compressive strength and designated test age.

When high-early-strength portland cement is permitted, the same strength requirements shall apply except that the indicated strengths shall be attained at 7 days instead of 28 days.

If, during the progress of work, the Contractor desires to use materials other than those approved originally, or if the materials from the sources originally approved change in characteristics, the Contractor shall, at his expense, have made new acceptance tests of aggregates and establishment of new basic mixtures by the approved testing laboratory. Objectionable changes in color of the structures shall not result from these modifications.

The silt content of fine and coarse aggregate for concrete mixing shall be less than that specified in Section 3.1.6. The Engineer may order to remove aggregates from the work site when he judges them as unsuitable for use. The Engineer also may order the cement content for any class of concrete to be increased over the quantity specified if he determines that such increase is necessary to attain the required strength. Such increased quantities of cement, if so ordered, shall be furnished by the Contractor at no additional cost to the Employer.

### **3.1.5 ACCEPTANCE TESTS**

Conformity of aggregates to this specification, and the actual proportions of cement, aggregates, and water necessary to produce concrete conforming to the requirements set forth in Section 3.1.4, shall be determined by tests made with representative samples of the materials to be used on the work. Tests shall be made by the approved laboratory selected by the Engineer. Representative samples shall be furnished by the Contractor at his cost.

Cement shall be subject to testing to determine that it conforms to the requirements of this specification. Methods of testing shall conform to the appropriate specification, but the place, time, frequency, and method of sampling will be determined by the Engineer in accordance with the particular need.

Samples of fine and coarse aggregate shall be furnished for examination and testing at least three weeks before the Contractor proposes to use them on the work.

Water content of the concrete shall be based on a curve showing the relation between water content at

7 and 28 days compressive strengths of concrete made using the proposed materials. The curves shall be determined by four or more points, representing an average value of at least three test specimens at each age, and shall have a range of values sufficient to yield the desired data, including all the compressive strengths shown on the drawings, without extrapolation. The water content of the concrete to be used, as determined from the curve, shall correspond to the test strengths of the laboratory trial mixtures.

### **3.1.6 MATERIALS**

#### **1. CEMENT**

All cement used for the work shall be standard brand portland cement from an approved source conforming to the requirements of JIS R5210 "Portland Cement" or other internationally accepted standard. A single brand and same color of cement shall be used throughout the work. The cement shall be suitably protected from exposure to moisture until used. Cement that has become lumpy shall not be used. Air entraining cements shall not be used.

High-early-strength cement may only be used with written approval of the Engineer.

#### **2. FINE AGGREGATE**

Fine aggregate shall consist of granular material conforming to the requirements of JIS A 5005 "Crushed Stone and Manufactured Sand for Concrete" and the following detailed requirements:

Sieve (mm)	Percentage Passing (Dry Weight)
10	100
5	90 - 100
2.5	80 - 100
1.2	50 - 90
0.6	25 - 65
0.3	10 - 35
0.15	2 - 15

#### Requirements

Fineness Modulus	2.3 - 3.1
Silt Content in Weight Percentage	1.0

### 3. COARSE AGGREGATE

Coarse aggregate shall consist of well-graded granular materials conforming to the requirements of JIS A 5005 "Crushed Stone and Manufactured Sand for Concrete" and the following detailed requirements:

Sieve (mm)	Percentage Passing (Dry Weight)
30	100
25	95 - 100
15	30 - 70
5	0 - 10
2.5	0 - 5
Silt Content in Weight	
Percentage	2.0 Percent maximum

The following designated sizes\* of aggregate shall be the maximum employed in concrete.

40 mm for plain concrete

25 mm for reinforced sections

15 mm for precast concrete

\* Note: The "designated size" and the corresponding gradations shown represent the end or combined gradation of the coarse aggregate to be used in the final concrete.

### 4. WATER

Water shall be clean and free from injurious amounts of oil, acid, alkali, salt, organic matter, or other deleterious substances and shall conform to the requirements of Annex 9 of JIS A 5380, "Water to Serve for Mixing Ready Mixed Concrete".

When subjected to the mortar strength test described in ASTM C87, "Effect of Organic Impurities in Fine Aggregate on Strength of Mortar," the 28-day strength of mortar specimens made with the water under examination and normal portland cement shall be at least 100 percent of the strength of similar specimens made with distilled water. Potable tap water will normally fulfill these requirements.

### 5. ADMIXTURES

At the Contractor's option, or at the request of the Engineer, but in either case at the expense of the Contractor, an admixture may be added to the concrete to control the set, effect water reduction and increase workability. Such admixture may be either a hydroxylated carboxylic acid type or a

lignin-sulfonate type, but shall contain no calcium chloride.

The admixture shall be of high quality acceptable to the Engineer and proportioning and mixing shall be as recommended by the manufacturer.

The required quantities of cement shall be used in the mix regardless of whether or not any admixture is used. The Admixture shall conform to the following standards or other internationally accepted standards:

- JIS A 6201 Fly Ash for Use in Concrete
- JIS A 6202 Expansive Additive for Concrete
- JIS A 6203 Polymer Dispersions and Redispersible Polymer Powders for Cement Modifiers
- JIS A 6204 Chemical Admixtures for Concrete
- JIS A 6205 Corrosion Inhibitor for Reinforcing Steel in Concrete
- JIS A 6206 Ground Granulated Blast-Furnace Slag for Concrete
- JIS A 6207 Silica Fume for Use in Concrete

## 6. STORAGE OF MATERIALS

Materials shall be stored so as to ensure preservation of their specified quality and fitness for the work. They shall be placed on a hard, clean surface and, when required, they shall be placed under cover. Stored materials shall be located so as to facilitate prompt inspection.

Aggregates shall be separately stored so as not to become mixed with one another and so as to prevent contamination. Materials of similar grading but from different sources or different types shall not be stored together unless approved.

Aggregate stockpiles shall be provided with impervious beds laid to facilitate drainage, and any adjacent roads shall be so formed as to prevent drainage to the stockpiles and bin loading areas.

Aggregate stockpiles shall be covered by a structure or structures which shall remain in position throughout the Contract, and this cover shall effectively protect the stockpiles from rain. For each size of aggregate, separate duplicate stockpiles shall be provided and worked on alternate days to allow all aggregates to drain for at least 16 hours prior to use.

Aggregate in stockpiles shall not be contaminated or crushed by trucks, bulldozers, or other plant equipment.

The Contractor shall avoid the buildup of fine material at the bottom of the stockpiles. Should such buildup occur, the layer which contains an excess of fine material shall be removed as directed by the Engineer.

Bulk cement shall be stored in a dampproof hopper or in sealed bags in a weatherproof shed, on a floor

above ground, and shall be used in the order of its delivery.

Different types or brands of cement shall be stored separately.

### **3.1.7 MEASURING MATERIALS**

Materials shall be measured by weighing except when otherwise authorized by the Engineer. The apparatus for weighing aggregates and cement shall be designed and constructed for this purpose. All scales shall have been certified. Each size of aggregate and the cement shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount.

Cement in standard packages (sacks) need not be weighed, but bulk cement and fractional packages shall be weighed.

The mixing water shall be measured by volume or by weight. The water measuring device shall control the volume or weight accurately to 1/2 percent. All measuring devices shall be subject to approval by the Engineer.

Admixtures shall be dispensed either manually with the use of calibrated containers or by an approved automatic dispenser designed by the manufacturer of the specific admixture.

### **3.1.8 MIXING**

Concrete shall be produced by equipment acceptable to the Engineer. Hand mixing will be allowed, only if authorized in writing by the Engineer for cases involving generally less than 2 cubic meters for work to be accomplished in one day. Adding water in controlled amounts during the mixing cycle shall be done only with the express approval of, and under the direction of the Engineer.

Concrete shall be mixed until there is a uniform distribution of the materials and shall be discharged completely before the mixture is recharged.

Site mixers shall be equipped with suitable charging hoppers and water storage and water measuring device, so constructed that some water will enter in advance of the cement and aggregate when the mixer is being charged with a batch. The mixing water measuring device shall have its adjustment locked in order to prevent tampering by unauthorized persons.

The loss of materials during charging will not be permitted. At regular intervals the mixers shall be cleaned of any hardened concrete which may have formed on the inside of the drum.

The cement, and fine and coarse aggregates shall be so mixed and the quantity of water added shall be such as to produce a homogeneous mass of uniform consistency. Dirt and other undesirable substances shall be carefully excluded. All concrete shall be thoroughly mixed in a batch mixer of an approved type and size, so designed to positively ensure a uniform distribution of all of the component materials



throughout the mass during the mixing operation. Outlet of the mixer shall be so designed to avoid segregation at the time of discharge.

The mixing of each batch shall continue not less than 1 1/2 minutes after all materials, including water, are in the mixer, during which time the mixer shall rotate at the speed which will produce a mass of uniform consistency at the end of the mixing period. The batch mixer shall be operated by an authorized person only.

Whenever necessary to secure proper results, the concrete shall be mixed for a longer period than herein specified, but over-mixing of the concrete or overloading of the mixer shall not be permitted.

Hardened concrete or mortar shall not be permitted to accumulate on the inner surfaces of the mixer. New materials shall be put into the mixer after all mixed concrete has been discharged.

If the Contractor intends to use ready-mixed concrete, he shall submit the proposed mix design, name of supplier, and their locations for the approval of the Engineer.

Ready-mixed concrete shall be transported to the site in watertight agitator or mixer trucks loaded not in excess of the rated capacities for the respective conditions as stated on the nameplate. Central mixed concrete shall be plant-mixed or agitated a minimum of 1 - 1 1/2 minutes per batch and then shall be truck-mixed or agitated a minimum of 8 minutes. Agitation shall begin immediately after the pre-mixed concrete is placed in the truck and shall continue without interruption until discharge.

The Contractor shall confirm the route and time for the transportation from the batching plant of the supplier to the delivery site to select the supplier. The time required for transportation shall be within that specified in Section 3.1.9.

The total elapsed time between the intermingling of the aggregates and cement and the start of mixing shall not exceed 30 minutes.

### **3.1.9 TRANSPORTING**

When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within 1 1/2 hours, or before 250 revolutions of the drum or blades, whichever comes first, after the introduction of the cement to the aggregates. Under conditions contributing to early initial set of the concrete, or when the temperature of the concrete is 30 degrees C, or above, a time less than 1 1/2 hours will be required.

When non-agitating hauling equipment is used for transporting concrete to the delivery point, discharge shall be completed within one hour after the addition of cement to the aggregates.

The retempering of concrete or mortar which has partially hardened and mixing with or without additional cement, aggregate, or water, will not be permitted.

The Contractor shall dispatch trucks from the batching plant so that they shall arrive at the site of the work just before the concrete is required, thus avoiding excessive mixing of concrete while waiting or delays in placing successive layers of concrete in the forms.

Precautions shall be taken in hot weather to prevent loss of slump. Mixer drums shall, when possible, be shaded and materials shall be kept as cool as possible.

### **3.1.10 FIELD TESTS**

Sets of six cylinder specimens will be taken at random by the Engineer during the progress of the work. The total number of specimens taken on the project may average one set per 50 cubic meters per class of concrete and in general not less than one set of specimens will be taken on any day that concrete is placed. The Contractor shall be responsible for all expenses in transporting the concrete specimens and conducting laboratory tests.

Three specimens shall be tested at 7 days and another at 28 days. Test reports shall be submitted to the Engineer in duplicate.

Specimen shall be required in accordance with JIS A 1132, "Method of Making and Curing Concrete Specimens" or other internationally accepted standards and compressive strength test shall conform to JIS 1108 "Method of Test for compressive Strength of Concrete" or other internationally accepted standards.

When it appears that the laboratory-cured specimens will fail to conform to the requirements for strength, the Engineer shall have the right to order changes in the concrete sufficient to increase the strength to meet these requirements including additional cement added to the mix. The strengths of any field-cured specimens intended to indicate the adequacy of protection and curing of the concrete and may be used to determine when the forms may be stripped, shoring removed, or the structure placed in service. When in the opinion of the Engineer the strengths of the field-cured specimens are excessively below those of the laboratory-cured specimens, the Contractor may be required to improve the procedures for protecting and curing the concrete.

The Contractor shall provide for the making of such tests to the extent of allowing free access to the work for the selection of samples, providing moist storage facilities for specimens, affording protection of the specimens against injury or loss through his operations, and furnishing material and labor required for the purpose of taking concrete specimens.

Slump tests will be made in the field in accordance with JIS A 1101, Method of Slump test for Concrete" or other internationally accepted standards by the Contractor in the presence of the Engineer.

### **3.1.11 INSPECTION AND CONTROL**

The preparation of forms, placing of reinforcing steel, embedded items, conduits, pipes, and sleeves, batch mixing, transportation, placing and curing of concrete shall be subject to the inspection of the Engineer.

### **3.1.12 CONCRETE APPEARANCE**

Concrete for every part of the work shall be a homogeneous structure which, when hardened, will have the required strength, durability and appearance. Formwork, mixtures and workmanship shall be provided to obtain that concrete surfaces, when exposed, will require no finishing.

When concrete surfaces are stripped, the concrete when viewed in good light from 3 m away shall be pleasing in appearance, and at 6 meters shall show no visible defects.

### **3.1.13 FORMS**

Forms shall be used for all concrete masonry, including footings. Forms shall be so constructed and placed that the resulting concrete will be of the shape, lines, dimensions, appearance, and to the elevations indicated on the drawings.

The Contractor shall assure full responsibility for the adequate design of all forms. However, any forms which, in the opinion of the Engineer, are unsafe or inadequate in any respect may be condemned at any time by the Engineer. The Contractor shall promptly remove the condemned forms from the work and replace them at his own expense.

Forms of all cast-in-place concrete shall be made of wood, metal, or other approved material. Wood forms shall have a smooth surface and be constructed of sound lumber or plywood of suitable dimensions free from knotholes and loose knots. Where used for exposed surfaces, boards shall be dressed and matched. Plywood shall be sanded smooth and fitted with tight joints between panels. Metal forms shall be of an approved type for the class of work involved and of the thickness and design required for rigid construction. All exposed concrete shall be formed with metal or plywood forms.

Edges of all form panels in contact with concrete shall be flush within 0.8 mm and forms for plane surfaces shall be such that the concrete will be plane within 0.20 cm each 4 meters. Forms shall be tight to prevent the passage of mortar and water and grout.

Molding or bevels shall be placed to produce a 2.0 cm chamfer on all exposed projecting corners, unless otherwise shown on the drawings. Similarly chamfer strips shall be provided at horizontal and vertical extremities of all wall placements to produce "clean" separations between successive placements as shown on the drawings.

Forms shall be sufficiently rigid to prevent displacement or sagging between supports, under all conditions, and shall be so constructed that the concrete will not be damaged by their removal. The Contractor shall be entirely responsible for their adequacy.

Forms shall be installed true to the line and level within an allowable tolerance of  $\pm 3$  mm and in an acceptable manner to the Engineer.

Forms shall be oiled before reinforcement is placed with an approved non-staining oil or liquid form coating not having a paraffin base.

Before form materials are reused, all surfaces that have been in contact with concrete shall be thoroughly cleaned, all damaged places repaired, all projecting nails withdrawn, and all intrusions or protrusions smoothed.

Form ties encased in concrete shall be designed so that after removal of the protecting part, no metal shall be within 2.5 cm of the face of the concrete. That part of the tie to be removed shall be at least 1.2 cm in diameter or be provided with a wood or metal cone at least 1.2 cm in diameter and 2.5 cm long. Form ties in concrete exposed to view shall be the cone-washer type. Through-bolts or common wire shall not be used for form ties.

Pipes, conduits and other miscellaneous items for embedding and cores or other devices for forming holes, ducts, chases, etc., shall be fixed rigidly in the forms and watertight to prevent escape of water and mortar.

Before placing concrete, the Engineer may inspect the forms, as to condition, cleanliness, joint preparation, and ascertain that all reinforcement and embedded items are adequately supported in the proper location. This inspection shall not relieve the Contractor of his responsibility for the adequacy of the forms or for the completeness and accuracy of embedded items.

The Contractor shall inform the Engineer at least 24 hours in advance, of his intention to have the forms ready for inspection.

Holes and seams in the forms shall be such that water and mortar will not escape. Forms in the vicinity of joints shall be retightened just prior to placing the next lift. During concreting, the Contractor shall maintain the forms tight and in position. Any necessary adjustment shall be made immediately.

#### **3.1.14 PLACING AND COMPACTING**

No concrete shall, unless otherwise ordered by the Engineer, be placed until all form work and installation of reinforcing steel, pipes and other miscellaneous items to be embedded have been approved by the Engineer.

No concrete shall be placed in any structure until all walls entering the space to be filled with concrete

have been properly cut off or have been diverted by pipe or other means and carried out of the forms. No concrete shall be deposited under water without the explicit permission of the Engineer; nor shall the Contractor, without explicit permission, allow still water to rise on any concrete until the concrete has attained its initial set.

Water shall not be permitted to flow over the surface of any concrete in such manner and at such velocity as will injure the surface finish of the concrete. Pumping and other necessary dewatering operations for removing ground water, if required, will be subject to the approval of the Engineer.

Exterior concrete slabs shall be pitched or crowned to prevent ponding and facilitate drainage. Unless otherwise permitted, the work shall be so executed that a section begun on any day shall be completed in daylight of the same day.

Transport of concrete from mixer to place of final deposit shall be done as rapidly as practical by methods which prevent the separation of ingredients and displacement of reinforcement, and which avoid re-handling. No partially hardened concrete shall be deposited.

Concrete shall be transported from the mixer trucks by skips, barrows, buckets on cranes, chutes, or conveyor belts. All equipment used to transport concrete shall be clean and free of debris and contaminants. In selecting the method or methods used for transport, consideration shall be given to the effects of the method on the properties of the concrete so as not to result in inferior concrete caused by segregation produced during transport.

Concrete which upon or before placing is found not to conform to the requirements specified herein shall be rejected and immediately removed from the Work. Concrete which is not placed in accordance with these specifications, or which is inferior in quality, as determined by the Engineer, shall be removed and replaced by and at the expense of the Contractor.

No concrete shall be placed except in the presence of a duly authorized representative of the Engineer. Concrete shall not be placed when unsuitable heat or wind conditions will prevent proper placement and curing, as determined by the Engineer.

Bottom opening skips or buckets shall not be used for transporting over long distances because of the consolidation, bleeding or loss of slump which may result. Buckets or skips shall be capable of free discharge of low slump concrete, with gate mechanisms which permit full control over the discharge with no appreciable segregation.

In considerable heights, concrete shall be placed using suitable hoppers, spouts with restricted outlets, or otherwise, as required or approved by the Engineer. Vertical drops of more than 1.5 meters shall not be permitted.

Chutes shall be U-shaped and of such size as to ensure a continuous flow in the chute. Flat chutes shall

not be used. Chutes shall be metal or metal lined and sections shall have approximately equal slopes. The slope shall be not less than 25 degrees and not greater than 45 degrees and shall be such as not to cause segregation of the ingredients. When the placing operation is intermittent, the chute shall discharge into a hopper. Chutes shall be so arranged or moved that the concrete is deposited at the intended locations. Concrete shall not be allowed to flow horizontally over distances greater than 150 cm. They shall be provided with a baffle and down pipe at the discharge end to provide a vertical drop thus minimizing segregation.

When concrete pumps are applied for concrete placing, piping shall, far as possible, be arranged straight and easy for movement and relocation.

As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcement bars which project.

Chutes, hoppers, spouts, and other equipment shall be thoroughly cleaned before and after each use. The water and debris shall not be discharged inside the form.

Precautions shall be taken to protect concrete during transport in hot weather. The elapsed time between mixing and placing shall be kept to a minimum and where possible, trucks waiting to discharge shall be kept in the shade.

“Cold Joints” are to be avoided, but if they occur, are to be treated as bonded construction joints by using epoxy. The method of applying epoxy shall be according to the manufacturer’s recommendation.

At construction joints the surfaces of the concrete already placed, including vertical and inclined surfaces, shall be thoroughly cleaned of foreign materials and laitance, and weak concrete shall be roughened with suitable tools to expose a fresh face. At least two hours before and again shortly before the new concrete is deposited, the joints shall be saturated with water. After glistening water disappears, the joints shall be given a thorough coating of neat cement slurry mixed to the consistency of a very heavy paste. The surfaces shall receive a coating at least 0.35 cm thick, well scrubbed-in by means of stiff bristle brushes wherever possible. New concrete shall be deposited before the neat cement dries.

Horizontal construction joints shall be accurately level. Before concrete is placed, marks by suitable means, shall be provided on forms to show the position and line of construction joints.

Forms at vertical construction joints shall be firmly fixed and watertight to avoid outflow of mortar.

Concrete deposited near the vertical joint shall be thoroughly compacted by vibrators so that any corner of the form can be filled with concrete.

The Contractor shall deposit concrete so as to maintain a plastic surface approximately horizontal until the completion of the unit. Vertical lifts shall preferably not exceed 40 cm.

Concrete, during and immediately after depositing in the forms or excavations, shall be thoroughly settled and compacted by means of suitable tools throughout the entire depth of the layer. Internal type mechanical vibrators shall be employed to produce the required quality of finish. Vibration shall be done by experienced operators under close supervision and shall be carried on sufficiently to produce homogeneity and optimum consolidation, filling all corners and angles, and thoroughly embedding the reinforcement without permitting segregation of the solid constituents or "pumping" or migration of air. All vibrators shall be supplemented by proper wooden spade puddling approximately adjacent to the forms to remove included bubbles and honeycomb.

All vibrators shall travel at least 10,000 rpm and be of adequate capacity. At least one vibrator shall be available for every eight (8) cubic meters of concrete placed per hour. In addition, one spare vibrator in operating condition shall be on the site. Concrete shall be fully compacted in the regions of waterstops.

Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed.

Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms

Concrete slabs on the ground shall be well tamped into place and foundation material shall be wet, tamped, and rolled until thoroughly compacted prior to placing concrete.

Concrete shall be deposited continuously in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams and planes of weakness within the section. If a section cannot be placed continuously, construction joints may be located at points as provided for in the drawings or as approved by the Engineer.

### **3.1.15 CURING AND PROTECTION**

The Contractor shall protect all concrete against injury or damage from excess heat, lack of moisture,

over-stress, or any other cause until final acceptance by the Engineer.

All concrete, particularly exposed surfaces, shall be treated immediately after concreting or cement finishing is completed, and shall be provided with continuous moist curing for at least 7 days, regardless of the ambient air temperature. Walls and vertical surfaces may be covered with continuously saturated burlap, or by other approved means; horizontal surfaces, slabs, and other items shall be kept continuously wet by watering.

Finished surfaces and slabs shall be protected from the direct rays of the sun to prevent checking and crazing.

Particular care shall be taken to prevent the drying of concrete and to avoid roughening or otherwise damaging the surface.

When directed by the Engineer to continue placing concrete during times of heavy rainfall, the Contractor shall protect the concrete surface. Only sufficient area shall be uncovered at a time as will permit the deposition of one load of concrete.

**3.1.16 PLACING CONCRETE IN HOT WEATHER**

Care shall be taken to prevent rapid drying of newly placed concrete. When the ambient temperature in the forms is more than 32 degrees C or when so directed, the temperature of the concrete as placed shall not exceed 32 degrees C. The fresh concrete shall be shaded as soon as possible after placing, and curing started as soon as the surface of fresh concrete is sufficiently hard. Concrete placement will not be permitted, if in the opinion of the Engineer, the Contractor does not have proper facilities available for placing, curing and finishing the concrete in accordance with these specifications.

**3.1.17 REMOVAL OF FORMS**

Forms shall be removed by static force without shock, vibration or damage to the concrete.

The time to strike the forms is to be subject to the Engineer's approval but the following may be taken as a guide to the time applicable during normal weather conditions.

<u>FORM LOCATION</u>	<u>DAYS</u>
Footing Sides	2
Walls, Columns and Beam Sides	4
Slabs and Beams	7

Shores shall not be removed until the concrete has attained at least 60 percent of the specified strength and also sufficient strength to safely support its own weight and the construction live loads upon it.



**3.1.18 FAILURE TO MEET REQUIREMENTS**

Should the strengths shown by the test specimens made and tested in accordance with the above provisions fall below the values given in Section 3.1.4, the Engineer shall have the right to require necessary changes in proportions to apply to the remainder of the work. Furthermore, the Engineer shall have the right to require additional curing on those portions of the structure represented by the test specimens which failed, the cost of such additional curing to be at the Contractor's expense. In the event that such additional curing does not give the strength required, as evidenced by core and/or load tests, the Engineer shall have the right to require strengthening or replacement of those portions of the structure which fail to develop the required strength. The cost of all such core borings and/or load tests and strengthening or concrete replacement required because strengths of test specimens are below those specified, shall be entirely at the expense of the Contractor. In such cases of failure to meet strength requirements, the Contractor and Engineer shall confer to determine what adjustment, if any, can be made in conformity with ASTM C94, "Ready-Mixed Concrete" or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

**3.1.19 PATCHING AND REPAIRS**

It is the intent to require forms, mixture of concrete and workmanship so that concrete surfaces, when exposed, will require no patching.

As soon as the forms have been stripped and the concrete surfaces exposed, fins and other projections shall be removed; recesses left by the removal of form ties shall be filled; and surface defects, which do not impair structural strength, shall be repaired. All exposed concrete surfaces and adjoining work stained by leakage of concrete, shall be cleaned to the satisfaction of the Engineer.

**3.1.20 CONSTRUCTION AND EXPANSION JOINTS**

Construction and expansion joints shall be formed in the locations and to the detailed dimensions indicated on the drawings. Keyways shall be formed to the dimensions indicated on the drawings. Joints where noted on the drawings shall be provided with PVC waterstop or joint sealer as specified in another section of these specifications.

The position of joints necessary for construction shall be arranged, in writing, between the Contractor and the Engineer before construction work is commenced. No intermediate horizontal construction joints shall be permitted in the free standing walls of any structure. Reinforcing steel shall be continuous through a construction joint, and bars projecting through a joint shall be kept clean. The surfaces of construction joints shall be prepared as specified.

The maximum length of any single wall for placing concrete shall not exceed 10 m. Adjacent sections of wall shall not be placed until at least seven days have elapsed following the placing of adjoining wall sections.

The maximum dimension of any single floor slab for placing concrete shall not exceed 10 m and the ratio of the maximum dimension to the minimum dimension shall not be greater than 2 to 1. At least three days shall elapse between adjoining placing concrete.

Visible horizontal construction joints shall be placed against a timber strip set in the forms to ensure a straight line.

When placing concrete is suspended, all necessary grooves for horizontal joints abutting future work shall be made before the concrete has had time to set.

Before depositing concrete on or against foundations, or adjacent concrete which has set or partially set, the forms shall be re-tightened, the surface shall be roughened, thoroughly cleaned of foreign matter and saturated with water.

### **3.1.21 FIELD CONTROL**

The Contractor shall advise the Engineer of his readiness to proceed, at least twenty four (24) hours prior to each concrete placement. The Engineer will inspect the preparations for concreting including the preparation of previously placed concrete, the reinforcing and the alignment and tightness of the formwork. No placement shall be made without the prior approval of the Engineer.

The Engineer may have cores taken from any questionable areas in the concrete work such as construction joints and other locations as required for the determination of concrete quality. The results of tests on such cores shall be the basis for acceptance, rejection or determining the continuation of the concrete work.

The Contractor shall cooperate in the obtaining of cores by allowing free access to the work and permitting the use of any ladders, scaffolding and such incidental equipment as may be required. The Contractor at his cost shall repair all core holes to the satisfaction of the Engineer.

### **3.1.22 SLEEVES, PIPES, AND OTHER ITEMS**

The Contractor shall place no concrete until reinforcing steel, pipes, conduits, sleeves, hangers, anchors, and other work required to be built into the concrete have been inspected and approved. All water and foreign matter shall be removed from the forms and excavation. All soil bottoms for slabs and footings shall be approved by the Engineer before placing concrete.

### **3.1.23 EQUIPMENT BASES**

All steel leveling and bearing plates, machinery and other equipment, bearing on concrete surfaces, shall be bedded on non-shrink grout and where necessary, core holes for anchor bolts shall be fully grouted with non-shrink grout. The grout bed shall not be placed until the member has been aligned, leveled, plumbed and finally secured in position.

The exact dimensions for all equipment bases will depend on the dimensions of the actual equipment furnished. No payment change will be allowed if the dimensions are different from those shown on the drawings.

### **3.1.24 NON-SHRINK GROUT**

To aid strength and bonding of multiple layer application of grout the Engineer may order the use of non-shrink metallic aggregate as an additive as follows:

<u>MATERIAL</u>	<u>PROPORTIONS</u>	
	<u>Volume</u>	<u>Weight</u>
Cement	1.0	1.0
Metallic Aggregate	0.15	0.25
Fine Aggregate	1.5	1.5

Non-shrink metallic aggregate shall be a prepared, size graded, metallic aggregate combined with a catalyzing agent and water reducing agent. When used as an aggregate in the proportioning of grout, mortar and concrete mixes, shrinkage shall be counteracted and basic qualities improved. The Contractor shall demonstrate to the Engineer that the product has successfully been utilized on similar projects for a minimum of five (5) years. Preparation of surfaces, mix proportions, application procedures, and precautions shall be followed in strict compliance with the manufacturer's directions.

For very heavy (generally formed) applications, the Engineer may order the addition of pea gravel, passing a 3/8" screen but retained on a 1/4" screen, to the mixture with the proportions modified as follows:

<u>MATERIAL</u>	<u>PROPORTIONS</u>	
	<u>Volume</u>	<u>Weight</u>
Cement	1.0	1.0
Metallic Aggregate	0.2	0.33
Fine Aggregate	1.0	1.0
Pea Gravel	1.5	1.5

In cases where metallic aggregate is employed in multiple layers and a rusty finish is not desired on the surface, such as on the exposed faces of walls, the final layer (or at least the final 1.2 cm) shall be composed of the 1:1.5 grout without metallic aggregate.

### **3.1.25 INSTALLATION SCHEDULE**

All reinforced concrete cast in place shall be as specified in the Particular Specifications.

**3.1.26 GENERAL STRUCTURAL NOTES**

The following general structural notes are to be considered as applicable to all structural drawings:

- a. Structural drawings shall be used in conjunction with civil, architectural, mechanical, electrical drawings; specifications and manufacturer's drawings.
- b. All dimensions and conditions must be verified in the field. Conditions not covered by the plans or specifications shall be brought to the attention of the Engineer before proceeding with construction.
- c. Shop drawings for reinforcing steel, precast and prestressed concrete members shall be submitted for approval in accordance with the specifications.
- d. Unless otherwise indicated, details shown on any drawing are to be considered typical for all similar conditions.
- e. The Contractor shall install pipe sleeves and cable conduits for mechanical and electrical works at locations shown on the drawings.
- f. The Contractor shall be responsible to provide openings for equipment and ducts, whether or not shown on structural drawings. **The Contractor shall make a plan for the access of the equipment to its final location in the facilities and buildings. In this regard, the Contractor shall arrange the structural arrangement of the facilities and buildings and the procedure of installation of the equipment at an early stage of the Contract.**
- g. All concrete footings, slabs, pile caps, shall be placed on a working mat consisting of 5 cm of lean concrete on 20 cm of granular material No. 3 unless otherwise required.
- h. Where indicated on the drawings, steel sheeting shall be left in place.
- i. No concrete shall be placed in water or on disturbed native material.
- j. Backfill behind walls shall be placed as specified and only after slabs and supporting walls are in place and concrete has been cured to the design strength.
- k. Reinforcement shall conform to Section 3.2 "Concrete Reinforcement".
- l. Continued reinforcement shall be lapped 40 and 30 times of bar diameters at splices for tension and compression bars respectively, unless shown on drawings differently.
- m. Spacing of bars shall be as noted on drawings.
- n. In concrete beams and girders deeper than 75 cm, the Contractor shall provide continuous bars placed at mid depth of either face in sizes and numbers as shown on the drawings.
- o. The Contractor shall provide extra bars along each side of openings larger than 30 cm as indicated by typical detail or as shown on drawings.
- p. Main reinforcing steel shall be placed and maintained at the minimum clear distances from surface of concrete as specified in Section 3.2, "Concrete Reinforcement" of this Division. Tie stirrups and spacer bars are not considered as main reinforcing steel, and may be projected into minimum clear distances.
- q. Exposed concrete edges shall have a chamfer in 2 cm.
- r. The use of construction joints at locations not indicated shall be as approved by the Engineer.
- s. All concrete walls shall have vertical construction joints spaced not more than 10 meters or as shown on the drawings.

- t. All concrete walls, slabs and beams shall be built so as to minimize the effect of concrete shrinkage, by placing slabs in checkerboard style, or skipping sections that are to be placed until after the adjoining concrete has had sufficient time to cure.
- u. At least two hours shall elapse after depositing concrete in piers, walls and columns before depositing in beams or slabs supported thereon.
- v. The Contractor shall be responsible to protect structures against flotation or up lift during construction.
- w. The Contractor shall provide temporary ties and bracing where necessary during construction, and until the building is completed.
- x. Water stops shall be provided in construction joints as specified in Section 3.4, "Concrete Joints" and as indicated on the drawings.

## **DIVISIONS 3 CONCRETE**

### **SECTION 3.2 CONCRETE REINFORCEMENT**

#### **3.2.1 SCOPE OF WORK**

The Contractor shall provide all labor, materials, equipment and incidentals required to furnish and install all steel bars, steel wire, and steel supports required for the reinforcement of concrete as shown on the drawings and specified herein.

#### **3.2.2 SHOP DRAWINGS**

Detailed working and shop drawings and schedules of all reinforcement required shall be submitted for approval.

Approval of shop drawings by the Engineer will be limited to general compliance with the contract drawings. The Contractor shall be fully responsible for accuracy of dimensions and details, and said dimensions and details will be checked in the field by the Engineer at the time of placement.

#### **3.2.3 MATERIALS**

Unless otherwise specified or required, the design, materials, workmanship and erection shall conform to the requirements of the Manual of Standard Practice, American Concrete Institute (ACI) 318 - 83, or JIS G 3112, Steel Bars for Concrete Reinforcement or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Reinforcing bars will be rejected if the weight of a bundle of one size of bars as delivered is underweight by 3.5 percent or more. An individual bar will be rejected if it is underweight by 6.0 percent or more.

Deformed bars will be subject to tests to determine spacing, height, and circumferential coverage of deformations as described in JIS G 3112 "Steel Bars for Concrete Reinforcement" or other internationally accepted standards or manufacturer's standards as approved by the Engineer. Bars which do not conform to the requirements for deformations in the above specifications will require an increase in lap splice as determined by the Engineer. The maximum length of splice required will be that required for a plain (round) bar.

Steel wire shall conform to JIS G 3532 "Low Carbon Steel Wires" or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

#### **3.2.4 FABRICATION**

Reinforcement shall be accurately fabricated to the dimensions indicated on the drawings. Particular care shall be exercised not to have stirrups oversized in order to maintain proper coverage of concrete.

Bends for all bars shall be made as shown on the standard drawings. All bars shall be bent cold. Bars reduced in section or with kinks or bends not shown on the drawings will not be accepted.

**3.2.5 HANDLING MATERIALS**

Reinforcement shall be stockpiled at the site of the work with bars of the same size and shape fastened in bundles with metal identification tags, giving size and mark, securely wired on. The identification tags shall be labeled with the same designations as shown on submitted bar schedules and shop drawings. The Contractor shall submit the mill certified report of test for each shipment of reinforcing steel to the construction site. The certification shall contain the results of chemical and mechanical tests required by the specifications.

All bars shall be stored off the ground and shall be protected from moisture and be kept free from dirt, oil, or injurious contaminants.

**3.2.6 INSTALLATION**

No reinforcing bars shall be welded either during fabrication or erection without prior written approval from the Engineer. If the Engineer approved the welding of reinforcing bars, the Contractor shall submit the sample of welded piece, the strength of welded piece shall be not less than such reinforcing bar. Any bars that have been welded, including tack welds, without such approval shall be immediately removed from the work.

Before being placed in position, reinforcement shall be thoroughly cleaned of loose mill scale, dirt, and other coatings that reduce or destroy bond. Where there is delay in depositing concrete after reinforcement is in place, bars shall be re-inspected and cleaned when necessary.

Reinforcement shall be accurately positioned as indicated on the drawings, and secured against displacement by using iron wire ties of not less than 1.2 mm or suitable clips at intersections.

Tolerances in placing reinforcement shall be

For members 60 cm or less in depth       $\pm 0.6$  cm

For members more than 60 cm in depth       $\pm 1.2$  cm

All accessories such as chairs and chair-bars, are an integral part of the reinforcement and shall be furnished and installed in sufficient quantity to satisfactorily position all steel in accordance with the best manner approved by the Engineer.

Splices of horizontal bars, unless otherwise shown, shall be staggered and the lapping of splices shall be 30 times of bar diameters minimum. Unless otherwise shown or specified on the drawings, vertical reinforcing bar splices in columns and all other bar splices shall be lapped 40 times of bar diameters minimum. The length of the lap splice of bars of different diameters shall be based on the larger

diameter.

Except as otherwise indicated on the drawings, reinforcement shall be installed with clearance for concrete coverage in centimeters as follows:

Footing bottoms .....	7.5
All surfaces in contact with water or soil .....	5
Underside of slab over water in enclosed conduits, and beams and columns not exposed to soil or water .....	4
Surfaces exposed to air and all interior surfaces in valve chambers and dry rooms .....	2.5
Concrete placed against earth .....	8

All slabs reinforcing shall be supported on concrete cubes or wafers of the correct height. Wafers shall contain soft steel wires embedded therein for fastening to reinforcing. Wafers shall have a minimum compressive strength of 2,500 N/cm<sup>2</sup> and shall have been cured as specified for concrete. Masonry units will not be permitted for supporting steel in bottom mats or elsewhere. For supporting the top steel in slabs, the Contractor shall furnish extra steel supports such as channels if required and shall construct blocks of concrete having the same quality as specified for the structure for use in supporting both top and bottom mat steel. Wood blocks, stones, brick ships, cinder blocks, or concrete building blocks shall not be allowed. Alternate methods for supporting top steel in slabs, such as vertical reinforcing fastened to bottom and top mats, may be used if approved.

Alternate methods of supporting bottom reinforcement for slabs and beams not exposed to the weather (such as plastic chairs, but not plastic-tipped bolsters) may be used only if specifically approved by the Engineer.

Reinforcement for vertical surfaces (beams, columns, walls) shall be properly and firmly positioned away from the forms at all points in an acceptable manner and using materials satisfactory to the Engineer.

Metal clips or supports shall not be placed in contact with the forms. Tie wires shall be bent away from the forms in order to provide the specified concrete coverage.

Reinforcement which is to be exposed for a considerable length of time after being placed shall be painted with a heavy coat of neat cement slurry, if required by the Engineer.

In no case shall any reinforcing steel be covered with concrete until the amount and positions of the reinforcement have been checked by the Engineer and his permission given to proceed with the concreting. The Engineer shall be given ample prior notice of the availability of the set reinforcement



for checking.

**3.2.7 STRAIGHTENING STEEL**

Reinforcing steel shall not be bent or straightened in a manner that will injure the material. Any use of such injured reinforcing steel will not be permitted.

**3.2.8 GENERAL STRUCTURAL NOTES**

General structural notes shall refer to in Section 3.1.26 of Division 3.

## **DIVISIONS 3 CONCRETE**

### **SECTION 3.3 CONCRETE FINISHES**

#### **3.3.1 SCOPE OF WORK**

The Contractor shall furnish all labor, equipment and incidentals necessary to finish cast-in-place concrete surfaces as indicated on the drawings and/or specified herein. The finishes herein specified apply to the surface finish of cast-in-place concrete as it is to be in the finished work, and as it to be finished to receive additional covering such as plastering.

#### **3.3.2 WORK SPECIFIED ELSEWHERE**

Concrete finish for precast concrete elements is specified in Division 3 titled "Precast Concrete". Painting of concrete, architectural finish covering, roofing, damp proofing and waterproofing are specified elsewhere. Repairs to existing concrete as required to make it suitable for bonding to new concrete or if it is to remain exposed are specified herein.

#### **3.3.3 GENERAL**

All concrete surfaces including those not exposed in the finished work such as those that are buried or covered by other material such as the interior of pipeline structures (i.e., man-holes), and inaccessible locations shall have all fins, burrs and projections removed. The holes and honeycomb areas shall be filled and patched.

Care shall be exercised to prevent rounding, chamfered edges, or obliterating the bevel line when removing the forms or doing any other work adjacent thereto.

Dusting of surfaces with dry materials to absorb moisture or to stiffen the mix will not be permitted. Sprinkling as an aid to troweling will not be permitted.

The top surfaces of concrete including separate concrete toppings and walls shall be screeded, compacted and floated.

The Contractor shall protect the floors from damage after they have been finished by laying protective timbers and minimizing traffic over the areas.

#### **3.3.4 TYPES OF FINISHES FOR CAST-IN-PLACE CONCRETE**

##### **1. CLEANED AND PATCHED**

All concrete surfaces regardless as to whether they are exposed or not in the finished work shall be cleaned and patched as specified in Section 3.1.19 "Patching and Repairs".

## 2. VERTICAL SURFACES

Vertical surfaces and the undersides of all slabs and beams shall be finished in accordance with the following schedule unless otherwise indicated on the drawings, or specified.

<u>Surface Identification</u>	<u>Type of Finish</u>
Exterior Surfaces	
Buried	Formed
Painted, Dampproof	Rubbed
Tile, Plastered, etc.	Rough
Interior Surfaces	
Submerged	Formed
Tile, Plastered, etc.	Rough
Painted	Rubbed
Waterproofed	Formed
Miscellaneous	
Surfaces not readily seen	Formed
Plastered, Tile, etc.	Rough

## 3. TYPES OF FINISH

The following describes the types of vertical finishes:

### 3.1 Rough finish

Concrete surface shall be roughened by means of hammering or other means to provide a surface texture that will develop a good mechanical bond. The concrete shall be free from paint, oil, dust or any material that might prevent satisfactory bond. Air and water should be used to remove loose material. Hammering shall be done by hand or power tools to expose clean virgin concrete (mortar or aggregate) over the entire surface. Not more than 10% of the surface (in any unit of area) shall remain unchipped.

### 3.2 Rubbed Finish

Immediate upon stripping forms and before concrete has changed in color, any fins shall be carefully removed with a hammer. While wall is still damp apply a thin coat of medium consistency neat cement slurry by means of bristle brushes to provide a bonding coat within any pits or blemishes in the parent concrete; avoid coating large areas of the finished surface with this slurry.

Before the slurry has dried or changed color, apply a dry (almost crumbly) grout comprising one

volume cement to 1 1/2 volume of clean masonry sand having a fineness modulus of approximately 2.25. Grout shall be uniformly applied by means of damp (neither dripping wet nor dry) pads of coarse burlap approximately 15 cm square used as a float. Grout shall be well scrubbed into the pits to provide a dense mortar in the imperfection to be patched. Allow the mortar to partially harden from one to two hours depending upon the weather. Avoid direct and hot sunlight. If the air is hot and dry keep the wall damp during this period using a fine, fog spray. When the grout has hardened sufficiently so it can be scraped from the surface with the perpendicular edge of a steel trowel without damaging the grout in the small pits or holes, cut off all that can be removed with trowel. Grout allowed to remain on the wall too long will get too hard and will be difficult to remove.

Next allow the surface to dry thoroughly and rub it vigorously with clean dry burlap to completely remove any dried grout. No visible film of grout should remain after this rubbing. The entire cleaning operation for any area must be completed the day it is started. Never leave any grout on the wall overnight. Allow sufficient time for grout to dry after it has been cut with the trowel so it can be wiped off clean with the burlap. This process removes slight discolorations and stains and gives a uniformly good appearance without effect on a paint coating.

On the day following the repair of pits and blemishes, the walls again should be wiped off clean with dry used pieces of burlap containing old hardened mortar which will act as a mild abrasive. After this treatment there should be no buildup film remaining on the parent surface. If, however, such is present, a fine abrasive stone must be used to remove all such material without breaking through the surface film of the original concrete. Such scrubbing should be light and sufficient only to remove excess material without working up a lather of mortar or change the texture of the concrete.

A thorough wash-down with stiff bristle brushes should follow the final bagging or stoning operation in order that no extraneous materials remain on the surface of the wall. The wall should be sprayed with a fine fog spray periodically to maintain a continually damp condition for at least 3 days after the application of the pit repair grout.

Areas larger than 2.5 cm diameter or 1.25 cm deep should be "dry-tap filled" as for form tie holes. Moisten the hole with water, followed by a 1.6 mm brush coat of neat cement slurry mixed to the consistency of a heavy paste. Immediately plug the hole with a 1 : 1.5 mixture of cement and concrete sand mixed slightly damp to the touch (just short of balling). Hammer the grout into the hole until dense, and an excess of paste appears on the surface in the form of a spider web. Trowel smooth with heavy pressure. Employ same source of cement and sand as used in the parent concrete. Adjust color if necessary by addition of proper amounts of white cement and/or limestone screenings. Rub lightly with a fine carborundum stone at an age of 1 to 5 days if necessary to bring the surface plane with the parent concrete. Exercise care to avoid damaging the virgin skin of the surrounding parent concrete. Wash thoroughly to remove all rubbed matter. If surface ultimately is to be painted, the color matching may be omitted.

No accelerating admixtures should be employed in surface treatment. An approved admixture may be utilized (in accordance with the manufacturer's directions) to reduce shrinkage and improve durability of the 1 : 1.5 mixture.

### 3.3 Formed Finish

All fins and other projections shall be carefully removed, honey-combing repaired, form ties cut out, and holes patched all as specified under Section 3.1.19 "Patching and Repairs".

## 4. HORIZONTAL SURFACES

The top or final surface of all concrete shall be finished in accordance with the following schedule unless otherwise indicated on the drawings, or specified.

<u>SURFACE IDENTIFICATION</u>	<u>TYPE OF FINISH</u>
Floors scheduled to be concrete floor	Wood float
Reservoirs and tank interiors	Light steel trowel
Exposed roof slabs with built-up roofing	Steel trowel
Tile	Light steel trowel
Pavements, walks and ramps	Broomed
Buried roof slabs	Screeded
Platforms	Broomed
Plastering	Broomed

## 5. METHODS OF FINISHING

The finishing of concrete surfaces shall not be started until stiffening of the concrete has taken place. The following describes the types of horizontal finishes.

### 5.1 Screeds

Screeds shall be set as guides so that slabs can be struck true to the required level or slopes shown. Particular care shall be exercised to prevent forming low or depressed areas that do not drain and result in ponding. Screeds shall be sufficiently rigid to resist distortion during the placing and leveling of the slab and shall be accurately set and protected until they are removed. Screeds and their supports shall be completely removed and their recesses filled.

5.2 Wood Float

Following the screeding of the surface to its required level a wood float straight edge shall be worked across the surface to make sure high spots and depressions are eliminated. Floating shall be continued just long enough to produce a true and smooth surface and if a steel trowel finish is required, to bring a small amount of mortar to the surface. Excessive floating shall be avoided.

5.3 Broomed

Concrete floors and slabs such as bridge decks and pavements where a non-slippery surface is required shall receive, following screeding, a broomed surface. As soon as the condition of the concrete permits, before it has hardened appreciably (and normally within 4 hours after depositing), all water, inadvertent film, crude laitance, and loose aggregate shall be removed from the surface by means of wire or bristle brooms in such a manner as to leave the coarse aggregate slightly exposed and the surface clean and generally in condition to provide a non-slippery surface. The brooms shall "roll" the film and laitance (if any) from the slab and leave it clean. Avoid "muddying" the surface by brooming too soon. Raking shall not be employed, and large depressions and general unevenness will not be allowed.

If, in the opinion of the Engineer, the surface finish is not properly done and the resulting surfaces are unsatisfactory, the Contractor shall, chip the surfaces to the satisfaction of the Engineer.

5.4 Steel Trowel

Steel troweling may be commenced as soon as the wood floated surface has hardened enough to prevent an excess of fins from working to the surface. This operation is to be performed by hand or by power driven troweling machines to produce a dense smooth surface free from blemishes. Troweling too soon or excessive troweling in one operation produce an unsound finish. Where a light steel trowel finish is specified light hand troweling shall be used.

**3.3.5 MORTAR PLASTERING**

1. GENERAL

Plastering shall consist of portland cement plaster applied to the limits and lines indicated on the drawings or specified. The thickness indicated or specified are the minimum thickness required and additional thickness will be required to provide for any unevenness in the masonry surface. In the event the average complete plaster thickness over an area in excess of 5 square meters will exceed 5 cm, a wire reinforcing square mesh of SWG 10 spaced at 15 cm shall be attached to the masonry and plastered into a scratch (base) coat. Before plastering all ground ends and corner bends shall be firmly secured in place. Concrete masonry and brick surfaces shall have sufficient roughness to provide proper bond and shall be dampened by brushing or spraying with clean water followed by a primary

coat of portland cement.

2. REPAIR OF DAMAGED CONCRETE

Where concrete is cut and removed to provide for new work, concrete surfaces will be formed which will require finishing. The two surface conditions considered herein are namely, damaged surfaces which are to be cleaned and plastered, and exposed in the finished work; and the surfaces to be incorporated in the new work. The only requirement for damaged concrete surfaces not to be exposed is that reinforcing steel be cut off flush with the concrete surfaces.

Bonding existing concrete to new structural concrete and damaged concrete against which new concrete is to be placed shall be thoroughly cleaned to remove any loose concrete. Reinforcing steel shall be straightened and incorporated in the new work as required. A neat cement slurry shall be applied to the surface just prior to placing new concrete.

Plastering of existing concrete damaged in connection with the new work and exposed to view shall be in conformance with the above specifications with the added requirement that a bonding admixture be incorporated into the plastering cement. The bonding admixture shall be an additive to the concrete mix made from natural or synthetic rubber or an organic polymer or copolymers and applied in accordance with the manufacturer's instructions.

3. MATERIALS

Cement shall be portland cement conforming to JIS R5202, "Chemical Analysis of Portland Cement" and JIS R5210 "Standard for Portland Cement" or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Fine aggregate or sand shall be clean, hard, durable and free from oil, organic matter and other deleterious substances and shall conform to the requirements of ASTM C 144, "Aggregate for Masonry Mortar" or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Water for mixing shall be clean, fresh and free from deleterious substances such as oil, acid, alkali or vegetable matter.

4. PROPORTIONING AND THICKNESS

Mortar plaster shall be mixed in the following proportions.

<u>Coat Identification</u>	<u>Concrete Surface</u>	<u>Masonry Surface</u>
Scratch Coat	1 part cement and 2 parts sand	1 part cement and 4 parts sand
Brown Coat	1 part cement and	

	3 parts sand	
Finish Coat	1 part cement and 3 parts sand	1 part cement and 3 parts sand

All plaster shall be applied where specified or indicated on the drawings with the following thicknesses. Standard thickness of mortar plaster shall be 25 mm for concrete surface and 15 mm for masonry surface.

<u>Coat Identification</u>	<u>Concrete Surface</u>	<u>Masonry Surface</u>
Scratch Coat	10 mm	10 mm
Brown Coat	9 mm	-
Finish Coat	6 mm	5 mm
Total Thickness	25 mm	15 mm

A vertical groove with a width of 3 cm shall be provided to the finish coat of plastering for the concrete wall exterior at every 1.0 m as required and directed by the Engineer.

## 5. APPLICATION

### 5.1 Scratch Coat

The scratch coat shall cover the full length of the wall to be applied. Before the scratch coat hardens, a cross - scratch shall be made to provide a mechanical key for the brown coat. The Contractor shall keep this coat moist for not less than 24 hours and allow it to set before applying the brown coat. The scratch coat shall be applied evenly and with sufficient pressure to produce full keys.

### 5.2 Brown Coat

Before applying the brown coat, dampen the surface of the scratch coat. The brown coat shall be brought to a true, even surface then roughened with a wood float or lightly cross scratched to provide a bond for the finish coat. The Contractor shall keep this coat moist for 4 hours and then it will be allowed to dry out.

### 5.3 Finish Coat

The finish coat shall be applied until the brown coat has seasoned for 7 days. Just prior to application of the finish coat, the brown coat shall again be wetted evenly. The finish coat shall be first floated to a true and even surface, then troweled in a manner that will force the sand particles down into the plaster, and free from rough areas, trowel mark, checks, or other blemishes. The finish coat shall be kept moist for at least 2 days, and thereafter shall be protected against rapid drying until properly and thoroughly cured.



**3.3.6 OTHER SURFACES**

All exposed edges shall be chamfered as specified on each side unless otherwise shown on the drawings or specified. Care shall be exercised to prevent rounding these edges or obliteration of the bevel line when removing the forms or doing any other work adjacent thereto.

**3.3.7 CLEANING**

All exposed concrete surfaces and adjoining work stained by leakage of concrete or other causes shall be cleaned.

## **DIVISION 3 CONCRETE**

### **SECTION 3.4 - CONCRETE JOINTS**

#### **3.4.1 SCOPE OF WORK**

The Contractor shall provide all labor, material, equipment and incidentals required to finish all joints in structural concrete as specified herein. Included are the materials required to complete expansion, control and construction joints including waterstops, fillers and sealants.

#### **3.4.2 GENERAL REQUIREMENTS**

All vertical and horizontal joints in concrete and peripheral walls of structures and conduits conveying or containing liquid, and of buried walls shall have waterstops, unless specifically noted otherwise. This requirement applies to control and construction joints in foundation slabs, and expansion and construction joints in walls and slabs.

All concrete jointing elements herein specified shall be furnished by a supplier that can give satisfactory evidence to the Engineer that they are capable of supplying the quantities for the schedule required and has an organization that is knowledgeable in the installation of these systems. A competent representative of the supplier shall instruct in the installation of these systems.

#### **3.4.3 MATERIALS**

Samples of all materials to be furnished under this section shall be submitted to the Engineer for approval.

##### **1. WATERSTOPS**

Waterstops shall be manufactured with high grade polyvinyl chloride compound and shall meet the requirements of JIS K6773 or approved equal. Water stops shall be the dumbbell with center bulb type, having ribs on webs at both sides of bulb to increase its bonding effect with concrete and the water penetration length.

The thickness, width and other dimensions shall meet the following requirements unless approved otherwise.

<u>Thickness of Concrete Member</u>	<u>Width of Waterstop</u>	<u>Thickness of Web</u>	<u>Number of Ribs</u>	<u>Center Bulb</u>	<u>Dumb Bell</u>
200 mm and less	230 mm	6 mm	2	20mm	18mm
More than 200 mm	300 mm	7 mm	2	24mm	23mm

The joints such as tees, crosses, etc. shall be shop fabricated unless otherwise approved. Joints shall be made in accordance with the manufacturer's instructions if field fabrication of them is approved, but the Contractor shall submit samples of the field fabrications for the approval of the Engineer.

## 2. JOINT FILLER

The joint filler shall be of the thickness indicated on the drawings and shall be the pre-formed non-extruding type joint filler being constructed of cellular sponge rubber or material of equivalent nature which shall meet the requirements of internationally accepted standards and approved by the Engineer.

## 3. SEALING COMPOUND

The sealing compound used with the pre-moulded joint filler shall be an elastic joint filling consisting of a cold application and essentially of urethane base. This material shall be resilient and adhesive, and capable of effectively sealing cleaned joints. It shall not flow from the joint at high temperatures. It shall be of equal quality to Sonolastic NP1 as manufactured by Sonneborn-Rexnord.

Color of sealing compound shall be gray and match the color of the concrete.

Back-up material produced by the same manufacturer of the sealing compound shall be used in accordance with the manufacturer's standards.

### 3.4.4 INSTALLATION

Waterstops for all joints as indicated on the drawings shall be continuous around all corners and intersections. Splices shall be made in accordance with the manufacturer's recommendations, subject to the approval of the Engineer.

The Contractor shall install waterstops in accordance with the method indicated on the drawings and conflict with the reinforcing bars shall be avoided. The Contractor may elect alternate methods subject to approval of the Engineer.

Particular care shall be taken to correctly position the waterstop during installation and prevent it from being moved or distorted by the concrete placement. The waterstops shall be thoroughly cleaned immediately prior to placing of concrete. Adequate provision shall be made to support the waterstop

during the progress of the work and to ensure proper embedment symmetrical about the joint. When PVS waterstops are to be left for future connections they shall be protected by tin plate as shown on the drawings.

Pre-moulded joint filler shall be installed and fixed with concrete nails at the locations and according to the details shown on the drawings.

Joint sealers shall be placed to the width and depth shown on the drawings. Surfaces in contact with sealers shall be clean, dry and firm with all traces of form oil or other coatings removed. Preparation of surfaces, priming, and the handling and preparation of materials shall be in complete compliance with the manufacturer's instructions.

## **DIVISION 3 CONCRETE**

### **SECTION 3.5 PRECAST CONCRETE**

#### **3.5.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials and plant to perform all work necessary for the design, fabrication and erection of such reinforced concrete components which by their definition are not normally constructed directly in their final location but elsewhere and installed thereafter as prefabricated units. This includes all inserts and all material for seating the precast members.

Grouting of joints, making connections and finishing the erected work are also included. All precast concrete work shall be carried out as shown on the drawings, or as directed by the Engineer and as specified herein:

The work, but not limited to, consists of the following:

- a. Precast concrete piles
- b. Precast concrete launder, trough or flumes
- c. Precast concrete underdrain blocks and end plates of filters
- d. Removable concrete covers
- e. Precast concrete curbs
- f. Miscellaneous precast concrete units

#### **3.5.2 SHOP DRAWINGS**

The Contractor shall submit to the Engineer for approval the detailed drawings and detailed calculations as required of all prefabricated elements and specifications outlining methods of fabrication, transportation, handling and sequence of erection. The shop drawings shall accurately locate and show dimensions of all necessary holes, embedded parts, inserts and other details as specified on the drawings.

#### **3.5.3 MATERIAL AND FABRICATION**

All precast concrete members shall be shop fabricated unless approved by the Engineer, and the Contractor shall notify the Engineer six (6) weeks ahead of the time of commencement of the work so that the Engineer can arrange for the necessary supervision, inspection and testing of materials and work.

The concrete shall conform in general to the Concrete Section of these specifications. The maximum size of concrete aggregate shall be 2 cm.

The precast units shall be manufactured by an approved manufacturer of precast concrete products. All

precast units shall be poured in accurately made forms with a concrete slump of not more than five (5) cm and shall be vibrated into place in a manner that will give a smooth even surface. All wires, strands or bars shall be free from oil, lubricants, loose rust and scale. Reinforcing steel in precast concrete shall conform to Section 3.2 "Concrete Reinforcement" of these specifications. Tolerance on all precast concrete work shall be within  $\pm 2$  mm.

All welding required for the anchorage of component parts as shown on the drawings shall be in accordance with the General Requirements of these specifications.

The forms shall be of substantial construction and shall produce a uniformly smooth surface on all formed sides. All forms shall be steel forms with smooth surfaces and accurate dimensions. A minimum concrete cover of 3 cm over all reinforcing steel shall be maintained with the use of spreaders or by bundling in areas adjacent to openings or inserts. Ties shall also have a minimum cover of 3 cm at these locations.

Void forms shall be held in place against uplift or lateral displacement during the placing and vibrating of the concrete by wire ties or other satisfactory means.

The concrete shall be vibrated internally or externally, or both. The vibrating shall be done with care and in such a manner as to avoid displacement of reinforcing steel, prestressing strands, void forms, or other components. There shall be no interruption in the concrete placement for any one of the elements. Concrete shall be carefully placed in the forms and vibrated sufficiently to produce a surface free from imperfections such as honeycomb, segregation, cracking, or checking. Any internal deficiencies noted, such as honeycomb or segregation, may be cause for rejection.

The topside surface of the element shall be given a uniformly smooth steel trowel finish to match the finished surface of the formed sides.

If elements are to be steam cured, the curing shall be done under a suitable enclosure to contain the live steam in order to minimize moisture and heat losses. The initial application of the steam shall be from two to four hours after the final placement of concrete to allow the initial set of the concrete to take place. The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 4 degrees C per hour until a maximum temperature in the range of approximately 60 to 70 degrees C is reached. The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam, the ambient air temperature shall not decrease at a rate to exceed 4 degrees C per hour until a temperature has been reached about 11 degrees C above the temperature of the air to which the concrete will be exposed.

Side forms carrying no load may be removed after 24 hours with the permission of the Engineer.

No patching or finishing of the completed elements will be allowed unless permitted by the Engineer. The Contractor's proposal for methods and materials to be used in the patching or finishing operation shall be submitted to the Engineer for his approval. Projecting fins and surface imperfections shall be removed from the elements in a workmanlike manner.

#### **3.5.4 INSPECTION AND TESTING**

The material and workmanship of all precast concrete elements shall, at any time, be subject to inspection by the Engineer. The Contractor or his subcontractors shall co-operate with the Engineer in permitting access for inspection at all times and to all places where work is being done. No precast concrete member shall be shipped from the manufacturer's plant until approved.

The Contractor shall design and submit for approval by the Engineer, a concrete mix, meeting the requirements of this specification. A minimum of three standard concrete test specimens shall be taken from each batch of concrete by the Contractor. One test specimen shall be broken to determine the 7-day strength. One test specimen shall be broken to determine the 28 day strength. The third specimen is a reserve specimen which may be used at either the time of transfer of prestress or after 28 days in case the first specimen does not show the required strengths. If the second test specimen does not show the required strength, it shall be cause for rejection. The cost of these tests shall be at the Contractor's expense.

The Contractor shall keep accurate records of the concrete mix, concrete strengths, and details of curing which shall be submitted to the Engineer upon his request. The Engineer shall have the right to duplicate the taking of concrete specimens and testing without additional cost to the Contractor. The results of these tests shall be also a basis for acceptance or rejection of the concrete elements and test results by the Engineer shall take precedence over tests taken by the Contractor.

#### **3.5.5 ERECTION AND INSTALLATION**

The installation of all precast concrete launders, wash water troughs, underdrain blocks and end plates especially, shall be made with due care. They shall be installed by experienced workmen true to lines and levels and in proper sequence. Any members damaged during shipment or installation shall be replaced. Repairs to damaged members may be allowed by experienced workmen under supervision of the supplier, if the Engineer orders to do so. No holes shall be cut or drilled in the field without the written approval of the Engineer.

## **DIVISION 4 MASONRY**

### **SECTION 4.1 MASONRY WORKS**

#### **4.1.1 SCOPE OF WORKS**

The Contractor shall furnish all labor, materials, equipment and incidentals required to complete all masonry work as indicated on the drawings and as specified herein.

The work shall consist of brick masonry and stone masonry or those structures shown on the drawings or directed by Engineer to be made masonry work.

The work shall include but not be limited to:

1. All solid brick walls including plastering
2. All brick wall shall be stiffened and tied by practical reinforced concrete, every 6-8 m<sup>2</sup> (2.00 m by 3.00 m or 2.50 m by 3.50 m)
3. Brick work for setting manhole frames and miscellaneous purposes.
4. Brick work for paving
5. Ventilation brick wall for exposed partitions
6. Stone masonry shall be used only for those structures such as light foundation of walls, catchpits; culvert spillway aprons or other protective works on slopes or around culvert ends, and others works be directed by Engineer.

#### **4.1.2 WORK SPECIFIED ELSEWHERE**

The plastering of masonry walls shall conform to the Standard Specifications titled "Concrete Finishes" of Section 3.3 and as herein specified.

Grouting of equipment is specified under the Standard Specifications titled Concrete of Division 3.

Dovetails for anchorage of masonry to concrete masonry are specified under Section 5.2 "Miscellaneous Metals" and Division 3 "Concrete".

#### **4.1.3 MASONRY UNITS (MATERIALS)**

The size of masonry units shall be in accordance with the details noted and/or as herein specified or on the shown drawings.

##### **1. BRICKS**

###### **1.1 Conventional Underburned Brick**

Bricks shall be common clay brick with nominal dimensions of:

Thickness      60 mm



Width	120 mm
Length	240 mm

They shall be fired with sharp and uniformly, clean arises and without cracks and enclosed impurities. The sizes of bricks shall not deviate excessively from the nominal size, but to suit local availability the nominal sizes may vary. The minimal ultimate compressive strength shall be 300 N/cm<sup>2</sup>. Brick tiles shall be used on non-load bearing walls and plastered on both sides.

### 1.2 Ventilation Bricks

Ventilation brick tiles shall be fabricated by machine and fired in high temperature (1080 degrees C), with sharp; uniform in shape-color and size. The ornamental shape shall be approved by Engineer. Size of the ventilation bricks shall be 120 mm by 115 mm by 240 mm and ultimate strength shall be 1440 N/cm<sup>2</sup>. Ventilation bricks shall be used only in non-load bearing walls as shown on the drawing.

### 1.3 Hollow Bricks

Hollow bricks shall be used in non-load bearing walls. Sizes of the hollow brick shall be 71 mm x 115 mm x 240 mm. The hollow brick shall be fired in high temperature, uniformly burned, rectangular and uniform in shape or size; and compressive strength shall be 1440 N/cm<sup>2</sup>.

### 1.4 Brick Tiles

All brick tiles shall be laid in cement and sand mortar in a full bed of mortar, with joints not exceeding 0.5 cm, uniform throughout and finished slightly concave and smooth.

All necessary brick tile cutting shall be neatly done by saws.

Size of brick tiles, shall be 19.5 cm by 9,5 cm by 25 cm thick.

All surfaces to which brick tiles are to be applied shall be even and true, free from dust and dirt and other foreign matter.

Tiles shall be set to correct levels, true to line and perpendicular.

## 2. STONES

- The stone shall be clean, hard, without weak seams or cracks and shall be of a kind known to be durable if necessary, stones shall be dressed to remove any thin or weak portions.
- The stones shall able to be dosely interlocked when placed together.
- Unless otherwise directed by the Engineer, stones shall have a thickness of not less than 15 cm, width of not less than one and a half times their respective thickness, and length of not less than one and a half times their respective widths.

## 3. CEMENT MORTAR

### 3.1 Materials

- a. CEMENT shall conform to the requirements of AASHTO M85-75 or JIS R 5210 or other internationally accepted standards or manufacturer's standards as approved by the Engineer
- b. Fine aggregate shall conform to the requirements of AASHTO M 45-70 or other internationally accepted standards or manufacturer's standards as approved by the Engineer
- c. Hydrated Lime shall meet the requirements for residue, popping and pitting, and water retention shown for type N in ASTM C 207 or other internationally accepted standards or manufacturer's standards as approved by the Engineer
- d. Water shall conform to the requirements of AASTO T 26 or other internationally accepted standards or manufacturer's standards as approved by the Engineer

Water known to be of potable quality may be used without test.

### 3.2 Mortar Mixes

MORTAR to be used for;

- a. Finishing or repairing defects in concrete work, shall be composed of cement and fine sand mixed in the same proportions as in the concrete being finished or repaired, or as specified in Section 3.3.5 "Mortar Plastering".
- b. Setting concrete block and brick and stone masonry shall be in the proportion of one part portland cement and four parts fine aggregate by volume, to which hydrated lime may be added in an amount equal to 10 percent of the Cement by Weight, or as other wise approved by the Engineer.
- c. Plaster of concrete block, Brick and Stone masonry shall be in the proportion of one part portland cement and five parts of fine aggregate or sand by volume to which hydrated lime may be added in an amount equal to 10 percent of the cement by weight, or as otherwise approved by the Engineer. Especially for water protection osmosis or waterproofing, the Contractor shall plaster up to 20 cm from the floor elevation by proportion of one part portland cement and two parts of fine aggregate or sand or as otherwise approved by the Engineer.

## 4.1.4 MIXING AND PLACING

### 1. MIXING

- a. All the materials except the water shall be mixed either in a tight box or in an approved mortar mixer, until the mixture assumes a uniform color, after which the water shall be added and the mixing continued for a five (5) to ten (10) minutes period. The quantity of water shall be such as to produce a mortar or the required consistency but shall be no more than seventy percent (70%) of the weight of the cement used.
- b. Mortar shall be mixed only in those quantities required for immediate use. If necessary, the mortar may be retempered with water within thirty (30) minutes from the time of the initial mixing process. Retempering after this time shall not be permitted.
- c. Mortar that is not used within forty-five (45) minutes after the water has been added shall be discarded.
- d. Mortar shall be mixed by mortar mixer or as otherwise approved by the Engineer.

### 2. PLACING

- a. Surfaces to receive mortar shall be cleaned from oil, or clay or other contaminants and thoroughly saturated before the mortar is applied. Free surface water shall be removed, however, before application of the mortar.
- b. When used as a surface finish, mortar shall be applied to clean damp surfaces in sufficient quantity to provide a minimum thickness of mortar of 1.5 centimeters, and shall be troweled to smooth and even surface.

#### **4.1.5 EXPANSION AND CONTROL JOINTS**

Expansion and control joints shall be made with self expanding cork or premoulded joint filler and a two component synthetic rubber compound.

#### **4.1.6 REINFORCING AND ANCHORS**

All reinforcing bars used in masonry shall conform to the Standard Specifications titled "Concrete Reinforcement" of Section 3.2.

Metal tie bars shall be 4 mm thick by 3 cm wide and 70 cm long and 4 cm right angle bends on each end.

Metal lath, if used, shall be 6 mm mesh galvanized. Dovetail type flat bars for embedded slots or inserts shall be 16 gage and 3 cm wide.

#### **4.1.7 SAMPLES-SAMPLE WALLS**

The Contractor shall submit to the Engineer for approval samples of all concrete block and brick and information on cement, lime and sand to be used.

Before commencing with the laying of any masonry that is to be exposed (not plastered) the Contractor shall construct a sample wall using the block and / or brick and joint spacing proposed for the finished wall. The sample wall shall be 2 meters long and one meter high showing type and tooling of joint, color of mortar, bonding type and width of joints. Sample walls shall be left in place until completion of the masonry work for which they were constructed and then shall be disposed of.

#### **4.1.8 INSTALLATION**

##### **1. GENERAL**

All masonry shall be laid plumb and true to lines and built to the thickness and bond required with courses level and joints and bond uniform. Masonry shall be carried up in a uniform matter. No one portion shall be raised more than a meter above adjacent portions, except with the approval of the Engineer.

##### **2. BRICK WORK**

- a. Conventional under burned solid bricks for wall shall be laid in common bond with all joints filled solidly with mortar and backs fully purged to plaster shall be lightly raked to provide a

bond for plaster. Solid brick for wall shall be plastered on both of sides. All bricks must be thoroughly saturated with water before being laid.

- b. Ventilation bricks and hollow bricks work be installed for partition wall, shall be laid in mortar with exposed joints not exceeding 1.0 cm, uniform throughout and finished slightly concave and smooth.
- c. Brick tiles shall be laid in good "Stack" bond, unless otherwise indicated, with joints not exceeding 0.5 cm and uniform throughout and finished slightly concave and smooth finish. All brick tiles which installed as paving, shall be laid in a full bed of cement mortar. Tiles shall be set true to the lines and levels, and proper pattern arrangement as specified or shown.

### **3. STONE WORK**

- a. The stones be installed as any light foundation shall be laid-in cement mortar with the composition consists of one part portland cement and four parts of sand.
- b. Fresh mortar at least 3 cm thick shall be placed on the prepared foundation immediately before placing each stone in the first course. Large stone selected stones shall be used for the bottom courses and in the corners. Care shall be taken to avoid groupings of stones of the same size.
- c. Prior to laying, the stones shall be cleaned and thoroughly wetted, ample time being allowed for the absorption of water to near saturation. The bed that is to receive each stone shall also be moistened and then mortar bedding layer shall be spread on the sides of stone adjacent to the one being placed.
- d. The thickness of the mortar bed shall be in the range 2 cm to 5 cm and shall be the minimum necessary to ensure all voids between the placed stones are completely filled.
- e. The extent of the mortar bedding placed at any one time shall be limited so that stone are placed only in fresh, unset mortar. If stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone railed with fresh mortar.
- f. Any drawing shown stone surface exposed, the stones shall be laid with longest faces horizontal and the pattern be arranged as balance composition.

#### **4.1.9 LINTELS, TIES AND MISCELLANEOUS ITEMS**

The Contractor shall build in or provide all miscellaneous items to be set in masonry including frames, lintels, reinforcing steel, electrical boxes and fixtures, sleeves, grilles, anchors and other miscellaneous items. All anchorage, attachments, and bonding devices shall be set so as to prevent slippage and shall be completely covered with mortar.

For placement of miscellaneous items refer to the drawings.

#### **4.1.10 GROUTING**

Grout and cement mortar for setting structural steel columns, railings, frames in walls and where otherwise required shall be done with mortar as hereinbefore specified. Before placing grout thoroughly clean all surfaces. Grout shall be tamped into place with a blunt tool to fill the entire void. In the event space does not permit tamping, the Contractor shall build the necessary forms and place grout by pouring from one side only. When grout is placed by pouring, a head of grout shall be maintained in the form. Grout shall be kept wet for three days and after the temporary supports or

adjusting wedges are removed the empty space shall be grouted and the surrounding grout pointed.

#### **4.1.11 CLEANING**

Masonry work to be exposed shall be thoroughly cleaned. Mortar smears and droppings on concrete block walls shall be dry before removal with trowel. Masonry work may be cleaned using a mild muriatic acid solution.

## **DIVISION 5 METALS**

### **SECTION 5.1 STRUCTURAL STEEL WORK**

#### **5.1.1 SCOPE OF WORK**

The Contractor shall provide all labor, materials, equipment and incidentals necessary to furnish and install structural steelwork and required to erect the structural framing as shown on drawings.

#### **5.1.2 DETAILING**

The Contractor shall submit complete sets of detailed working and shop drawings and schedules of all structural steelwork.

The Contractor shall furnish a mill certified report, in triplicate, of the tests for each heat of steel from which the material is to be fabricated. The certification shall contain the results of chemical and physical tests required by the specification for the material. In the event the results of any test are not in conformance with the requirements of these specifications, the Engineer reserves the right to make additional mill and laboratory tests. When additional tests are required, the Contractor shall furnish, cut and machine additional test specimens in accordance with ASTM, JIS or other internationally accepted standards or manufacturer's standards as approved by the Engineer. The additional costs of furnishing, cutting and machining additional test specimens shall be borne by the Contractor.

Shop drawings shall show any field welding necessary for the assembly or erection of the steelwork.

#### **5.1.3 MATERIALS**

Materials, used in the work, shall meet the following requirements of those hereinafter specified under the particular item:

<u>ITEM</u>	<u>APPLICABLE STANDARD</u>	
Structural shapes, plates and bars		
Unless otherwise specified	JIS G 3101	Rolled Steel for General Structure, SS400 or better
Square steel columns	JIS G 3466	Carbon Steel Square Pipes for General Structural Purposes
Steel pipe	JIS G 3452	Carbon Steel Pipes for Ordinary Piping
Galvanized steel pipe	JIS G 3442	Galvanized Steel Pipes for Ordinary Piping

#### **5.1.4 WORKMANSHIP**

Unless otherwise specified, structural steel shall be fabricated in accordance with modern engineering practice. All members shall fit closely together and shall be straight and true, and the finished work

shall be free from burrs, bends, twists, and open joints.

Materials for welding shall be in accordance with the recommendations of the manufacturer of the material to be welded and in accordance with JIS HANDBOOK, Welding. All holes, angles, supports, and braces shall be provided as required. All field assemblies shall be shop assembled and disassembled prior to shipment. Any unmatched holes in shop assemble of field connections shall be reamed and the pieces match marked before disassembly. During erection, approved temporary bracing shall be installed as required to prevent distortion or damage to the framework due to wind or erection forces.

### **5.1.5 FIELD CONNECTIONS**

Field connections shall be made by welding or high-strength bolting as shown on the drawings or approved shop drawings.

### **5.1.6 BOLTING**

High-strength bolts shall be JIS B 1186, “Sets of High Strength Hexagon Bolts, Hexagon Nuts and Plain Washers for Friction Grip Joints”.

Anchor bolts shall be of mild steel with hexagonal nuts. Threads shall be clean cut and conform to or JIS B 0205, Metric Coarse Screw Threads.

Anchor bolts shall be accurately set before the concrete is poured unless specifically permitted otherwise by the Engineer. To facilitate the setting of anchor bolts, the Contractor shall utilize screed plates.

Anchor bolts with pipe sleeves shall be in accordance with the details shown on the drawings.

### **5.1.7 PAINTING**

#### **1. SHOP PAINTING**

All structural steel shall be given shop primer after fabrication and cleaning but before shipping in accordance with the Standard Specifications titled “Painting” of Section 9.1.

All steel work shall be thoroughly cleaned of all loose mill scale, rust, and foreign matter before shop painting. Each individual piece shall be painted prior to assembly. Edges where field welding is required shall not be painted.

Paint shall be applied only to dry surfaces.

#### **2. FIELD PAINTING**

After erection the Contractor shall thoroughly prepare and clean the entire surface of all structural

steel of all dirt, grease, rust or other foreign matter. The entire surface of all members shall be field painted as specified in the Standard Specifications titled “Painting” of Section 9.1.



## **DIVISION 5 METALS**

### **SECTION 5.2 MISCELLANEOUS METALS**

#### **5.2.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals necessary to supply and install all miscellaneous metals, concrete anchors and ornamental iron required and as shown on the drawings.

#### **5.2.2 SHOP DRAWINGS**

Shop drawings shall show size, welding details, thickness and gauge of all materials and all installation details. Field dimensions shall be specifically noted on the shop drawings.

Unless otherwise approved in writing by the Engineer, the Contractor shall furnish a mill certified report, in triplicate, of the tests for each material to be utilized in the work. The certification shall contain the results of chemical and physical tests required by the specifications for the materials.

#### **5.2.3 COORDINATION**

Not applicable.

#### **5.2.4 MATERIALS**

Materials used in the work shall conform to the following requirements or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

<u>ITEM</u>	<u>APPLICABLE STANDARD</u>	
Ductile iron	JIS G 5502	Spheroidal Graphite Iron Castings
Cast iron	JIS G 5501	Gray Iron Castings
Structural steel bars and shapes	JIS G 3101	Rolled steel for General Structures SS400
Steel pipes	JIS G 3452	Carbon Steel Pipes for Ordinary Piping
Stainless steel pipe	JIS G 3459	Stainless Steel Pipes
Stainless steel plate, sheet, bars and shapes		Type specified in JIS
Aluminum for structural shapes	JIS H 4100	Aluminum and Aluminum Alloy Extruded Shapes
Square steel columns	JIS G 3466	Carbon Steel Square Pipes for General Structural Purposes

#### **5.2.5 FABRICATION**

All miscellaneous metal work shall be formed true to detail, with clean, straight, sharply defined

profiles, and smooth surfaces of uniform color and texture and free from defects impairing strength or durability.

Connections and accessories shall be of sufficient strength to safely withstand stresses and strains to which they will be subjected accessories and connections to steel or cast iron shall be steel, unless otherwise specified. Threaded connections shall be made so that the threads are concealed by fitting.

Welded joints shall be rigid and continuously welded or spot welded. The face or fields shall be dressed flush and ground smooth. Welds, not to be ground, shall be so noted on the drawings. Exposed joints shall be close fitting and joined where least conspicuous.

### **5.2.6 FINISHES**

All steel work shall be thoroughly cleaned, by effective means, of all loose mill scale, rust, grease and foreign matter and shall be given one shop coat of paint after fabrication but before shipping. Shop painting shall be in accordance with the Standard Specifications titled "Painting" of Section 9.1. Paint shall be applied to dry surfaces and shall be thoroughly and evenly spread and well-worked into joints and open spaces. Abrasions in field erection shall be touched up with primer immediately after erection.

Galvanized surfaces shall be painted with PAINT SYSTEM F plus specified PAINT SYSTEM in accordance with the Standard Specifications titled "Painting" of Section 9.1.

All exposed stainless steel surfaces shall be polished finish free from die markings, welding discolorations or other surface blemishes.

### **5.2.7 BOLTS AND NUT**

Unfinished bolts shall have hexagonal heads and hexagonal nuts. The bolts shall be long enough to extend entirely through the nut more than four (4) threads beyond. Washers under nuts shall be furnished.

Unless otherwise specified, bolt and nuts shall be galvanized and threads for all nuts and bolts shall comply JIS B 0205, Metric Coarse Screw Threads or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Anchor bolts shall include washers and hexagonal nuts.

### **5.2.8 HAND RAILINGS**

Hand railings indicated to be galvanized steel pipe shall be fabricated from galvanized steel pipe specified in Section 15.2 Piping of Standard Specifications.

Hand railings indicated to be stainless steel shall be fabricated from type 304, stainless steel, light

weight pipe, plate, sheet bars and shapes.

Railings shall be double or single row type with vertical posts or wall anchorage all as indicated on the drawings. Size of railings shall be also as indicated on the drawings.

Where steel toe boards are noted on the drawings they shall be 100 mm high of 4 mm thick steel plate attached to the railing posts by means of clips to prevent movement. Toe boards shall be continuous.

Fasteners for joining rails will only be permitted at removable sections, expansion joints, or as indicated.

Removable pipe railing shall be provided where shown and as detailed.

### **5.2.9 GRATING**

Grating shall be steel, galvanized after fabrication, and type, depth and thickness shall be as shown.

Dimensions of grating shall include proper clearances for erection and removal purposes. Grating, set in concrete, shall rest on embedded steel angle frames. Unless otherwise noted, all grating shall be banded. Grating, in the final position, shall have all surfaces firmly bearing.

### **5.2.10 STAIRS**

Steel stairs shall be mild steel and conform to the details shown. Attachments for pipe railing shall be provided. Stairs shall be of the open riser type, unless noted otherwise.

### **5.2.11 LADDERS**

#### **1. GENERAL**

Ladders shall be stainless steel or steel as shown and be of the type shown. Ladder shall be ship ladders wherever possible. Vertical ladders shall be used where ship ladders are impractical.

#### **2. SHIP LADDERS**

Ship ladders shall be constructed with stringers and treads. Stringers shall be set at an angle of 60 degrees with the floor, unless otherwise shown. Attachments for pipe railings shall be provided.

#### **3. VERTICAL LADDERS**

Stringers and rungs shall be as shown.

Vertical ladders, over 4.5 m in height, shall be provided with continuous safety cages. Safety cages shall start 2.0 m above the floor or ground and continue to the top of the stringers. Cages shall be fabricated from steel vertical bars and horizontal hoops. Size of vertical bars and horizontal hoops shall be minimum 32 mm x 6.0 mm and 50 mm x 6.0 mm respectively. The Cage shall have equally

spaced, horizontal hoops welded to the stringers and vertical bars, and spacing of the hoop shall be maximum 1.0 m. The cage shall extend a minimum 0.8 m out from the ladder.

The tops of vertical ladders shall be designed to provide convenient access to the upper level. Stringers at the top shall extend 0.9 meters above the upper level, unless noted otherwise.

### **5.2.12 CAST IRON FRAME AND COVERS**

Cast iron frames and covers shall be made of cast iron or ductile cast iron conforming to JIS G5501 or JIS G5502 respectively and shall conform to the details shown.

Frames with flanges shall have equally spaced side braces. All covers and grates shall have two (2) lift holes located 180 degrees apart, unless noted otherwise. Frames, covers and grate seats shall be machined to a true plane surface and shall seat firmly without rocking.

Covers required to be locked shall be provided with locking devices which will secure the covers to the frame and which will only be operated by a special wrench.

Covers required to be watertight shall be similar to those required to be locked and in addition a round rubber gasket shall be provided for the cover seat.

Covers required to be vent type shall be similar to those required to be locked and in addition vent holes shall be provided for the cover seat.

Heavy load type cover shall be designed and manufactured based on truck load with 20 ton.

All covers shall have letters cast in and marking shall be as directed by the Engineer. The Contractor shall receive approval of shop drawings prior to casting.

### **5.2.13 WALKWAY AND PASSAGE**

Walkway and passage as shown shall be fabricated from steel angle, standard I and H, plate and checkered plate unless otherwise specified.

Design uniform live load of walkway and passage shall be minimum 4900 N/m<sup>2</sup>. Each support leg shall have base plate, minimum 9.0 mm thick which shall be anchored to the concrete structure by two (2) anchor bolts, minimum 16 mm in diameter. Concrete pad shall be provided for each base plate specified and height of the concrete pad shall be minimum 100 mm.

Checkered plate shall be safe and durable. Raised lugs shall be especially designed to increase skid resistance to prevent accidents. Lug pattern shall be submitted for approval. Build up of weld metal for a lug pattern will not be permitted.

All checkered plates shall have a minimum thickness of 4.5 mm with unit weight of 362.5 N/m<sup>2</sup> unless noted otherwise.

All plates shall be adequately fastened to prevent rocking. Welding of plates will not be permitted without prior approval. The Contractor shall provide sufficient bracing to minimize plate deflections to less than  $L/180$  when the plate is uniformly loaded with  $4900 \text{ N/m}^2$  live load. Removable plates shall have recessed handles. Hinges shall be provided where shown.

## **DIVISION 5 METALS**

### **SECTION 5.3 METAL FABRICATION**

#### **5.3.1 WORKMANSHIP**

Material shall be thoroughly straightened by methods that will not result in injury, except that sharp kinks or bends in members to be straightened will be cause for rejection. Finished members shall be free from kinks or bends. Shearing shall be accurately done, and all portions of the work neatly finished. Corners shall be square and true, unless otherwise shown on the drawings. Where re-entrant cuts cannot be made by shearing, a rectangular punch may be used. Re-entrant cuts shall be filleted, unless otherwise approved by the Engineer. Bends, except for minor details, shall be made by approved dies or bending rolls. Where heating is required, precautions shall be taken to avoid overheating the metal and it shall be allowed to cool in such a manner as not to destroy the original properties of the metal. Steel with welds will not be accepted, except where welding is definitely specified, called for on the drawings, or otherwise approved. All bolts, nuts, and screws shall be tight. The ends of pipes, except for handrailing, shall be reamed.

#### **5.3.2 WELDING**

##### **1. GENERAL**

Welding shall be in accordance with modern engineering practice and shall only be done where shown, specified, or permitted by the Engineer.

Before welding, all steel shall be thoroughly wire brushed, clean of all scale and rust, and thoroughly straightened by approved methods that will not injure the materials being worked on. Welding shall be continuous along the entire line of contact except where tack or intermittent welding is permitted. Where exposed, welds shall be cleaned of flux and ground smooth.

##### **2. WELDER**

All welding shall be done only by certified welders who have sufficient experience and qualifications for welding work.

The Contractor shall submit the past experience and qualifications of proposed welders for the approval of the Engineer.

##### **3. WELDING**

Welding of pressure vessels shall be in accordance with JIS B 8270:1993, "Pressure Vessels (General Standard)" or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Welding of steel water pipe shall be in accordance with AWWA C 206 Field Welding of Steel Water Pipe Joints or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

## **DIVISION 6 CARPENTRY**

### **SECTION 6.1 CARPENTRY**

#### **6.1.1 SCOPE OF WORK**

The Contractor shall furnish all materials, equipment, labor and incidentals required for all items of rough and finish carpentry and mill work complete as shown on the drawings and/or specified herein.

Wood forms for concrete are as specified in Division 3, Concrete.

Wood for temporary structures are as specified in Division 2, Site Works.

Steel gusset plates, bolts, and appurtenances required for wood framing, are specified in Section 5.2, Miscellaneous Metals.

#### **6.1.2 MATERIALS**

##### **1. GENERAL**

All lumber to be incorporated into the permanent work shall be sound stock delivered dry and shall be fully protected at all times from injury and dampness.

Kinked, split, knotted, broken, insect bored, or otherwise damaged pieces will not be allowed in the work.

Gradation shall be select grade which is defined as selected lumber, generally clear, high quality, of good appearance, and suitable for use without waste and for natural finish.

Wood Water Content shall not exceed 75%.

##### **2. HARDWOOD**

Hard wood shall be heavy, and close-grained.

##### **3. SOFTWOOD**

Soft wood shall be relatively light in texture and easily worked.

#### **6.1.3 WORKMANSHIP**

##### **1. PREPARATION BEFORE START OF WORK**

Before carpenters start to work, they shall complete preparation with the wood equipment.

##### **2. SPLICING**

Framing members shall not be spliced between bearing points, and shall be free from pronounced



defects. Joints and splices shall be bolted or spiked together and shall occur over bearing locations only.

All carpentry and millwork shall be accurately cut, fitted and installed as detailed on the drawings.

Anchors shall be installed where indicated or required, to anchor carpentry, or other items securely to masonry or to concrete.

**3. MISCELLANEOUS WOOD FORM WORK**

Forms for structural concrete work are specified in Division 3.

The Contractor shall provide all other miscellaneous wood form work as may be required for the completion of the work.

All staging, exterior and interior, shall be erected by the Contractor and maintained in a safe condition by him.

All edges of sills, projected masonry courses, concrete steps and masonry liable to be damaged during construction shall be protected with temporary wooden covers.

**4. PAINTING WOOD WORK**

All wood work shall be painted in accordance with “Finishes” of Division 9.

**6.1.4 WOOD CABINETS AND CLOSETS**

Where wood cabinets, closets and other wood furniture are detailed on the drawing they shall be constructed to the dimensions and details shown.

Exterior grade teak plywood of sufficient thickness not less than 6 mm, and strength for the use intended shall be incorporated into the work.

Especially for door construction laminated teak plywood of sufficient thickness, not less than 4 mm shall be used.

The thickness and the amount of plywood laminations shall be as follows:

<u>Thickness</u>	<u>Number of laminations</u>
4 and 6 mm	3
12 and 15 mm	5
18 and 25 mm	7

The frame shall be teak wood of size and details shown.

Finished hardware is specified in Division 10.



shall be removed or repaired as directed.

#### **6.1.10 LAMINATED PLASTIC**

Where counter tops, door and other surfaces are noted on the drawings to have a Formica surface, a laminated plastic surfacing shall be applied to a thickness of 1.2 mm.

The materials, adhesives and method of fabrication shall conform to general purpose grade.

The finish shall be semigloss, and the color white unless otherwise specified.

#### **6.1.11 DIMENSIONS**

The sizes shown for wood on the drawings are the so called nominal sizes. All dressed lumber after planing shall not vary from the indicated dimensions by more than 10%. Thickness and width of lumber shall be uniform throughout its length. Lumber shall not be delivered to the site in lengths shorter than 2.5 meters.

#### **6.1.12 PRESERVATIVE TREATMENT**

All wood that is to be installed outside buildings, for bridges, wheel stops, signs and appurtenances and not specified to be painted shall be dipped in a 50 percent strength of pentachlorophenol. The preservative solution shall be a mixture of one (1) part pentachlorophenol to nine (9) parts diesel fuel oil. The pentachlorophenol shall be added slowly to the fuel oil while vigorously stirring the mixture. All lumber to be dip treated shall be immersed in the solution for a minimum of 3 minutes for every 25 mm thickness of the lumber. If it is to be dipped in a bundle; each piece shall be separated from the next with a thin piece of lath board. After immersion, the lumber shall be allowed to drain and excessive preservative shall be dissipated by drying. All cuts, screwed, planed and bored surfaces shall be given a heavy brush coat of the same preservative treatment. Cutting, trimming and drilling shall be done prior to treatment insofar as practicable.

#### **6.1.13 WOOD PURLINS AND JOISTS**

Wood purlins and joists shall be of hardwood, to the dimensions shown on the drawings, and treated properly by residual oil, or shall have a preservative treatment as specified above in 6.1.12.

#### **6.1.14 STOP LOGS**

Wood stop logs of sizes, number and details indicated on the drawings shall be furnished. Wood shall be sound stock, regular size, straight, dry and untreated wood. Split or otherwise damaged pieces shall not be allowed in the work.

Galvanized steel lifting accessories and recesses shall be provided where indicated.

## **DIVISION 7 MOISTURE PROTECTION**

### **SECTION 7.1 ROOFING**

#### **7.1.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals necessary to complete all roofing and flashing as indicated on the drawings and as specified herein.

Roof drains shall be furnished and installed as specified herein, all other work to be installed on roofs such as roof fans and pipe vents are to be furnished and installed as specified under other sections. Roofing and flashing shall be done as specified herein.

Steel purlins are specified in Division 5 “Metals”.

The work included herein applies to roofing materials installed on concrete roof slabs where required on the drawings.

Concrete roof slabs are specified in Division 3 “Concrete”.

#### **7.1.2 SHOP DRAWINGS**

The Contractor shall submit for approval description literature of materials and shop drawings of all fabricated materials to be furnished.

Included shall be the manufacturer's recommendations for installation, sizes, colors and sample.

#### **7.1.3 CONCRETE ROOF SLAB PROTECTION**

The roof shall have a smooth surface with minimum 1% slope toward drain unless specified otherwise or approved.

To protect the surface of concrete roof slabs from water penetration, bituminous sheet shall be used as specified in Section 7.4.4 “Prefabricated Waterproofing Membrane”.

Roof and floor drainage shall be as specified in Division 15, Mechanical Works, Section 15.9 “Plumbing”.

## **DIVISION 7 MOISTURE PROTECTION**

### **SECTION 7.2 CAULKING**

#### **7.2.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials and equipment necessary to complete all caulking as indicated on the drawings and as specified herein.

The work shall include but not be limited to caulking for:

- (1) Wood doors, windows and louver frames.
- (2) Masonry control and expansion joints.
- (3) Caulking for roof penetrations and masonry wall openings.
- (4) Expansion joints where caulking is noted on the drawings and for mosaic and ceramic floor tile.
- (5) Frames for ventilation equipment in masonry openings.

#### **7.2.2 MATERIALS**

##### **1. BACKING**

Joint backing shall be polyethylene foam, neoprene or butyl rope oakum, bituminous or impregnated metals will not be permitted.

##### **2. CAULKING**

Caulking material shall be elastic, non corrosive and of water resistant polysulphide liquid polymers that when set shall be firm but not brittle.

Caulking shall be delivered in original sealed containers and applied in accordance with the manufacturer's directions.

The color shall be gray unless otherwise specified.

#### **7.2.3 INSTALLATION**

Installation of caulking shall be carried out according to the manufacturer's directions and the Contractor shall furnish the services of a person knowledgeable to instruct workmen in the application of caulking or applying the caulking material. All joints, regrets and opening to be caulked shall be clean, dry and free from dust and foreign matter. Where required, a joint cleaner shall be used. Deep joints shall be filled with joint backing to not less than 1 cm of the surface and not less than the thickness of the joint. Joint backing where used shall be furnished by the suppliers of the caulking material. Joint primers shall be applied when required by manufacturer's instructions.

**7.2.4 CLEANING**

Excess caulking material shall be cleaned immediately from surfaces of adjacent work.

## **DIVISION 7 MOISTURE PROTECTION**

### **SECTION 7.3 DAMPPROOFING**

#### **7.3.1 SCOPE OF WORK**

The Contractor shall furnish all material, labor, equipment, and appliances required to do all dampproofing and related work, necessary for the proper completion of the project, as required by the drawings and/or specified herein.

#### **7.3.2 APPLICATION SCHEDULE**

The exterior sides of all wall surfaces in contact with earth specified or shown on the drawings are to be dampproofed from 15 cm below the finished ground elevation down to and including the top of footing. This, in general, applies to the exterior walls of pump rooms and other dry spaces below grade. The walls of manholes, underground vaults, etc. not normally occupied are not to be dampproofed unless specifically required.

#### **7.3.3 MATERIALS**

Dampproofing shall be the product approved by the Engineer.

#### **7.3.4 APPLICATION**

Surfaces to be treated shall be free from oil and dirt and shall be in the proper condition as recommended by the manufacturer prior to the application of the dampproofing material. The concrete shall have been completely cured and the surface shall be dry.

Surfaces to be dampproofed shall receive two heavy coats, the first coat being carefully applied so that holes or untreated air-bubble depressions in the surface shall be completely filled and the second coat shall guarantee 100 percent coating of the surface. The coating shall be applied at a coverage rate not in excess of manufacturer's recommendation for the surface to be covered.

Particular care shall be given to the application of dampproofing at all construction joints which are encountered.

#### **7.3.5 CLEAN-UP**

Upon completion of dampproofing, the Contractor shall remove all excess material from the site. Any splatter on adjacent work shall be removed.

## **DIVISION 7 MOISTURE PROTECTION**

### **SECTION 7.4 WATERPROOFING**

#### **7.4.1 SCOPE OF WORK**

The Contractor shall furnish all materials, labor, equipment and incidentals required to do all waterproofing and related work necessary for the proper completion of work as required by the contract documents and as herein specified.

The Contractor's attention is directed to the fact that the walls will be subjected to a hydrostatic test for leakage before this waterproofing is applied.

It is not the purpose of this waterproofing to repair leaks in concrete, but it is for ensuring that moisture cannot penetrate through.

#### **7.4.2 APPLICATION SCHEDULE**

In general waterproofing is to be applied to the exterior roofs, interior walls of water reservoirs, tanks, pump wells and others containing filtered or finished water. The drawings describe in more detail the limits of waterproofing for the individual structures.

#### **7.4.3 GENERAL REQUIREMENTS**

The work is to be done under conditions as recommended by the manufacturer. The Contractor shall include in his submission for approval, job sites where the material has been previously used and the Engineer may wish to visit the location and see first hand how the material is performing.

Waterproofing materials are not to be applied until 30 days has elapsed since the concrete to be treated was placed or after the hydrostatic test, whichever occurs later.

Adequate ventilation of areas where epoxy and tar base pitch containing solvents are being applied shall be provided. Interior areas shall have forced ventilation and face masks are recommended, as well as suitable protective clothing. The Contractor shall provide approved arrangements in order that the Engineer may inspect the work in progress.

#### **7.4.4 MATERIALS**

##### **1. GENERAL**

Waterproofing shall be either a cement based coating, tar base pitch, epoxy coating or prefabricated waterproofing membrane sheet.

##### **2. CEMENT BASED COATING**



Waterproofing by the use of a cement based coating shall be the product approved by the Engineer.

An acrylic polymer shall be used as an admixture to improve adhesion, such as acryl 60. This is a three coat treatment consisting of a painted prime coat, steel trowel applied cement coating and a sponged coating.

**3. TAR BASE PITCH**

Waterproofing by the use of a tar base pitch shall be approved by the Engineer. This is a four coat treatment consisting of two prime coats and two finish coats.

**4. EPOXY COATING**

Waterproofing by the use of an epoxy coating shall be approved by the Engineer. This system shall be applied in three coats including prime coat. Waterproofing by use of hydro epoxy coating shall be non-solvent epoxy resins base approved by the Engineer. Two coats on prime coat shall be applied.

**5. PREFABRICATED WATERPROOFING MEMBRANE**

Waterproofing by the use of single-ply sheet in a roll with a base of suitably modified bitumen shall be subject to the approval by the Engineer.

**7.4.5 APPLICATION**

**1. GENERAL**

In general, concrete surfaces shall be free of deteriorated concrete, laitance and contamination such as oil, grease, etc.

Concrete surfaces exposed to the sun shall be cooled by water and shaded during application.

**2. CEMENT BASED COATING**

An initial prime coat of cement based coating and water shall be applied and allowed to cure. The material shall be troweled or followed by a sponge float to build up a layer not less than 3 mm thick. Where there are areas of uneven absorption an initial light trowel finish may be required before the finish covering.

To prevent too rapid drying the surface shall be shaded and kept moist until sunset.

**3. TAR BASE PITCH**

Two coats of prime coat shall be applied on the concrete followed by two coats of tar base pitch. Each coat of the latter shall have a 13 to 18 mil thickness and the first coat shall be dry before the second is applied.

4. EPOXY COATING

The Contractor shall mix components thoroughly in accordance with the manufacturer's recommendations. Epoxy coating shall consist of a primer and two coats. Paint may be applied by brush, spray, or rollers all in conformance with the manufacturer's recommendations.

5. PREFABRICATED MEMBRANE WATER-PROOFING

The Contractor shall check the slopping of concrete surface to ensure a regular slope without any asperity.

Before install the membrane sheet, all concrete surfaces should be treated with primers of special chemical composition in accordance With manufacturer's recommendations.

The overlaps between two contiguous rolls should be around 10 cm wide and should be carried out carefully using the torch. The surface of waterproofing membrane sheet should be painted with color Elastomul paint (Special water/solvent-resin emulsion).

## **DIVISION 8 DOORS, WINDOWS, GLASS AND FLOATING FLOOR/ACCESS FLOORING**

### **SECTION 8.1 WOOD DOORS**

#### **8.1.1 SCOPE OF WORK**

The Contractor shall furnish and install all wood doors including furniture doors as shown on the drawings and as herein specified.

Included is the furnishing and installation of frames with necessary incidentals and hardware for wood doors.

#### **8.1.2 SHOP DRAWINGS**

The Contractor shall submit for approval shop drawings showing location, size and details of construction of all doors.

#### **8.1.3 WORK SPECIFIED ELSEWHERE**

Masonry openings are to be prepared under “Masonry” of Division 4.

Caulking is included under “Caulking” of Section 7.2.

Glass and glazing is included under “Glass and Glazing” of Section 8.3.

#### **8.1.4 MATERIALS**

Wood for doors shall be of sound stock, thoroughly seasoned, dried and neatly and accurately framed.

Wood shall conform to the applicable section under “Carpentry” of Division 6 approved by the Engineer, and shall be the type of wood indicated on the drawings.

In general, frames shall be laminated by teak plywood 4 mm First Quality, unless otherwise shown.

All door frame joints shall be mortise and tenon and shall be joined with an approved type of glue.

All wood work shall be sanded, filled, resanded and painted as specified in “Painting” of Section 9.1.

Wood panel door frames shall have a 10 cm width for still vertical frame and shall have a 15 cm width for a horizontal frame stiffening rod vertically centered on the lock or handle and latch assembly.

Joints between teak plywood of 4 mm thickness and door frame shall be by wood glue and nails.

Frames for panel doors shall have a drip-jamb, shall rest on sills, and the bead shall rest on the jamb.

Doors shall be made at a shop specializing in this type of work and not to be made the site. Doors shall

be rigidly framed, smoothly finished at 3.5 cm until 4 cm thick unless otherwise specified.

Teak plywood doors shall have either a solid or hollow core, however, all exterior wood doors shall be solid core. Hollow core shall adequately support the outer plywood and afford strength and stability sufficient for the use intended. Stiles shall not be less than 2 cm and rails shall not be less than 7 cm. A lock block shall be provided 1.0 m from bottom, midway on stile, and shall be securely connected to the stile. Veneer for cross binding and faces shall be plywood of two or more plies with a combined minimum thickness of 7 mm before sanding. Face veneer shall be of plain sliced teak, laid with grain at right angles to cross binding, glued under pressure and heat and sanded smooth.

Flush doors shall be 3.75 cm thick with kamper frame unless otherwise noted. Sash doors shall be solid with standard rails and mullions.

#### **8.1.5 FINISH**

After fabrication and before installation, wood doors, shall be given polish by teak oil and protected from damage until installation.

#### **8.1.6 INSTALLATION**

All wood doors shall be fitted plumb and square in the structural and masonry opening with concrete nails, caulking, wood shims, and appurtenances as indicated on the drawings.

Concrete nails 4.8 mm in dia. shall be through nailed to masonry at 40 cm intervals. Frames shall be set with double wedge blocking in back of nailing points, in back of butts and lock strikes. Caulking shall be installed between the wood frame and the masonry on the inside and outside unless noted otherwise.

## **DIVISION 8 DOORS, WINDOWS, GLASS AND FLOATING FLOOR/ACCESS FLOORING**

### **SECTION 8.2 ALUMINUM DOORS, WINDOWS AND LOUVERS**

#### **8.2.1 SCOPE OF WORK**

The Contractor shall furnish and install all aluminum windows and louvers as shown on the drawings and as herein specified. Included is the furnishing and installation of frames with necessary incidentals. Included herein is the hardware for aluminum windows.

#### **8.2.2 SHOP DRAWINGS**

The Contractor shall submit for approval shop drawings showing location, size and details of construction of all aluminum doors, windows and louvers.

#### **8.2.3 WORK SPECIFIED ELSEWHERE**

Masonry openings are to be prepared under "Masonry" of Division 4, caulking is included under "Moisture Protection" of Division 7.

Glass and glazing is included under "Glass and Glazing" of Division 8.

#### **8.2.4 MATERIALS**

Aluminum for windows and louvers shall be anolok Aluminum. Anolok is an aluminum patented color anodizing process and through the anolok process aluminum extrusion can be treated in a durable inorganic color to yield a finish which is permanent, lightfast, abrasion and corrosion resistant and unchanging in color intensity.

The color of aluminum doors, windows and louvers shall be brown (black-brown), and approved by the Engineer before installing.

Aluminum Framing shall be prepared under "Aluminum Framing" of Section 8.5.

Other requirements of aluminum material for doors, windows and louvers shall be referred to the product data of the manufacturer, especially in, standard finishes, temper designation, alloy specification and standard tolerance.

Frames for doors, windows and louvers shall have a drip.

Jamb shall rest on sills and the bead shall rest on the jamb.

Doors shall be made at a shop specializing in this type of work, and not made at the site such as Alcan Shop Specializing. Doors, windows and louvers shall be rigidly framed, and smoothly finished.

### **8.2.5 FINISH**

After fabrication and before installation, aluminum doors, windows and louvers shall be protected from damage until installation.

### **8.2.6 INSTALLATION**

All aluminum doors, windows and louvers shall be fitted plumb and square in structural and masonry openings with adequate means in accordance with product data from the manufacturer as approved by the Engineer. Caulking and appurtenances shall be as indicated on the drawings.

Such fixtures shall be thoroughly installed to masonry at proper intervals as recommended by the manufacturer.

Frames shall be set with double wedge blocking in back of fixtures points. In back of butts and lock strikes caulking shall be installed between the aluminum frame and the masonry on the inside and outside unless noted otherwise.

## **DIVISION 8 DOORS, WINDOWS, GLASS AND FLOATING FLOOR/ACCESS FLOORING**

### **SECTION 8.3 GLASS AND GLAZING**

#### **8.3.1 SCOPE OF WORK**

The Contractor shall provide all labor, materials, equipment and incidentals necessary to furnish and install all glass as shown and/or specified herein.

#### **8.3.2 WORK SPECIFIED ELSEWHERE**

Mirrors for toilet room are specified in Section 15.9 titled "Plumbing" or as shown on the drawings. Glazing in aluminum frame is specified in "Aluminum Framing" of Section 8.5.

#### **8.3.3 MATERIALS**

##### **1. GENERAL**

Each piece of glass shall bear the manufacturer's label showing grade, thickness and type of glass and all labels shall remain until the glass has been set and inspected. When glass is not cut to size by the manufacturer, the Contractor shall furnish an affidavit stating the grade, thickness and type of glass and manufacturer of the glass furnished.

For the thickness of the glass, reference shall be made to the drawings of doors, windows and louvers.

##### **2. SHEET GLASS**

All clear glass and heat absorbing glass shall be 5 mm thick.

Glass shall be distortion free.

#### **8.3.4 INSTALLATION**

Clear sheet glass shall be used except where indicated otherwise. The glass shall be cut and installed with any visible lines or waves running horizontal.

Glazing in wood shall have rabbets and beads primed and painted. The glass shall be firmly seated into the previously bedded and back-bedded rabbet with glazing compound and secured in place with wood beads, attached with not less than 2.5 cm length finish nails, or flat headed screws, countersunk and set approximately 15 cm on center. Nails or screws, used in beads shall be of the corrosion resistant type.

Glazing in aluminum shall be referred to the data of the manufacturer, including joints of aluminum frame, vinyl gasket and position of 5 mm glass.

**8.3.5 CLEAN UP**

All glass shall be cleaned at the completion of construction and any broken glass replaced.



## **DIVISION 8 DOORS, WINDOWS, GLASS AND FLOATING FLOOR/ACCESS FLOORING**

### **SECTION 8.4 ROLLING SHUTTER DOOR AND FOLDING DOOR**

#### **8.4.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals required for the complete installation of the overhead rolling shutter steel door and the folding door as shown and/or as specified herein. See the drawings for quantity and dimensions of them.

#### **8.4.2 SHOP DRAWINGS**

The Contractor shall submit for approval shop drawings, details of construction, schedule of materials and erection details of the rolling shutter door and the folding door. Method of operation and details of steel guides shall be included as well as a sample of the curtain.

#### **8.4.3 MATERIALS**

Rolling shutter door and the folding door shall have a curtain of interlocking single face formed of rolled zinc galvanized steel or anodized aluminum.

Gauge shall be 18 unless otherwise noted. The door shall be of the dimensions indicated.

Slats and slat lugs at guides shall be sufficient section to give curtain strength adequate to safely resist a 900 N/sq. m wind load.

Galvanizing shall be of zinc applied by a hot-dipped process on both sides. Zinc shall be applied at not less than 0.04 gm/sq.cm of steel and in such a manner as to provide a ductile coating, tightly adherent to base metal.

For the rolling shutter door, the counter balance, coil brackets, and hood shall be fabricated in accordance with the manufacturer's standard. The coil shall be housed in a sheet metal hood, galvanized and bonderized. The folding door shall be hanged from beams and such device, hood and etc. shall be in accordance with the manufacturer's recommendation. Guides shall be fabricated of structural steel of sufficient depth to retain the curtains in the guides against the wind load specified. Guides shall be provided with anchors for wind locks.

Operation of the rolling shutter door shall be by a hand crank shafting and reduction gearing. Crank hoist shall be suitable for face of wall mounting outside building, unless noted otherwise.

The rolling shutter door shall have a continuous rubber cushion along the bottom.

#### **8.4.4 INSTALLATION**

The rolling shutter door and the folding door shall be installed and adjusted to the manufacturer's instructions.

#### **8.4.5 PAINTING**

All surfaces, not galvanized, shall be shop primed with a paint compatible with paint to be applied after installation as specified in "Painting" of Section 9.1. The color of the paint shall be as scheduled or as approved by the Engineer.

## **DIVISION 8 DOORS, WINDOWS, GLASS AND FLOATING FLOOR/ACCESS FLOORING**

### **SECTION 8.5 ALUMINUM FRAMING**

#### **8.5.1 SCOPE OF WORK**

The Contractor shall provide all labor, materials, equipment and incidentals required for furnishing and installing all framing for aluminum doors, windows and louvers as indicated on the drawings and as specified herein.

The work shall include:

- 1) Aluminum frames and sashes for doors, windows and louvers.
- 2) Glazing beads and weather stripping for glass in aluminum sashes.

#### **8.5.2 WORK SPECIFIED ELSEWHERE**

Aluminum thresholds are specified in “Miscellaneous Metals” of Section 5.2.

Glass is specified in “Glass and Glazing” of Section 8.3.

Aluminum grid system for acoustic tile is specified in “Acoustical Treatment” of Section 9.3.

Caulking of aluminum frames is specified in “Caulking” of Section 7.2.

Aluminum gravity shutters and duct work are specified in “Ventilation Systems” of Section 15.10.

#### **8.5.3 SHOP DRAWINGS**

The Contractor shall furnish for approval shop drawings of all aluminum framing. The Contractor shall verify all dimensions at the site for the fit of the materials. The drawings shall show assembly and installation details including anchoring and reinforcing. Samples of frames, sash, and glazing, and accessories shall be furnished. Frame samples shall show method of connections for various sections, and surface finish.

#### **8.5.4 PROTECTION OF MATERIALS**

All materials for the work of this section shall be delivered, stored and handled so as to prevent damage of any nature. Materials that have been damaged shall be removed from the site.

#### **8.5.5 MATERIALS**

All framing sections shall be extruded members of architectural alloy (anodized/aluminum anodizing color process by manufacturer).

Doors shall be of the top and bottom hung type, fabricated of hollow aluminum sections with no exposed seams. Mechanical joints shall be accurately milled to a hairline watertight joint. The minimum wall thickness of door members shall be not less than 3 mm. The doors shall be fabricated to the details indicated on the drawings including steel tension rods, top and bottom, and wool pile weathering on the sides.

Glazing members for doors and windows shall be of such design that they are snapped in, eliminating the use of exposed screws. Glass shall be seated in vinyl weather stripping as indicated on the drawings using neoprene setting blocks.

Hardware reinforcement on doors and windows shall be fastened in place without the attaching method being visible.

Sliding windows shall be fabricated of the shapes indicated on the drawings.

Vinyl weather stripping shall be furnished to the contours indicated on the drawings.

Neoprene setting blocks shall be closed cell neoprene 85 + 5 durometer hardness.

#### **8.5.6 FINISHES**

All exposed surfaces of aluminum doors and windows including sash, framing and partition framing shall be finished to a mirror like surface, free from defects or other surface blemishes.

The finish shall be polished, etched, and anodized (Caustic Etched - Anodized 0.0004 mil thickness). After anodizing the surface shall be coated with a lacquer, or oil for protection.

Edges of door handles and appurtenances shall be ground-off smooth to remove burrs.

#### **8.5.7 INSTALLATION**

All structural concrete and masonry openings shall be prepared plumb and square. Door and window frames shall be installed in the opening, plumb and in true alignment. Frames shall be firmly secured to the floors, walls, heads, ceilings and support members by means of anchors.

#### **8.5.8 PROTECTION AND CLEANING**

The Contractor shall protect all exposed surfaces of aluminum against damage from staining, abrasion or other injury and shall be responsible for final cleaning of the aluminum.

## **DIVISION 8 DOORS, WINDOWS, GLASS AND FLOATING FLOOR/ACCESS FLOORING**

### **SECTION 8.6 STEEL DOORS**

#### **8.6.1 SCOPE OF WORK**

The Contractor shall provide all labor, materials, equipment and incidentals required for furnishing and installing steel doors, frames and appurtenant works as indicated on the drawings and as specified herein.

The work shall include:

- (1) The doors for entering the building.
- (2) The doors for special functions.
- (3) The doors for openings to enter basement or underground ducting.

#### **8.6.2 WORK SPECIFIED ELSEWHERE**

Frames shall be set in concrete or masonry in conformance with the concrete and masonry specifications.

Painting shall be in conformance with "Painting" of Section 9.1.

#### **8.6.3 SHOP DRAWINGS**

The Contractor shall submit, for approval, shop drawings showing location, size, and details of construction and erection of all steel doors, frames and accessories. The shop drawing shall be subject to the approval by the Engineer.

#### **8.6.4 MATERIALS**

Steel plate doors and frames shall be installed to the dimensions indicated on the drawings. Metal sizes shall be the sizes indicated with two (2) mm minimum thickness and framing by elbow steel.

Frames shall be set-up, all welds ground smooth with three (3) jamb anchors each side into concrete and three (3) strap anchors as indicated into concrete masonry. Top of frame shall have a rain lip.

Doors shall be constructed of steel plate and frame as indicated. All doors and frames shall be finished as specified in Section 9.1 "Painting".

## **DIVISION 8 DOORS, WINDOWS, GLASS AND FLOATING FLOOR/ACCESS FLOORING**

### **SECTION 8.7 FLOATING FLOOR/ACCESS FLOORING**

#### **8.7.1 SCOPE OF WORK**

The Contractor shall furnish and install all floating floor/access flooring components as shown on the drawings and as herein specified. Included are the furnishing and installation of all panels, pedestal, interlock and floor covering materials.

#### **8.7.2 SHOP DRAWINGS**

The Contractor shall submit for approval shop drawings showing location, size and details of construction of all floating floor/access flooring components.

#### **8.7.3 WORK SPECIFIED ELSEWHERE**

Anchorage of pedestal to concrete slab is specified under the specification titled “Concrete” of Division 3.

Vinyl tile/sheet for floating floor/access flooring covering is specified under the specification titled “Vinyl Floor Tiles/Sheets” of Section 9.5.

#### **8.7.4 MATERIALS**

The panels shall be module sized at approximate 600 mm x 600 mm die cast aluminum construction.

Panels shall combine the excellent strength characteristics of aluminum with a carefully engineered rib structure. The flat surface of each floating floor/access flooring panel shall be supported by a matrix of major and minor ribs symmetrically spaced and sized for optimum load bearing performance.

To assure lateral stability, the under side of each panel at each corner shall have a female socket which interlocks with a protective edge trim that is pressure-inserted and fastened with adhesive into a machined recess in the edge of each panel.

Solid panels, when in place and functioning as part of the complete floor system, shall be capable of supporting a concentrated load of 454 kg per 645 mm<sup>2</sup> anywhere on the panel, with a maximum deflection of 1.02 mm.

Floor shall be capable of carrying a uniform live load of 16,750 N/m<sup>2</sup>, with a maximum deflection of 1.02 mm.

Maximum permanent set at design load shall not exceed 25 mm. Minimum safety factor at design load

shall be greater than 2.5.

Floor covering on panel surface shall be a vinyl covering material to be compatible with the manufacturers approved adhesives.

Wear surface to be factory applied to required tolerance with creep resistant or conductive adhesive.

Ramps, steps, hand rails, perimeter fascias, plenum dividers, air registers, cable cutouts, access grommets, underfloor utility service boxes, cove bases and panel lifters shall be provided as shown on the drawings or as specified on the floating floor/access flooring design.

Floating floor/access flooring components shall have positive contact for safe, continuous electrical grounding of the entire floor system.

Maximum electrical resistance to be 1 ohm from the top of the panel, less wear surface, to the pedestal base.

The floor panel, exclusive of wear surface and edge trim, shall be fabricated completely of non-combustible materials.

Results of independent laboratory flame spread test, shall be in accordance with ASTM E 84.

#### **8.7.5 INSTALLATION**

The Contractor shall be responsible for providing a level and dry subfloor free of irregularities.

The concrete subfloor shall be cured a minimum of 28 days before installation of the floating floor/access floor.

The installation area shall be free of construction debris and other trades at the time of installation.

The Contractor shall provide a dry and secure storage area and clear access to the site to permit trucks to reach the building under their own power.

The installation area shall be enclosed and the temperature maintained between 15 degrees to 30 degrees C, with relative humidity of 20% - 70%.

The floating floor/access floor shall be installed by a duly authorized and approved representative of the manufacturer.

Prior to allowing other trades on the floating floor/access floor, the Contractor shall accept the floor system.

The Contractor shall protect the finished floating floor/access floor from damage and misuse by

providing and applying a six (6) mm tempered hard board for traffic of equipment to be moved across the floor. The Contractor shall provide and apply additional hardboard, as and where required by the Engineer.

All pedestals are to be of the height required and vertically true, located on centers to positively locate the floor panels. The pedestal head shall provide positive interlocking of panels and pedestals to prevent lateral movement.

Pedestal heads shall be equipped with a conductive grounding pad.

Pedestals shall conform to the panel specifications with regard to load bearing characteristics. Each pedestal will support a 2,268 kg axial load without deformation.

### **8.7.6 FINISHES**

All tile/sheet for covering shall be cleaned after completion and protected from damage. Any damaged work shall be removed and replaced.

The Contractor shall close off work areas when necessary to avoid damage to finished surfaces before they are set up.

The Contractor must remove all of his refuse and waste materials as they accumulate.



**DIVISION 9 FINISHES****SECTION 9.1 PAINTING****9.1.1 GENERAL****1. SCOPE OF WORK**

The Contractor shall furnish labor, materials and equipment necessary to complete all painting work as indicated and as specified herein. All painting shall be done strictly in accordance with the manufacturer's instructions and specifications.

**2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS K5622	Red-Lead Anticorrosive Paint
JIS K5623	Lead Suboxide Anticorrosive Paint
JIS K5633	Etching Primer
SSPC	Standards of Steel Structure Painting Council

**3. GENERAL REQUIREMENTS**

It is the intent of this specification to require the painting of all exposed and submerged metal, exposed masonry and concrete walls of buildings, exposed wood, equipment, piping, frames and all other surfaces obviously required to be painted, unless otherwise specified. The omission of minor items in the painting schedule shall not relieve the Contractor of his obligation to include such items where they come within the general intent of the specifications as stated herein.

The following surfaces are not to be painted unless specifically designated in the Painting Schedule:

- a. Interior waterproofing to surfaces of reservoirs, tanks vaults, access houses and other water containing structures
- b. Top of exterior slabs of reservoirs and miscellaneous structures and slabs on grade concrete floors, sumps
- c. Top of concrete stairs including treads, risers and landings
- d. Wall tile, asbestos roofing
- e. Finished hardware
- f. Non ferrous metals unless specifically noted otherwise
- g. Packing glands and other adjustable parts, name plates and identification devices
- h. Stainless steel

- i. Reinforced concrete gutter interiors
- j. Underside of stairs and ramps
- k. Headwalls and rip rap
- l. Sides of concrete pads above floor
- m. Concrete power poles and lighting standards
- n. Parts of buildings and structures not exposed to sights unless specifically noted otherwise
- o. Masonry surfaces
- p. Concrete bridge structures, except railings

### **9.1.2 MATERIALS**

All painting materials shall be obtained from one manufacturer so that complete compatibility between successive coats may be achieved, unless specified hereunder.

Where shop priming must be done with primers other than specified herein, they shall be approved by the paint manufacturer of the finish coat(s) which must be field applied to them.

All materials shall be delivered in the shop or on the site in unbroken, sealed and labeled containers of the paint manufacturer, and shall be subject to inspection by the Engineer. Labels shall clearly state name of manufacturer, name of paint and type, color and date.

### **9.1.3 SUBMITTALS**

The Contractor shall submit the following to the Engineer for approval before application of all material furnished under this section.

#### **1. MANUFACTURER'S SPECIFICATIONS**

Manufacturer's specifications shall include, as a minimum, the following:

- a. Surface preparation recommendations;
- b. Type of primer, if required to be used;
- c. Maximum dry and wet micron thickness per coat;
- d. Minimum and maximum curing time between coats, including atmospheric conditions for each;
- e. Curing time before submergence in water;
- f. Thinner to be used with each paint;
- g. General ventilation requirements;
- h. Atmospheric conditions during which the paint shall not be applied;

- i. Allowable methods of application;
- j. Maximum allowable moisture content and minimum age of plaster, concrete and wood surfaces at time of paint application;
- k. Certification from the recognized public health authorities for lining in potable water service.

**2. MANUFACTURER'S STATEMENTS OF COMPATIBILITY**

Manufacturer's statements of compatibility to be furnished when products of different manufacturers are employed in the same system shall be in the form of letters, on manufacturer's letterhead, and signed by an officer of the company, stating that different products are compatible when used together and have previously been so used.

**9.1.4 SCAFFOLDING**

The Contractor shall supply, erect and afterwards remove all scaffolding, ladders, and temporary platforms, required for all painting work.

This scaffolding shall be permitted to be used by other trades for the hanging and replacing of fittings, fixtures, and appurtenances which have been temporarily removed to allow for the proper proceeding of the painting work. The work of the other trades shall not interfere with or impede the painter's work.

The support or bracing of any part of any scaffolding from or to any wall, sill, or window frame is strictly prohibited. All scaffolding must be strongly and safely built as an independent structure supported only by the floor or ground.

**9.1.5 PREPARATION OF SURFACES**

**1. GENERAL**

All surfaces to be painted shall be thoroughly cleaned, by effective means, of all foreign substances. Cleaning shall be done with approved solvents, power wire brushing, scraping or sandblasting.

Hardware, electrical fixtures and similar accessories shall be removed or suitably masked during preparation and painting operations.

**2. METAL SURFACES**

Metal surfaces shall be clean and free from flaking, bubbling, rust, loose scale and welding splatter. Sharp edges shall be dulled by grinding. Oil and grease shall be thoroughly removed by mineral spirits or solvents. Priming shall be done immediately after cleaning to prevent new rusting.

**3. WOOD SURFACES**

Wood surfaces shall be sanded to a smooth surface. No wood shall be painted or finished unless it is

sufficiently dry. All sapwood, streaks and knots shall be sealed with filler. Excess natural resin shall be removed with a blow torch, scraper or solvent. The prime coat shall then be applied after which, when dry, nail and knot holes shall be filled with putty, allowed to dry, and sandpapered.

#### **4. CONCRETE AND MASONRY SURFACES**

Concrete and masonry surfaces shall be left at least one month before painting. All concrete surfaces shall be cleaned of all dust, form oil, curing compounds and other foreign matter. Efflorescence shall be removed using a 15 to 20 percent muriatic acid solution.

#### **5. PLASTERED SURFACES**

Plastered surfaces shall be painted not less than 60 days after application. No efflorescence shall appear.

### **9.1.6 WORKMANSHIP**

All painting shall be done strictly in accordance with manufacturer's specifications, and recommendations.

Work areas will be designated by the Engineer for storage and mixing of all painting materials. Painting materials shall be stockpiled in a neat manner to facilitate finding them and preventing their loss or misuse. Painting wastes shall be disposed of promptly in proper containers outside the building. No plumbing fixtures or drainage system shall be used for disposal.

### **9.1.7 APPLICATION OF PAINTS**

#### **1. GENERAL**

The Contractor shall apply each coating in quantities and/or thickness as indicated in Subsection 9.1.16 "Painting System" of this Section, producing an even film of uniform thickness. If paint has thickened or must be diluted for application by spray gun, the coating shall be built up to the same film thickness achieved with undiluted material. The coverage of paint must remain the same, whatever method of application shall be used. Each coat of paint shall be in a different tint to the succeeding one.

#### **2. DRYING**

Drying time shall be allowed before additional coats shall be applied. Where conditions are other than normal, because of weather, or where painting is done in confined areas, longer drying time will be necessary.

#### **3. APPLICATION**

### 3.1 General

Paint shall be applied either with brushes, by means of rollers, or by spraying machines to obtain a uniform even coating.

Paint shall be approximately of the same temperature as that of the surface on which it shall be applied.

All surfaces shall be sanded lightly between coats and dusted before the succeeding coat shall be applied.

Four (4) liters of paint as originally furnished by the manufacturer shall not cover a greater area when applied by spray gun than when applied unthinned by brush. Deficiencies in film thickness shall be corrected by the application of additional coat(s).

On masonry, application rates will vary according to surface texture; however in no case shall the manufacturer's stated coverage rate be exceeded.

On porous surfaces it shall be the painter's responsibility to achieve a protective and decorative finish either by decreasing the coverage rate or by applying additional coats of paint.

### 3.2 Brush

The primary movement of the brush shall describe a series of small circles to thoroughly fill all irregularities in the surface after which the coating shall be smoothed and thinned by a series of parallel strokes.

### 3.3 Roller

This application shall be done by rolling the second coat at right angles to the first coat.

### 3.4 Sprayer

Spray painting shall only be permitted in areas approved by the Engineer. Any equipment located in such areas shall be completely enclosed in a manner satisfactory to the Engineer. Spray equipment shall be of ample capacity for the work and shall at all times be kept clean and in good working order. Spray guns shall be suited to the type of paint specified, and shall be operated with orifices, nozzles and air pressure adjusted to consistency. Spray painting shall be done by persons experienced with this type of equipment.

Paint pots shall be of ample capacity and shall be equipped with means of controlling air pressure on the pot, independently of the pressure on the gun.

Air lines shall be equipped with water traps to positively remove condensed moisture.

If satisfactory work with any one of the application methods is not expected or not obtained, the Engineer will decide which method shall be used. On surfaces inaccessible for brushes, and where spraying is not being employed, the paint shall be applied with sheepskin daubers specially constructed for the purpose.

### **9.1.8 VENTILATION**

In enclosed areas where painting systems using strong solvents are specified, a forced air ventilation system shall be provided.

All treatment shall be done in accordance with the manufacturer's instructions.

### **9.1.9 SHOP PAINTING**

#### **1. GENERAL**

Except for galvanized metal surfaces and other specified coating, all mechanical and electrical equipment and ferrous metals are to be painted at the place of manufacture or fabrication. This shall be carried out to the extent and as required under the various other sections of the specifications. The Contractor shall be responsible for checking the compatibility of the shop paints with the field applied touch-up and finish paints. Items shop painted shall not be transported until adequate drying time has elapsed. Shop painting consists of either shop priming or shop applied finish coating.

#### **2. SHOP PRIMING**

All structural steel, miscellaneous ferrous metal and metal castings, shall be shop primed before delivery to the site. This prime coat is to be applied after fabrication and before exposure to the weather.

#### **3. SHOP APPLIED FINISH COATING**

All equipment which is customarily provided with a baked-on enamel finish or a standard factory finish shall be well painted to provide protection for ocean shipment and for possible extended storage periods.

### **9.1.10 FIELD PAINTING**

#### **1. GENERAL**

All painting at the site shall be designated field painting and shall consist of field priming and field painting to provide finish coating. The work shall be under the close supervision of the Engineer. The Engineer shall be advised of all painting work in advance so that surface preparation may be inspected

and approved prior to application.

## 2. FIELD PRIMING

Any structural steel, miscellaneous metal and other metals which arrive at the site unpainted shall be cleaned and field primed. Surfaces that have been shop primed and have been damaged in shipment and/or in installation or where shop prime has deteriorated shall be promptly cleaned and retouched before any successive painting is done in the field. Shop primed surfaces damaged by field welding shall be cleaned and field primed.

## 3. FIELD PAINTING

Equipment which is customarily shipped with a baked-on enamel finish or with a standard factory finish shall not be field painted unless the finish has been damaged in transit or during installation.

Successive coats of paint shall be tinted so as to make each coat easily distinguishable from each other with the final undercoat tinted to the appropriate shade of the finished coat. Finish surfaces shall not show brush marks or other irregularities. Under coats of metal surfaces shall be sanded to remove defects and provide a smooth surface. Tops and bottoms of doors shall be painted.

Painting shall be continuous and shall be accomplished in an orderly manner so as to facilitate inspection. Surfaces of exposed members that will be inaccessible after erection shall be cleaned and painted before erection. Any defective paint changes in color or incompatible paint with undercoat shall be scraped off and repainted.

Any pipe or other metal surfaces to be painted a color other than black that have a coating of tar or asphalt-compound shall be painted with a paint specifically designed to isolate the finish paint from the tar surface.

### 9.1.11 APPEARANCE

The finished surfaces shall be free from runs, drops and brush marks, exhibiting good hiding, spreading and leveling.

Only erection marks will be allowed. After the erection has been completed, the Contractor shall paint over all erection marks, areas left unpainted for erection purposes, and damaged spots. Touching up shall be done with the same primers and finish coats as used originally on both shop and field painted surfaces.

### 9.1.12 MIXING AND THINNING

Paints shall be thoroughly stirred, strained and kept at a uniform consistency during the application.

Mixing of pigment to be added shall be done strictly as recommended by the manufacturer.

Where thinning is required, only the products of the manufacturer furnishing the paint and recommended for the particular purpose shall be allowed, according to instructions of the manufacturer.

### **9.1.13 COLORS**

Colors shall be as shown on the Color Schedule to be provided ~~at a later date~~.

All pipelines shall be painted in solid colors. Identification shall be by color tapes attached to the exposed pipes at intervals of 4 meters. Legends and other tapes shall be in black or white. Tapes shall be approximately 5 cm by 15 cm. The tapes and pipes shall be in the following piping color code schedule.

#### **PIPING COLOR CODE SCHEDULE**

Type of Piping	Color	Process Fluid Abbreviation
<b>1. Water Treatment Plant</b>		
Raw water	Yellow green	RW
Filtered water	Blue	FW
Finished water	Light blue	FNW
Plant water (potable water)	Light blue	PW
Drains	Dark brown	PD
Air scour	Cream	AS
Coagulant solution	Orchid	CS
Flocculant solution	Butter milk	FS
Chlorine solution	Yellow	CLS
Activated carbon solution	Dark gray	AC
Compressed dry air	Teak	DA
<b>2. Sewage Treatment Plant</b>		
Sewer	Grey	SE
Sludge	Brown	SL
Compressed air pipe	Green	CA
Air pipe	White	AI
Wash water (reclaimed water)	Black	WW
Potable water	Light blue	PW

### **9.1.14 PROTECTION AND CLEANING**

The Contractor shall protect all floors, walls and other adjacent areas and equipment from droppings by covering with tarpaulins, masking or otherwise. Dripped or spattered paint shall be promptly removed.



Painted surfaces shall be carefully protected upon completion of the work.

### **9.1.15 INSPECTION**

All phases of the work shall be subject to inspection by the Engineer to assure proper performance of the specifications. Deficiencies shall be remedied.

Prime coats and each succeeding coat shall be inspected and approved before additional coats shall be applied.

### **9.1.16 PAINTING SYSTEM**

#### **1. GENERAL**

Painting system to be applied under this Contract shall be specified as follows and surface preparation specified hereinafter shall conform to SSPC.

#### **1.1 System A (Alkyd Resin Paint System)**

System A, alkyd resin paint system shall be :

ITEM	NAME OF PAINT	MINIMUM DRY FILM THICKNESS (Microns)
a. Surface preparation	: SSPC-SP-6 or SP-3	
b. Primer	: Etching primer	20
c. First coat	: Red lead or lead suboxide primer	35
d. 2nd coat	: Ditto	35
e. 3rd coat	: Long oil alkyd resin paint	45
f. 4th coat	: Ditto	20
g. Finish coat	: Ditto	20

Etching primer shall conform to JIS K5633 class 2 or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

First coat of red lead and lead suboxide primer shall conform to JIS K5622, Class 1 and JIS K5623, Class 1 respectively.

2nd coat of red lead and lead suboxide primer shall conform to JIS K5622, Class 2 and JIS K5623, Class 2 respectively.

1.2 System B (Chlorinated Rubber Paint System)

System B, chlorinated rubber paint system shall be:

ITEM	NAME OF PAINT	MINIMUM DRY FILM THICKNESS (Microns)
a. Surface preparation	: SSPC-SP-6 or SP-3	
b. Primer	: Organic zinc rich primer	20
c. First coat	: Ditto	40
d. 2nd coat	: Chlorinated rubber paint	40
e. 3rd coat	: Chlorinated rubber middle coat	35
f. Finish coat	: Chlorinated rubber finish coat	35

1.3 System C (Epoxy Resin Plus Urethane Paint System)

System C, epoxy resin plus poly urethane paint shall be:

ITEM	NAME OF PAINT	MINIMUM DRY FILM THICKNESS (Microns)
a. Surface preparation	: SSPC-SP-10	
b. Primer	: Inorganic zinc rich primer	75
c. First coat	: Epoxy primer	60
d. 2nd coat	: Ditto	60
e. 3rd coat	: Poly-Urethane resin paint	30
f. Finish coat	: Ditto	30

1.4 SYSTEM D1 (Epoxy Resin Paint System)

System D1, epoxy resin paint system shall be suitable for drinking water service and paint shall be certified by recognized public health Authorities for linings in potable water. The Contractor shall submit certification of paint which is suitable for drinking water service.

System D1 shall be:

ITEM	NAME OF PAINT	MINIMUM DRY FILM THICKNESS (Microns)
a. Surface preparation	: SSPC-SP-10	
b. First coat	: Epoxy resin	125
c. 2nd coat	: Ditto	125
d. Finish coat	: Ditto	125

1.5 SYSTEM D2 (Epoxy Resin Paint System)

System D2, epoxy resin paint system shall be:

ITEM	NAME OF PAINT	MINIMUM DRY FILM THICKNESS (Microns)
a. Surface preparation	: SSPC-SP-10	
b. Primer	: Inorganic zinc rich primer	75
c. First coat	: Epoxy primer	60
d. 2nd coat	: Ditto	60
e. 3rd coat	: Epoxy resin paint	50
f. Finish coat	: Ditto	50

1.6 SYSTEM E1 (Tar Epoxy Resin Paint System)

System E1, tar epoxy resin paint system shall be suitable for drinking water service and paint shall be certified by recognized public health Authorities for linings in potable water. The Contractor shall submit certification of paint which is suitable for drinking water service.

System E1 shall be:

ITEM	NAME OF PAINT	MINIMUM DRY FILM THICKNESS (Microns)
a. Surface preparation	: SSPC-SP-3 or SP-10	
b. First coat	: Tar epoxy resin paint	200
c. 2nd coat	: Ditto	200
d. Finish coat	: Ditto	200

1.7 SYSTEM E2 (Tar Epoxy Resin Paint System)

System E2, tar epoxy resin paint system shall be:

ITEM	NAME OF PAINT	MINIMUM DRY FILM THICKNESS (Microns)
a. Surface preparation	: SSPC-SP-3 or SP-10	
b. Primer	: Organic zinc rich primer	40
c. First coat	: Tar epoxy resin paint	200
d. 2nd coat	: Ditto	200
e. Finish coat	: Ditto	200

1.8 SYSTEM F (Paint System for Galvanized Surfaces)

System F, paint system for galvanized surfaces shall be :

a. Surface preparation and primer

Surface shall be free from moisture, dust or other contaminants with use of solvent cleaning. Damaged galvanized area shall be cleaned by using hand or power tool, and surface shall be finished as SSPC-SP3 and painted with etching primer, minimum dry film thickness of 20 microns.

b. Coat

After finishing surface preparation, painting system A, B, C, D1, D2, E1 or E2 shall be applied unless otherwise specified.

**9.1.17 AREA OF APPLICATION**

Painting systems specified in the previous section shall be applied to the following area and items.

	Area and Items	Painting System
1.	Ungalvanized ferrous metal, outdoor service, except buried, submerged and other surfaces specifically included elsewhere.	System A
2.	Ungalvanized ferrous metal, indoor service, except special areas specified, buried, submerged and other surfaces specifically included elsewhere.	System B
3.	Ungalvanized ferrous metal, outdoor service, specially specified, except buried, and submerged. a. Coarse and fine screen steel work b. Sludge scraper steel work c. Solids contact clarifier, alternative offer, steel work d. All areas and items specified	System C
4.	Ungalvanized ferrous metal, indoor service, corrosive environment. All steel surfaces in alum building, chlorine building, utility duct and other areas specified, including doors and door frames, control panels, piping, mechanical equipment and miscellaneous metal work.	System D2
5.	Galvanized ferrous metal, outdoor service, except buried, submerged, and other surfaces specifically included elsewhere.	System F plus System A
6.	Galvanized ferrous metal, indoor service, except buried, submerged and other surfaces specifically included elsewhere.	System F plus System B
7.	Galvanized ferrous metal, indoor service, corrosive environment. All galvanized steel surfaces in alum building, chlorine building, utility duct and other area specified.	System F plus System D2
8.	Ungalvanized ferrous metal, submerged. a. All steel work, submerged or intermittently submerged in water, potable water production process b. All steel work, submerged or intermittently submerged in water, especially the filter process c. All steel work, submerged or intermittently submerged in water, except the potable water production process	System E1 or System D1 System D1 System E2
9.	Galvanized ferrous metal, submerged. a. All galvanized steel work, submerged or intermittently submerged in water, and potable water production process b. All galvanized steel work, submerged or intermittently submerged in water, specifically the filter process c. All galvanized steel work, submerged or intermittently submerged in water, except the potable water production process	System F plus System E1 or System D1 System F plus System D1 System F plus System E2
10.	Buried miscellaneous ferrous surfaces.  Buried valves, flange, flexible joints sleeve coupling, victaulic coupling and other ferrous materials, unless otherwise specified.	Petrolatum corrosion protection tape as specified in Section 15.2.12 of the Standard Specifications

## **DIVISION 9 FINISHES**

### **SECTION 9.2 CERAMIC WALL AND FLOOR TILE**

#### **9.2.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals required for glazed ceramic wall and floor tile as indicated on the drawings and/or as specified herein.

#### **9.2.2 GENERAL**

Grounds, door bucks, plumbing fixtures, sleeves and all fittings shall be in place and other openings shall be properly closed before any tile is installed. All tile shall be delivered to the job site in original, unopened sealed packages unless otherwise permitted and cartons shall be kept dry until tiles are removed and checked. Precautions shall be taken to protect tiles from breakage or staining.

#### **9.2.3 SAMPLES**

The Contractor shall submit for approval samples of all tile proposed. Colors will be selected by the Engineer if not specified.

#### **9.2.4 MATERIALS**

##### **1. GENERAL**

Glazed ceramic wall tile shall have square edge and nominal face sized noted on the drawings.

Wall tile with soft gray color shall be 10 cm by 10 cm by 0.7 cm or otherwise specified and shown on the drawings.

Wall and floor tile indicated on the drawings shall be glazed ceramic tile. Color shall be as selected by the Engineer unless noted otherwise.

Anti-acid glazed ceramic floor tile shall have square edges and nominal face sizes as noted on the drawings. Unless otherwise specified the floor shall be of anti acid ceramic tile.

Anti-acid ceramic tile shall be 30 cm by 30 cm by 0.7 cm. Color shall be as selected by the Engineer unless noted otherwise.

##### **2. TILE ACCESSORIES**

Tile accessories shall be ceramic type tile and of soft gray color or otherwise specified and shown on the drawings. Tile accessories shall be furnished for wall and floor tile only.

The location of tile accessories shall be as indicated on the drawings.

### **3. BACKING AND GROUT**

Tile backing on walls shall be a portland cement mortar not greater than 2 cm thick installed in conformance with "Concrete Finishes" of Section 3.3. Mix shall be 1 part cement to 4 parts sand.

Grout for setting wall tiles shall be 1 part color cement (soft - gray) and 1 part fine sand by volume with the addition of a bonding additive such as a water based polyvinyl acetate liquid approved by the Engineer.

The mix proportion of admixture and grout coverage shall be in conformance with the recommendations of the admixture manufacturer.

#### **9.2.5 INSTALLATION**

All surfaces to which wall tile is to be applied shall be even and true, free from dust and dirt and other foreign matter. A skim coat of grout shall first be applied with a flat trowel and allowed to dry. Openings around pipes and fixtures shall be sealed by packing with grout. Backs of tiles shall be spread with grout and set in place by a slight twisting motion to assure suitable contact. Tiles shall be set to correct levels, true to line and perpendicular, and neatly cut around piping, fixtures and electrical receptacles.

Excessive grout shall be removed and after tile has set, joints shall be filled with grout to bottom edge of the bevel. Grout shall be forced into joints followed by sponging and tooling.

#### **9.2.6 CLEANING, FINISHING AND PROTECTION**

All tile work shall be thoroughly cleaned after completion and protected from damage. Under no circumstances shall any tile be cleaned with an acid solution or an abrasive cleaner. Any damaged work shall be removed and replaced. The Contractor shall close off work areas when necessary to avoid damage to finished surfaces before they are set up. The Contractor must remove all of his refuse and waste materials as they accumulate.

#### **9.2.7 ADDITIONAL MATERIALS**

The Contractor shall furnish and deliver to the Employer 30 sq. meter of additional tiles of each type installed, properly packed in a carton, and clearly marked on the outside.

## **DIVISION 9 FINISHES**

### **SECTION 9.3 ACOUSTICAL TREATMENT**

#### **9.3.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals required for acoustical ceilings as shown on the drawings and as specified herein.

All acoustical materials shall be flame resistant.

#### **9.3.2 SAMPLES AND LITERATURE**

The Contractor shall submit for approval samples of all materials proposed and descriptive literature and data.

Shop drawings shall be furnished for approval showing the proposed layout of the ceiling including ventilation grills, light fixtures and moulding.

#### **9.3.3 MATERIALS**

Acoustical lay-in ceiling shall be the size indicated on the drawings, square edge calcium silicate non combustible boards approved by the Engineer.

Acoustical tile shall be subject to the approval by the Engineer.

Suspended galvanized steel or aluminum grid system shall be an exposed system with main components being galvanized steel or aluminum. Main runners, cross T's and wall moulding where exposed in the finished work shall be free from galvanized defects, die marks, scratches, streaks or other surface blemishes.

Included with the grid system shall be the necessary splicers, springs, clips and fasteners to ensure proper alignment and rigidity of the grid system.

Steel wire hangers and hooks for support of the grid system shall be of the dimensions and installed at the spacings as indicated on the drawings.

#### **9.3.4 INSTALLATION**

Acoustical lay-in ceiling shall be installed in a manner so as to be easily removed.

The grid system and panel shall be installed as required for lighting fixtures and ventilating registers.

Recessed, regressed or coffered lay-in light fittings are recommended to integrate properly with the suspended ceiling. For all types of fittings to be installed unless the suspensions have been properly reinforced, the Contractor shall support them from the structure above.



Air supply and return shall be via air handling light fittings, or the CMC linear system, with T-bar type diffusers.

**9.3.5 ADDITIONAL MATERIAL**

Six (6) additional acoustical lay-in panels shall be supplied in a carton properly identified.

**9.3.6 CLEANING**

Following installation and before completion the Contractor shall clean any dirty or discolored surfaces and replace any damaged or unsatisfactory acoustical lay-in panels.

## **DIVISION 9 FINISHES**

### **SECTION 9.4 PORTLAND CEMENT COLORED FLOOR TILE**

#### **9.4.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals required for colored portland cement floor tile as indicated on the drawings and/or as specified herein.

#### **9.4.2 GENERAL**

All portland cement tile shall be delivered to the job site in original condition and the quality shall be checked and approved by the Engineer.

Precautions shall be taken to protect colored portland cement tiles from breakage or staining.

#### **9.4.3 SAMPLES**

The Contractor shall submit for approval samples of all colored Portland Cement proposed. Color to be selected by Engineer or as indicated on the drawings.

#### **9.4.4 MATERIALS**

##### **1. GENERAL**

Colored portland cement tiles shall have square edges and nominal face sizes as noted on the drawings.

Portland cement floor tile shall be 30 cm by 30 cm by 2.6 cm with first quality performance standard. Patterns and color shall be shown on the drawings.

##### **2. BACKING AND GROUT**

Portland cement tile backing on floor shall be a cement mortar not greater than 2 cm thick installed in conformance with "Concrete Finishes" of Section 3.3. Mix shall be one (1) part portland cement to three (3) parts sand.

Grout for setting floor tile shall be 1 part white cement and 1 part of the same color as the colored cement tile.

#### **9.4.5 INSTALLATION**

Colored portland cement tile shall be installed by experienced workmen on tile installing.

All surfaces of floor to which portland cement tile is to be applied shall be even and true, free from dust and dirt and other foreign matter.

A skim coat of grout shall first be applied with a flat trowel and allowed to dry.

Openings around pipes and fixtures shall be sealed by packing with grout.

Tiles shall be set to correct levels, true to line and perpendicular, and neatly cut around piping, fixtures, electrical ductwork, and mechanical foundations.

#### **9.4.6 CLEANING, FINISHING AND PROTECTION**

All tile work shall be thoroughly cleaned after completion and protected from damage. Any damaged work shall be removed and replaced. The Contractor shall close off work areas when necessary to avoid damage to finished surfaces before they are set up.

The Contractor must remove all his refuse and waste materials as they accumulate.

## **DIVISION 9 FINISHES**

### **SECTION 9.5 VINYL FLOOR TILE/SHEET**

#### **9.5.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals required for the complete vinyl floor, and for the floating floor covering as indicated on the drawings and/or as specified herein.

#### **9.5.2 SAMPLES**

The Contractor shall submit for approval sample of materials to be installed showing size, color range and general characteristics.

#### **9.5.3 MATERIALS**

##### **1. GENERAL**

Materials shall be first quality only, as specified, delivered to the site in the original sealed packages of the manufacturer and labeled with brand name, size, color, etc. Tiles/sheets shall conform to Industrial Standard for vinyl floor tiles/sheets.

##### **2. VINYL FLOOR TILE/SHEET**

Unless otherwise specified, tiles/sheets shall conform to the size of floating floor component with the minimum thickness of 2.5 mm and shall be of non-asbestos type shall be the material as manufactured in accordance with JIS A 5705:1988 "Floor covering-PVC" and other internationally accepted standards. Color shall be as approved by the Engineer.

##### **3. ADHESIVE**

The adhesive to be used for the installation of vinyl floor tile/sheet shall be a waterproof adhesive as recommended by the tile manufacturer for installation.

#### **9.5.4 INSTALLATION**

Installation shall not commence until work of other trades, including painting has been substantially completed. All materials shall be installed by competent craftsmen experienced in this type of work, and in strict accordance with the directions of the manufacturer whose materials are used.

Flooring materials shall be installed with an adhesive in such a manner as to produce smooth and even finished surfaces with tiles/sheets in a tight jointed, accurately aligned manner, and the upper surfaces smooth, clean and free from imperfection.

Unevenness, spalled or soft areas shall be properly repaired and made level before installation of the

flooring.

The adhesive shall be spread over the surface as much as may be covered in 10 to 15 minutes in accordance with the manufacturer's instructions.

Flooring shall be neatly scribed and cut to fit around all built-in fixtures, equipment, pipes, door jambs, etc. Seams and joints shall be straight and true, parallel with floor line unless otherwise indicated and shall be made as inconspicuously as possible.

During and for at least 48 hours after installation adequate ventilation shall be provided for removal of moisture and volatile fumes.

### **9.5.5 CLEANING AND PROTECTION**

As soon as practicable after the flooring has bonded firmly to the sub floor, flooring shall be washed with a neutral liquid or powder cleaner recommended by the manufacturer of flooring material, rinse with clear water, allowed to dry, cleaned and thoroughly buffed.

After the flooring is cleaned and dried thoroughly, two thin coats of the manufacturer's standard wax shall be applied, with machine buffing and polishing after each coat.

Finished floors shall be covered with heavy, clean building paper and boards, or closed to traffic as required to adequately protect floors from damage due to subsequent building operations.

### **9.5.6 MAINTENANCE**

At the completion of the work the Contractor shall deliver one unopened carton of each color of vinyl tile/sheet used and 10 meters of vinyl base to the Employer for future maintenance.

Cartons shall be plainly marked as to contents.

## **DIVISION 15 MECHANICAL WORKS**

### **SECTION 15.1 GENERAL**

#### **15.1.1 SCOPE OF WORK**

The Contractor shall provide all labor, materials, equipment and incidentals to furnish and install the complete mechanical work as shown on the drawings and/or as specified herein.

It is the intent of these specifications, that when completed the mechanical work shall be suitable in every respect for the service intended, and the Contractor shall, at no extra cost, supply all the materials and do all the work which may be reasonably implied as being incidental to the work.

The Contractor shall be responsible for all piping, and testing and placing in satisfactory operation the complete mechanical work to the approval of the Engineer.

#### **15.1.2 MANUFACTURER'S EXPERIENCE**

Unless specifically named in the detailed specifications, a manufacturer shall have furnished equipment of the type and size specified which has demonstrated successful operation and is in regular use in similar applications.

#### **15.1.3 FACTORY INSPECTION**

The Engineer may inspect fabricated equipment at the factory. The cost shall be borne by the Contractor. The Engineer will notify the Contractor in sufficient time so that the factory inspection can be arranged. Factory inspection will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations. 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.

#### **15.1.4 STANDARD OF QUALITY**

Where items of equipment are specified by the name of a manufacturer, it is for the purpose of establishing a standard of quality, construction, and acceptable experience. Substitute equipment will be acceptable if it can be demonstrated to the Engineer that the substitute is in accordance with the specifications and equal in quality to those models specifically named. Manufacturers listed as "equal" have been determined by the Engineer to style and model. However, this shall not relieve the named Manufacturer from the responsibility of meeting all specified requirements. All mechanical equipment furnished shall be new and of current design.

#### **15.1.5 EQUIPMENT GUARANTEE**

The Contractor shall guarantee all equipment supplied against defects in workmanship or materials for a period of one year, unless stipulated otherwise, following acceptance of the completed project.

Under this guarantee the Contractor agrees to correct without delay at his own expense any failure of such parts due to faulty materials, construction, or installation or to the failure of any such equipment to successfully perform within the limits of the specifications and further shall make good any damage to any part of the work caused by such failure.

The Engineer will give prompt written notice of observed defects. If the Contractor after notice, fails to proceed promptly to comply with the terms of this guarantee, the Contractor will be held liable for all expenses incurred.

### **15.1.6 INTERPRETATION OF DRAWINGS**

Process requirements for piping, valves and fittings are shown on the drawings and are specified. Any deviation from these requirements shall be considered a substitution and shall be submitted in accordance with the specified procedures for substitutions. The drawings indicate the desired configuration of piping, valves and fittings. The drawings shall not be construed as being complete assembly plans, but rather as guidelines to be followed in order to provide the necessary piping, valves and fittings shown on the drawings. In addition, any piping or appurtenances not shown on the drawings which are required for a complete and operable system shall be furnished.

### **15.1.7 SUBMITTALS**

#### **1. SHOP DRAWINGS**

Prior to fabrication, the Contractor shall obtain from the Manufacturer, shop drawings for all equipment. Shop drawings shall include fabrication, assembly, foundation drawings, piping diagrams and materials used, power drive, assembly, parts, devices, and other accessories forming a part of the equipment to be furnished. After checking the shop drawings for accuracy and suitability, the Contractor shall submit three (3) copies of the shop drawings and material lists to the Engineer for approval.

#### **2. CERTIFIED TEST CURVES**

The Contractor shall submit three (3) copies of certified performance or certified test curves for all pumps specified herein. The Contractor shall notify the Engineer four (4) weeks prior to any testing to allow the Engineer to witness the tests.

#### **3. CERTIFIED REPORTS**

The Contractor or his authorized representative, shall submit a notarized written report with respect to his equipment certifying that (1) the equipment has been properly installed and lubricated under his supervision (2) the equipment is in accurate alignment, (3) he was present when the equipment was placed in operation, (4) he has checked, inspected, and adjusted the equipment as necessary, (5) the equipment is free from any undue stress imposed by connecting piping or anchor bolts, (6) the

equipment has been operated under full load conditions and operated satisfactorily, and (7) the equipment is fully covered under the terms of the guarantee.

#### 4. OPERATION AND MAINTENANCE MANUAL

The Contractor shall submit the operation and maintenance manual as specified in Division P14 Special Systems.

##### **15.1.8 ROUTING OF PIPELINES**

It is the responsibility of the Contractor to route all piping unless otherwise shown on the drawing or directed by the Engineer. Piping shall be routed in such a way so as not to interfere with other piping, equipment, instrumentation, electrical work or structures. Pipeline routing shall be in accordance with the guidelines presented in the drawings. Minor changes due to differences in equipment, size or configurations will be permitted provided that such changes do not interfere with other work. Any major deviations from the layouts shown on the drawings will be considered substitutions and shall require approval as such. All piping layouts shall be subject to approval by the Engineer prior to installation.

All exposed piping shall be located against walls, under ceilings, on floor or in floor trenches. If floor trenches are used, gratings shall be installed to cover the trench. Piping shall not be routed under floor slabs unless specifically shown as such on the drawings. In no case shall piping be located so as to interfere in any way with traffic or access to equipment. Minimum head room shall be 2 metres unless otherwise specifically shown on the drawings.

All piping running below concrete structures shall be encased in concrete even if not specifically shown on the drawings.

Unless specifically shown on the drawings or approved by the Engineer, no wall penetrations shall be made underwater.

##### **15.1.9 PATENTS**

The Contractor shall assume all costs of patent fees or licenses for equipment or processes and shall safeguard and save harmless the Employer and the Engineer from all damages, judgments, claims and expenses arising from license fees or claimed infringement of any letters, patents, or patent rights or because of any royalty or fee for the use of any equipment or process, structural feature or arrangement of the component parts of the installation. The price stipulated for payment under this Contract shall be deemed to include payment for all such patent fees, licenses or other cost pertaining thereto.



### **15.1.10 MATERIALS**

Materials to be used for manufacturing and installation of the equipment herein specified shall be selected from the best available for the purpose of use considering strength, ductility, durability, and on the basis of the best current engineering practice. Materials shall be (1) New, unused and of first quality, (2) Free from defects and (3) Suitable for the application and not overstressed mechanically or electrically.

### **15.1.11 EQUIPMENT**

All Equipment furnished under this Contract shall be new and guaranteed free from defects in materials, design and workmanship. It shall be the Contractor's responsibility to determine the conditions and service under which the equipment will operate and to warrant that operation under those conditions shall be successful. All parts of the equipment shall be amply proportioned for all stresses that may occur during fabrication, erection, and intermittent or continuous operation.

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 size 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.

### **15.1.12 LUBRICATION**

A complete schedule of recommended lubricants and the name of manufacturers and suppliers and comparable products shall be submitted to the Engineer for approval. The number of different types of lubricants shall be kept to a minimum.

Equipment lubrication systems shall be provided that require attention no oftener than weekly during continuous operations, do not require attention during start-up or shut down, and do not waste lubricants.

Grease lubrication systems shall preferably be of the pressure type. Grease application points shall be easily accessible and where needed, extension piping shall be provided. When a number of such points can be grouped, they shall be brought to a rigidly constructed battery plate and each point shall be clearly labeled. A permanently labeled grease gun shall be supplied for each type of grease required and each type of nipple fitted.

The Contractor shall provide lubricants of types approved by the Engineer in quantities sufficient for consumption up to and including completion, testing and final acceptance. A two-year supply of each lubricant shall also be provided.

### **15.1.13 EQUIPMENT BASES AND BEDPLATES**

Equipment assemblies shall be mounted on a single heavy cast iron or welded steel bedplate unless otherwise shown or specified. Bases and bedplates shall be provided with machined support pads, tapered dowels for alignment or mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. Seams and contact edges between steel plates and shapes shall be continuously welded and welds shall be ground smooth. Bedplates to support machinery or piping shall not be used other than that which is factory installed.

### **15.1.14 ANCHOR BOLTS**

The Contractor shall furnish anchor bolts, nuts, and washers of adequate design as required for proper anchorage of the bases and bedplates to the concrete bases. Anchor bolts, nuts, washers and sleeves used under submerged or intermittently submerged conditions shall be stainless steel, Class 304 of JIS G 4303.

### **15.1.15 SAFETY GUARDS**

Belt or chain drives, fan blades, couplings, exposed shafts and other moving or rotating parts on all sides shall be covered with safety guards conforming to all local safety codes and regulations and conform to the most restrictive requirements. Guards shall be designed for easy installation and removal, complete with necessary supports, accessories, and fasteners, all hot dip galvanized. Outdoor service guards shall be designed to prevent entrance of rain and dripping water, and provide drainage for condensation

### **15.1.16 REDUCTION GEARS**

Reduction gear to be specified under these specifications shall be of cycle reduction gear or equivalent. The cycle type reduction gear shall be fully enclosed in an oil tight casing. Mechanism of this reduction gear shall be of a combination of a planet gear and a fixed-internal sun gear. Wear resistance parts shall be in rolling contact. The reduction gear shall consist of casing, ring gear housing, low speed and high speed shafts, low speed shaft roller and shaft pin, and cycloid discs. The cycloid disc namely planet gear shall have cycloidal-shaped teeth, and sun gear circular pin teeth. The torque transmitting components of the gear shall be made of high carbon chromium bearing steel. The lubrication shall be in accordance with the current practice of the manufacturer.

### **15.1.17 NAME PLATES**

Equipment name plates shall be engraved or stamped on metal plates and fastened to the equipment in an accessible location. Name plates shall indicate :

- a. Name of manufacturers;
- b. Type of unit and model number;

- c. Serial number; and
- d. Rated capacity, voltage, or other pertinent information.

#### **15.1.18 EQUIPMENT TAGS**

Each item of mechanical equipment shall be tagged with permanent, legible Tags readily visible after installation. Tags shall be of stainless steel plate, minimum thickness 1.0 mm and shall be provided with anchoring chain. Minimum size of Tag shall be 120 mm x 60 mm. Each tag shall be engraved with at least following.

- a. Name of equipment
- b. Equipment identification number
- c. Others as directed by the Engineer.

#### **15.1.19 VIBRATION CONTROL**

All rotating and reciprocating machinery shall be statically and dynamically balanced to eliminate excessive vibration. Where necessary, special vibration isolators shall be utilized.

#### **15.1.20 SAMPLE COCKS, METERS AND GAUGES**

Sample cocks shall be provided on the discharge of each pump installed under this Contract. Meters and gauges shall read in SI units as approved by the Engineer.

#### **15.1.21 TOOLS**

The Contractor shall supply one (1) complete set of required tools necessary for the assembly, adjustment, and dismantling of the equipment for every piece of equipment. All tools shall be of the best quality.

Each set of tools shall be neatly mounted in a painted steel tool case of suitable design and identified on the outside with an itemized list of contents. A complete set of instructions shall be supplied to describe the proper use of all tools.

#### **15.1.22 SPARE PARTS**

The Contractor shall furnish all spare parts specified hereinafter and three (3) sets of spare parts supply and check list. Spare parts supply and check list specified shall be properly booked on international A4 size hard paper and list shall be filed with A4 size hard plastic files having four (4) inclined D-rings. Form of lists shall be approved by the Engineer.

All spare parts shall be properly preserved and packaged for a long period of storage before use, and in a cold and dry climate and shall be properly marked in the Russian and English languages on the outside to permit easy identification of the contents without opening and exposing the contents to the

atmosphere.

#### **15.1.23 EQUIPMENT PROTECTION**

All Equipment shall be boxed, crated, or otherwise completely enclosed and protected for overseas shipment, handling and storage. All equipment shall be protected from exposure to the elements and shall be kept thoroughly dry at all times. Pumps, motors, electrical equipment, and other equipment having antifriction or sleeve bearings shall be stored in weathertight storage facilities such as warehouses.

#### **15.1.24 PAINTED SURFACES**

Painted surface shall be protected against impact, abrasion, discoloration, and other damage. All painted surfaces which are damaged prior to acceptance of equipment shall be repainted to the satisfaction of the Engineer.

#### **15.1.25 INSPECTION AND PREPARATION**

Each item of equipment shall be inspected for damage, defects, completeness, and correct operation before installing. Previously installed related work shall be inspected and verify that it is ready for installation of equipment.

The Engineer shall be notified in event that any equipment or material is damaged. Repairs to damaged products shall not be made without prior approval by the Engineer.

Prior to installing equipment, installation areas shall be clean and concrete or masonry works completed. The areas shall be maintained in a broom-clean condition during installation operations. Equipment shall be cleaned, conditioned and serviced in accordance with the approved Instruction Manuals and requirements in other sections of these specifications before installing.

#### **15.1.26 EQUIPMENT INSTALLATION**

The Contractor shall install all equipment specified herein in full accordance with the drawings, specifications, equipment manufacturer's recommendations and good practice.

All parts to be installed shall be cleaned thoroughly. All packing compounds, rust dirt, grit and other foreign matter shall be removed. All holes and grooves for lubrication shall be cleaned. All enclosed chambers or passages shall be examined to make sure that they are free from injurious materials.

For major equipment items specified hereinafter the equipment manufacturer's factory trained service personnel shall be on-site to supervise the installation.

The Contractor shall have an experienced, competent, and authorized representative of the manufacturer or supplier of each major item of equipment visit the site of the work and inspect, check,

adjust if necessary, and approve the equipment installation. In each case, the equipment manufacturer's representative shall be present when the equipment is placed in operation. The Contractor shall have the equipment manufacturer's representative revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation is satisfactory to the Engineer.

Prior to being placed in operation, major equipment and materials 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. If required, full load tests shall be performed and results of such tests shall be recorded. Unsatisfactory performance shall be corrected and tests shall be repeated until the equipment performance meets the specifications.

Upon completion of the entire installation, the Contractor shall issue to the Engineer a formal notice of completion, stating that the equipment is ready for acceptance testing.

#### **15.1.27 REFERENCE STANDARDS**

The reference standards mentioned hereinafter, in their current editions, shall form a part of these specifications to the extent specified herein.

## **DIVISION 15 MECHANICAL WORKS**

### **SECTION 15.2 PIPING**

#### **15.2.1 GENERAL**

##### **1. SCOPE OF WORK**

All pipe, fittings and appurtenances shall be furnished by the Contractor. In addition the Contractor shall furnish all labor, materials, equipment and incidentals required to install the piping, fittings and appurtenances as shown on the drawings. The completed installation shall be fully functional as shown on the drawings. The fittings are shown as a convenience to the Contractor. It may be necessary to supply and install additional fittings other than those shown on the drawings or to install fittings in different locations. The Contractor shall refer to the Particular Specifications for a general description of the scope of work.

Also included under this section is the supplying and installing of certain miscellaneous items and appurtenances as hereinafter specified. Work to be done shall include hauling, laying, installing, jointing, welding, insulating, wrapping, testing, chlorinating and all other work necessary to produce a completed facility. The Contractor shall furnish and install couplings, fittings, gaskets, insulation, flanges, bolts, nuts, wall sleeves, wall pipes, harnesses and all other materials necessary to properly install the work shown on the drawings and as specified.

Certain piping systems are shown diagrammatically as an indication of the work to be installed. The Contractor shall coordinate the work so that all work may be installed in the most direct and workmanlike manner, and so that interference between piping, ducts, equipment, architectural and structural features and appurtenances and other work will be avoided.

The work of installing pipe in earth excavations, earth fills and earth trenches is specified in the Standard Specifications titled "Installation of Underground Piping and Fittings", Section 2.3.

##### **2. SHOP DRAWINGS**

The Contractor shall submit detailed working and shop drawings and schedules of all pipe, fittings and appurtenances. Shop drawings shall include but not be limited to the following:

- a. Lists and schedules of material, linings and coatings.
- b. Schedules of pipe lengths and thickness.
- c. Details of proposed joints, harnesses and installation details.
- d. Names of suppliers and identification of materials and equipment to be supplied.
- e. Dates of delivery of materials to job site.
- f. Special enclosures.

For reinforced concrete pipe, the Contractor shall furnish all information related to placement of steel reinforcement, and a complete set of design calculations.

Installation manuals shall also be furnished when requested.

Shop drawings shall show the locations of unions, bolted flanged connections or other appurtenances to permit ready dismantling of piping systems.

The work of this section shall be completely coordinated with the work of other sections. The Contractor shall verify at the site, both the dimensions and work of other sections which adjoin his materials. Field measurements shall be taken at the site and incorporated in the shop drawings, with specific notes.

The Contractor shall furnish a mill certified report, in triplicate, of the tests for materials to be specified in the work. The certifications shall contain the results of chemical and physical tests required by these specifications for the materials.

For both shop and field welds of steel pipe, the following information shall be submitted if necessary.

- a. Method of welding - automatic or manual.
- b. Type of welding rods.
- c. Method of preparing edges.
- d. Welding procedure.
- e. Cleaning of welds.

The Contractor shall submit samples of materials to be supplied under this section upon written direction of the Engineer.

The Contractor shall submit, for approval, exact details of various joints that are proposed for use on this project which originate in different countries and which differ from these specifications. In the event the Engineer approves these different joints, the Contractor shall assume all responsibilities regarding the coordinating and providing of proper joints and connections.

### 3. PIPE AND FITTINGS

#### 3.1 General

Each pipe, fitting and casting shall bear clear and durable markings showing the nominal diameter, class or schedule, type, year of manufacture and the manufacturer's name or trade mark. Marking on pipe lengths shall always be at the same end. Painting of data will be acceptable for all pipe material except ductile iron and cast iron pipe. Each pipe and fitting of ductile iron and cast iron material shall bear cast-on markings showing the data described above.

Pipes and fittings shall be compatible and have equal or higher pressure ratings as specified.

Pipes, fittings and appurtenances shall be installed in full conformance with the manufacturer's recommendations.

Bedding, hanger details, supports and wall and floor penetrations shall be as shown on the drawings, or specified hereinafter.

When cutting of pipe is required, the cutting shall be done by machine in a neat and workmanlike manner without damage to the pipe, coating or lining. Cut ends shall be smooth and at right angles to the axis of the pipe. Pipe ends to be used with rubber joints shall be beveled and filed or ground smoothly to conform to the manufactured spigot end.

The Contractor shall furnish and install transition pieces at all locations when one type of pipe joints a second.

At the conclusion of the work the Contractor shall clean all piping and pipelines as specified in Section 1.2 titled "Control of Work", and testing and disinfection of piping and pipelines for conveying portable water as specified in Section 1.5 titled "Special Provisions".

### 3.2 Handling

Care shall be taken during loading, transporting, and unloading to prevent injury to the pipes, fittings, or coatings. Under no circumstances shall pipe or fittings be dropped or rolled against one another. All pipes or fittings shall be examined and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.

If any defective pipe or fitting is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be thoroughly cleaned before installation.

Special handling of pipes and fittings shall be in accordance with the manufacturer's instructions.

All pipes shall be bundled or packaged in such a manner as to provide adequate protection for the ends, threaded or plain, during transportation from the manufacturer to the Contractor. All special provisions for ocean shipment shall be provided.

### 3.3 Inspection

The quality of all materials, the process of manufacture, and the finished piping shall be subject to inspection and approval by the Engineer. Such inspection may be made at the place of manufacture, or at the site after delivery, or at both places, and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipes may have been accepted as satisfactory.



When any routine chemical analysis fails to meet the requirements of these specifications or when any specified test fails to meet the requirements, all pipe in the same sampling period shall be rejected, except that any pipe that is subsequently retested and is judged acceptable, may be accepted.

All pipes, and appurtenances will be inspected by the Engineer upon delivery to the site and those pieces, not conforming to the requirements of this specification, will be rejected and must be immediately removed from the site by the Contractor. The Contractor shall furnish all labor necessary to assist in inspecting the material.

On completing the installation, the inside of the pipe shall be carefully cleaned of tools, scrap, dirt and debris. The Engineer will make a full and complete inspection of all lines before acceptance and the Contractor shall fully flush out the lines with water or air prior to inspection.

### 3.4 Flanged Joints

Flanged joints shall be furnished complete with gaskets, bolts and nuts.

Gaskets shall be cut to the proper size so that no part protrudes. Prior to application of gaskets, the face of the flanges shall be thoroughly cleaned.

All gaskets supplied with each flange fitting shall be styrene butadiene rubber (SBR) conforming to JIS K6353, "Rubber Goods for Water Works" Class III or equivalent. Thickness of gasket shall be 3 mm.

Flange assembly bolts shall be standard hexagon head machine bolts with hexagon nuts. Threads shall conform to ISO 68-1, "ISO General Purpose Screw Threads-Basic Profile" or JIS B0205 "Metric Coarse Screw Threads". Material for bolts and nuts shall be steel conforming to JIS, ASTM, DIN or BS or other internationally accepted standards, and shall have a minimum yield strength of not less than 225 N/mm<sup>2</sup>. Steel bolts and nuts shall be galvanized. Bolts and nuts for intermittent or continuous underwater pipe work shall be Type 304 stainless steel. Bolts and nuts for stainless steel flanges shall be stainless steel and type of stainless steel shall be the same as the flanges.

Bolts in flanged joints shall be tightened alternately on opposite ends of joints diameters, in rotation around the flange and evenly.

The bolts shall not protrude more than 3 mm beyond the nuts. Should the bolts protrude more than 3 mm, the bolt ends shall be machined cut and refinished.

Mating dimensions of flanges, nominal diameter 100 mm to 2,000 mm shall conform to ISO 7005-1 "Metallic flanges -- Part 1: Steel Flanges", PN 10 and shown on the following FLANGE SCHEDULE or other equivalent standards approved by the Engineer. Mating dimensions and thickness of flange, nominal diameter 80 mm and smaller shall conform to ISO, JIS, ANSI, DIN, or BS or internationally accepted standards and the working pressure of the flange shall be 0.98MPa.

FLANGE SCHEDULE (Dimensions in Millimeters) (ISO 7005-1:1992)

DN	D	C	DIAMETER	BOLT	BOLT
			d	NUMBER	SIZE
100	220	180	18	8	M16
125	250	210	18	8	M16
150	285	240	22	8	M20
200	340	295	22	8	M20
250	395	350	22	12	M20
300	445	400	22	12	M20
350	505	460	22	16	M20
400	565	515	26	16	M24
450	615	565	26	20	M24
500	670	620	26	20	M24
600	780	725	30	20	M27
700	895	840	30	24	M27
800	1,015	950	33	24	M30
900	1,115	1,050	33	28	M30
1,000	1,230	1,160	36	28	M33
1,200	1,455	1,380	39	32	M36
1,400	1,675	1,590	42	36	M39
1,600	1,915	1,820	48	40	M45
1,800	2,115	2,020	48	44	M45
2,000	2,325	2230	48	48	M45

Definitions :

- DN - Nominal diameter of pipe
- D - O.D. of flange
- C - Diameter of bolt circle
- d - Diameter of bolt holes.

Note: Bolt holes shall straddle the vertical center line of the flange.

**15.2.2 SCHEDULE**

The Particular Specifications contain a piping schedule which includes the service and location, nominal size, pipeline material, lining and coatings and type of joints for the major piping systems. The range of sizes is shown on the schedules for piping and piping systems with smaller piping are noted without sizes. Reference to the drawings is required for these smaller sizes.

The completeness of these schedules is not guaranteed and the omission of piping in the schedule needed to complete the work shall not relieve the Contractor from his responsibility for installation of the work complete.

**15.2.3 DUCTILE IRON PIPE****1. GENERAL**

All piping shall be designed for a minimum working pressure of 0.98 MPa unless noted otherwise.

Ductile iron pipes and fittings, joint materials and accessories shall be manufactured in accordance with all provisions specified hereinafter and a single standard. Outside diameter of pipes and fittings in all sizes shall conform to a single standard, JIS or ISO. All dimensions of joints of pipes and fittings shall also be in accordance with a single standard and all provisions specified hereinafter.

**2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

ISO 2531	Ductile Iron Pipes, Fittings, Accessories and their Joints for Water or Gas Applications
JIS A5314	Mortar Lining for Ductile Iron Pipes
JIS G5502	Spheroidal Graphite Iron Castings
JIS G5526	Ductile Iron Pipes
JIS G5527	Ductile Iron Fittings
JIS K6353	Rubber Goods for Water Works
AWWA C104	Cement-Mortar Lining for Ductile- Iron Pipe and Fittings for Water

**3. PIPES**

Ductile iron pipes shall exhibit the following physical characteristics:

- |                              |  |
|------------------------------|--|
| a. Minimum Tensile strength: | 420 N/mm <sup>2</sup> (Centrifugal Cast)     |
|                              | 400 N/mm <sup>2</sup> (Not Centrifugal Cast) |

## b. Minimum Elongation

## i) Centrifugal Cast

1,000 mm and smaller in diameter: 10%

1,100 mm and larger in diameter: 7%

## ii) Not Centrifugal Cast 5%

The pipes shall conform to ISO 2531 or JIS G 5526 and its full length shall not exceed nine (9) meters. The pipe shall be manufactured by the centrifugal casting method. The pipe, unless otherwise specified, shall have a minimum wall thickness and outside diameter as stipulated in the following schedule:

SCHEDULE OF MINIMUM WALL THICKNESS AND OUTSIDEDIAMETER OF DUCTILE IRON PIPES

NOMINAL DIAMETER (mm)		MINIMUM WALL THICKNESS t (mm)		OUTSIDE DIAMETER (mm)	
JIS	ISO	JIS (D3)	ISO	JIS	ISO
75	-	6.0	-	93.0	-
-	80	-	6.0	-	98.0
100	100	6.0	6.1	118.0	118.0
-	125	-	6.2	-	144.0
150	150	6.0	6.3	169.0	170.0
200	200	6.0	6.4	220.0	222.0
250	250	6.0	6.8	271.6	274.0
300	300	6.5	7.2	322.8	326.0
350	350	6.5	7.7	374.0	378.0
400	400	7.0	8.1	425.6	429.0
450	-	7.5	-	476.8	-
500	500	8.0	9.0	528.0	532.0
600	600	9.0	9.9	630.8	635.0
700	700	10.0	10.8	733.0	738.0
800	800	11.0	11.7	836.0	842.0
900	900	12.0	12.6	939.0	945.0
1,000	1,000	13.0	13.5	1,041.0	1,048.0

1,100	-	14.0	-	1,144.0	-
1,200	1,200	15.0	15.3	1,246.0	1,255.0
1,350	-	16.5	-	1,400.0	-
-	1,400	-	17.1	-	1,462.0
1,500	-	18.0	-	1,554.0	-
1,600	1,600	19.0	18.9	1,650.0	1,668.0
1,650	-	19.5	-	1,701.0	-
1,800	1,800	21.0	20.7	1,848.0	1,875.0
2,000	2,000	23.5	22.5	2,061.0	2,082.0
2,100	-	24.5	-	2,164.0	-
2,200	2,200	25.5	24.3	2,280.0	2,288.0
2,400	2,400	27.5	26.1	2,458.0	2,495.0
2,600	2,600	29.5	27.9	2,684.0	2,702.0

#### 4. FITTINGS

Ductile iron fittings shall exhibit the following physical characteristics:

- a. Minimum Tensile Strength: 400 N/mm<sup>2</sup>
- b. Minimum Elongation: 5%

Fittings shall have dimensions conforming to JIS G 5526 and G5527 or ISO 2531.

If fittings and special castings, specified herein or shown on the drawings, are not covered in these specifications, the Contractor shall submit shop drawings or manufacturer's specifications to the Engineer for approval prior to casting.

#### 5. COATINGS AND LININGS

##### 5.1 Coatings

All non-exposed pipes and fittings buried in the ground shall have a epoxy coating with a minimum thickness of 0.08 mm. The finished coating shall be continuous, smooth, neither brittle when cold nor sticky when hot, and strongly adherent to the fittings.

All pipes and fittings which will be exposed to view in the finished work, or to be in an intermittent or continuous submerged condition shall be painted on the exterior in accordance with the Standard Specifications titled "Painting" of Section 9.1 unless otherwise noted.

##### 5.2 Linings

All pipes shall have a cement mortar lining conforming to JIS A5314 or ISO 4179 or manufacturer's standards approved by the Engineer. A minimum lining thickness shall be as specified in the following schedule:

SCHEDULE OF MINIMUM CEMENT MORTAR LINING THICKNESS  
FOR DUCTILE IRON PIPES

DN Group	Normal	Minimum Mean Value	Minimum Value at One point
300 mm and smaller	3	2.5	1.5
350 to 600 mm	5	4.5	2.5
700 to 1200 mm	6	5.5	3.0
1400 to 2000 mm	9	8.0	4.0
2200 mm and larger	12	10.0	5.0

Defective or damaged areas of lining shall be patched with stiff mortar in accordance with paragraph 4-7.2 of AWWA C104, or with epoxy resin filler or paste by cutting out the defective or damaged lining to the metal so that edges of the lining not removed are perpendicular or slightly undercut. Materials of epoxy resin filler or paste shall be approved by the Engineer before applied.

All fittings shall be lined with non-toxic type epoxy and total dry film thickness of the lining shall be not less than 300 microns. The lining material shall be certified by the recognized public health authorities for linings in potable water service.

## 6. JOINTS

### 6.1 General

Type of joints shall be to the specified on the drawings or Piping Schedule of the Particular Specifications.

All joints shall be designed to have the same characteristics and strength as the connecting pipe.

### 6.2 Mechanical Joints

Mechanical joints shall conform to JIS G 5526 and G 5527, Form K or other internationally accepted standards or manufacturer's standards approved by the Engineer. The mechanical joint shall be designed to have a minimum effective depth of socket as stipulated in the following schedules.

SCHEDULE OF MINIMUM EFFECTIVE SOCKET DEPTH  
OF MECHANICAL JOINTS

Nominal Diameter (mm)	Socket Depth (mm)
300 and smaller	60.0
350 to 600	80.0
700 to 1200	100.0
1350 and larger	130.0

All ductile iron pipes and fittings of the mechanical joint type shall be provided with complete jointing materials unless otherwise specified.

Gasket of the mechanical joint shall be styrene butadiene rubber (SBR) conforming to JIS K 6353 or equivalent

Reclaimed rubber shall not be used. Gland and bolts and nuts shall be of spheroidal graphite iron castings conforming to JIS G 5527: FCD(420-10) or JIS G 5502: FCD400-15, FCD450-10 or equivalent.

### 6.3 Push-on Joints

Push-on joints shall conform to JIS G 5526 and G 5527, Form T, or internationally accepted standards, or the manufacturer's standard approved by the Engineer.

The plain end of the pipe shall have a slight taper to ease its sliding-fit with the gasket when the joint is made. Field cut pipe shall be ground to have a taper the same as the factory manufactured spigot ends.

Push-on joint pipe shall be furnished complete with gaskets and lubricant as recommended by the manufacturer. Gaskets shall be the same material specified for mechanical joints of the previous subsection.

Fittings for push-on joint pipe shall be mechanical joint fittings unless otherwise specified.

### 6.4 Flanged Joints

All flanges shall be integrally cast with the pipe or fittings and shall have raised faces on the gasket surface.

Flange thickness shall conform to the following schedule:

**SCHEDULE OF FLANGE THICKNESS FOR DUCTILE IRON PIPES AND FITTINGS**

NOMINAL DIAMETER (mm)	MINIMUM FLANGE THICKNESS (mm)
100	16.0
150	16.0
200	17.0
250	19.0
300	20.5
350	20.5
400	20.5
500	22.5
600	25.0
700	27.5
800	30.0
900	32.5
1000	35.0
1200	40.0
1400	41.0
1600	44.0
1800	47.0
2000	50.0

Notes: Flange thickness enumerated in the above schedule shall exclude the height of the raised face of the flange.

All ductile iron pipes and fittings of the flanged joint type shall be provided with complete jointing materials.

**15.2.4 STEEL PIPE**

**1. GENERAL**

All piping shall be designed for a minimum working pressure of 0.98 MPa, unless noted otherwise.

All welding shall be in accordance with the Standard Specifications titled "Metal Fabrication" of Section 5.3. Unless otherwise specified, all field welding will not be permitted.



## 2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

ISO 559	Steel tubes for water and sewerage
ISO 7/1	Pipe threads where pressure-tight joints are made on the threads -- Part 1
ISO 1460	Metallic Coatings -- Hot Dip Galvanized Coating on Ferrous Materials -- Gravimetric Determination of the Mass per Unit Area
ISO 1461	Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles -- Specification and Test Methods
JIS B2301	Screwed Type Malleable Cast Iron Pipe Fittings
JIS B2311	Steel Butt-Welding Pipe Fittings for Ordinary Use
JIS G3442	Galvanized Steel Pipes for Ordinary Piping
JIS G3451	Fittings of Coated Steel Pipes for Water Service
JIS G3452	Carbon Steel Pipes for Ordinary Piping
JIS G3443	Coated Steel Pipes for Water Service
JIS G4051	Carbon Steels for Machine Structural Use
JIS H9124	Recommended Practice for Zinc Coating (Hot Dipped)
AWWA C200	Steel Water Pipe 6 In. (150 mm) and Larger
AWWA C203	Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied
AWWA C206	Field Welding of Steel Water Pipe
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C210	Liquid-epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA MANUAL	
	Steel Pipe -- A Guide for Design and Installation (M11)
ASTM A283	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A1011/A1101M-01a	
	Standard Specification for Steel, Sheet and Strip, Hot-rolled Carbon, Structural, High-strength Low-alloy and High-strength Low-alloy with Improved Formability

## 3. PIPES

### 3.1 Materials and Fabrication

### 3.1.1 Seamless or welded type

Steel pipe shall be fabricated from steel sheets or plates and shall be arc welded or electric-resistance welded, shop fabricated, tested and cleaned.

Steel sheets or plates shall have a minimum yield point not less than 215 N/mm<sup>2</sup> and shall conform to the following materials.

- a. ISO 559     ST360
- b. JIS G3101   SS 400
- c. JIS G3443   STW 400
- d. ASTM A283/A283M   Grade D
- e. BS534         Steel Grade 360
- f. Other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Fabrication of steel pipe shall be in accordance with JIS G3452 and JIS G3443 or AWWA C200 or internationally accepted standards. The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means except that with approval of the Engineer, manual welding by a qualified procedure and welder shall be used.

All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt welded. The maximum allowable number of shop seams shall be one longitudinal seam and three girth seams per length of pipe. The longitudinal seams shall be staggered on opposite sides for adjacent section. No reinforcing ring plate or saddle shall be provided on the exterior or interior of pipe.

### 3.1.2 Screwed and socketed joints steel pipe

Steel pipe shall be fabricated from steel sheets or plates and shall be arc welded or electric-resistance welded, shop fabricated, tested and cleaned.

Steel sheets or plates shall have a minimum tensile strength not less than 294 N/mm<sup>2</sup> and shall conform to the following materials.

- a. JIS G3452   SGP
- b. BS 1387     Medium grade
- c. Other internationally accepted standards or manufacturer's standards as approved by the Engineer.

## 3.2 Pipe Dimensions

The nominal pipe diameters shown on the drawings shall be of the following outside diameters and

wall thickness before lining and coating.

### 3.2.1 Seamless or welded type

#### OUTSIDE DIAMETER AND WALL THICKNESS OF STEEL PIPE

NOMINAL DIAMETER		OUTSIDE DIAMETER	MINIMUM WALL THICKNESS
A	B	(mm)	(mm)
50	2	60.3	2.0
65	2 1/2	76.1	2.3
80	3	88.9	2.3
100	4	114.3	2.6
125	5	139.7	2.6
150	6	168.3	2.6
200	8	219.1	2.6
250	10	273.0	3.6
300	12	323.9	4.0
350		355.6	4.0
400		406.4	4.0
450		457.0	4.0
500		508.0	5.0
600		610.0	5.6
700		711.0	6.3
800		813.0	7.1
900		914.0	8.0
1,000		1,016.0	8.8
1,050		1,067.0	8.8
1,100		1,118.0	8.8
1,200		1,219.0	10.0
1,400		1,422.0	12.5
1,600		1,626.0	14.2
1,800		1,829.0	14.2

2,000	2,032.0	16.0
2,200	2,235.0	17.5
2,500	2,540.0	20.0

### 3.2.2 Screwed and socketed joints steel pipe

#### OUTSIDE DIAMETER, WALL THICKNESS AND OTHER FACTOR OF GALVANIZED STEEL PIPE

Nominal Size (inches)	Outside Diameter (mm)	Minimum Wall Thickness (mm)	Test Pressure (N/mm <sup>2</sup> )
1/4	13.9	2.3	5
3/8	17.4	2.3	5
1/2	21.7	2.6	5
3/4	27.2	2.6	5
1	34.2	3.2	5
1 1/4	42.9	3.2	5
1 1/2	48.8	3.2	5
2	60.8	3.6	5
2 1/2	76.6	3.6	5
3	89.5	4.0	5
4	114.9	4.5	5
5	140.6	5.0	5
6	166.1	5.0	5

Tolerances : Outside Diameter  $\pm 1\%$

Wall Thickness: - 10% max

## 4. FITTINGS

### 4.1 Seamless or welded type

Fittings shall be shop fabricated and shall be designed to have the same strength as piping. Reinforcing rings or saddles shall be provided where required in accordance with AWWA Manual M11 and to meet the operating conditions of 0.98 MPa.

Dimensions of fittings shall conform to the followings:

125 mm and smaller : JIS B2311

150 mm and larger : JIS B2311 (up to 500 mm) or JIS G3451  
or AWWA C208

(Table 1 and Fig.1 and Tables 2A to 2B and Fig.2)

Bends having a deflection angle of 22.5 degrees and smaller shall be two-piece bends. Bends having a deflection angle of over 22.5 degrees and up to 45 degrees shall be fabricated using three pieces. Bends having a deflection angle of over 45 degrees shall be four-piece bends.

#### 4.2 Screwed and socketed joints steel pipe

Fittings shall be shop fabricated and shall be designed to have the same strength as piping.

Dimensions of fittings shall conform to the followings:

JIS B2302

BS 1387

### 5. COATINGS AND LININGS

#### 5.1 Exterior Protection

All pipes and fittings which will be exposed to view in the finished work, or be in intermittent or continuous under water shall be painted in accordance with the Standard Specifications titled "Painting" of Section 9.1 unless otherwise noted.

The outside of piping which will be below ground shall have a polyurethane coatings as specified in JWWA K151 or equivalent, or a coal tar enamel and bonded double asbestos felt wrap as specified in AWWA C203 or JIS Standards as directed by the Engineer.

The primer and coal tar enamel shall be as follows:

Primer : Type B conforming to Sec. A.2.4 of AWWA C203

Coal tar enamel : Type I conforming to Sec. A.2.5 Table 1 of AWWA C203–

The construction of exterior protection described above shall be as follows:

- a. Primer, Type B specified above;
- b. Coal tar enamel, Type 1 specified above, dry film thickness  $2.4 \text{ mm} \pm 0.8 \text{ mm}$ ;
- c. Bonded asbestos felt;
- d. Coal tar enamel, Type I same as the above, dry film thickness 0.8 mm minimum;

- e. Bonded asbestos felt; and
- f. One coat of water-resistant whitewash.

## 5.2 Linings

Unless specifically noted otherwise, all steel pipe and fitting shall be epoxy lined on the inside in accordance with AWWA C210 or JWWA K135

The lining systems such as epoxy shall be shop applied. They shall consist of the following:

### 5.2.1 Epoxy System

- a. One (1) coat of liquid two-part chemically cured rust-inhibitive epoxy primer
- b. One (1) or more coats of a liquid two-part epoxy finish coat which contains no coal tar

The epoxy lining system may alternatively consist of two or more coats of the same epoxy coating without the use of a separate primer. This alternative system shall conform to requirements of AWWA C210 and the first coat of this alternative system shall be considered as the primer.

The total dry film thickness of coating systems shall not be less than 400 microns nor more than 600 microns.

## 5.3 Coatings and Linings at Pipe Ends

### 5.3.1 Beveled Ends

At beveled ends of pipe and fittings 700 mm and larger in diameter, both shop lining and coating shall have a cutback of 15 centimeters to facilitate field welding.

At beveled ends of pipe and fittings 600 mm and smaller in diameter, only the coating shall have a cutback of 15 centimeters, and lining shall be extended to the pipe ends to facilitate field welding.

All interior and exterior surfaces left as cutback at beveled ends shall be given one (1) shop coat specified in the previous sections of 5.1 Exterior Protections and 5.2 Linings.

After field welding, the interior surface left as cutback shall be lined with epoxy system specified in the previous section 5.2 Linings and the exterior surface left as cutback shall have a heat-shrinkable corrosion protection sleeve which will be specified hereinafter.

### 5.3.2 Plain-Ends and Shouldered-Ends

At all plain-ends and shouldered-ends under ground specially prepared for sleeve couplings and other flexible or expansion joints, only the coating except primer shall have a cutback of required length for replacing the coupling or joint. The exterior area which may contact with handling liquid shall have the same coating as the pipe lining specified after removing the said primer completely. After setting

couplings or joints, the remaining area which has only the said primer and the exterior of couplings or joints shall be finished with petrolatum corrosion protective tape which will be specified hereinafter. The lining shall be extended to the pipe ends.

At all plain-ends and shouldered-ends above ground specially prepared for couplings and joints, the exterior area which may contact with the handling liquid shall have the same coating as the pipe lining specified after removing primer shop applied completely. After setting couplings and joints, the remaining area and the exterior of coupling or joints shall be painted in accordance with the Standard Specifications titled "Painting" of Section 9.1 unless otherwise noted. The lining shall be extended to the pipe ends.

### 5.3.3 Flanged Ends

At all flanged ends, no cutback of lining and coating shall be provided. The entire surface of the flange shall be painted with the epoxy system specified in the previous Section 5.2 Linings.

## 5.4 Galvanized

Galvanized steel pipe shall conform to JIS G3442 or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Galvanized coating on the inside and outside of pipe with zinc shall conform to JIS H9124 or ISO 1460 and ISO 1461 or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Thickness of galvanized coating shall be not less than 550 g/m<sup>2</sup>.

Field cutting with flame and field welding of galvanized steel pipe will not be permitted.

## 6. JOINTS

### 6.1 General

Piping shall be furnished with standard flanged, welded or threaded joints as required by the drawings or specifications. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

Pipe and fittings for use with sleeve couplings, transition couplings, or expansion joints shall have plain ends.

### 6.2 Flanged Joints

Flanges shall be made as seamless forgings or cut and fabricated from steel plate. Flanges shall be designed for the design maximum working pressure of 0.98 MPa.

Flanges shall be raised face neck flange which shall be made as seamless forgings or cut and fabricated from steel plate, and shall be attached to pipe or fittings by means of single butt-weld as shown on the drawings. Steel plate flanges having either a raised or flat face may be allowed to be used for pipes or fittings of 300 mm and smaller in diameter. Steel plate flanges shall be attached to pipes or fittings by means of two (2) filler joints of the size shown on the drawings.

Flange dimensions other than specified in Section 15.2.1 Flange Schedule shall conform to ISO, JIS, ANSI, DIN or BS or internationally accepted standards.

### 6.3 Welded Joints

Welded joints shall conform to the requirements of AWWA C206 or other internationally accepted standards or manufacturer's standards as approved by the Engineer and have beveled pipe ends.

Unless otherwise specified, field-welded joints shall be butt-welded joints.

Ends for field welding pipes in sizes 600 mm and under shall be beveled to permit "single-welded butt joints" from the outside of the pipe.

Ends for field welding pipes in sizes 700 mm and over with a wall thickness of 15 mm and thinner shall be beveled to permit "single-welded but joints" from inside of the pipe.

Ends for field welding pipes in size 700 mm and over with wall thickness of 16 mm and thicker shall be beveled to permit "double welded butt joints" form both side, outside and inside of the pipe.

### 6.4 Screw Joints

Screw joints shall conform to ISO 7-1. Joints shall be made with an approved graphite compound or with polytetrafluoroethylene tape applied to the male threads only.

## **15.2.5 POLYVINYL CHLORIDE PIPE**

### 1. GENERAL

All piping shall be designed for a maximum working pressure of 0.98 MPa, unless noted otherwise.

Any pipe or fitting with an indentation greater than 10% of the wall thickness shall be rejected. Any pipe or fitting distorted out of round more than 5% shall be rejected.

All piping shall not be exposed to direct sunlight for any extended period.

### 2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:



ISO 4422-1	Pipes and Fittings made of Unplasticized Poly(vinyl Chloride) (PVC-U) for Water Supply – Specifications – Part 1 : General
ISO 4422-3	Pipes and Fittings made of Unplasticized Poly(vinyl Chloride) (PVC-U) for Water Supply – Specifications – Part 3 : Fittings and Joints
ISO 7-1	Pipe threads where pressure-tight joints are made on the threads
JIS K6741	Unplasticized Poly(vinyl Chloride) (PVC-U) Pipes
JIS K6743	Unplasticized Poly(vinyl Chloride) (PVC-U) Pipe Fittings for Water Works

### 3. MATERIALS

#### 3.1 Pipes

Pipes shall be rigid, unplasticized, polyvinyl chloride (PVC) pipe and shall conform to ISO 4422 unless otherwise specified. The pipe shall be suitable for field cutting, welding, bending and coupling. Outside diameter and minimum wall thickness shall conform to the following schedule.

#### OUTSIDE DIAMETER AND WALL THICKNESS OF POLYVINYL CHLORIDE PIPE

Nominal Outside Diameter (mm)	Nominal Wall Thickness (mm)
12	1.5
16	1.5
20	1.5
25	1.5
32	1.6
40	1.9
50	2.4
63	3.0
75	3.6
90	4.3
110	5.3
125	6.0
140	6.7
160	7.7
180	8.6
200	9.6

225	10.8
250	11.9
280	13.4
315	15.0

### 3.2 Fittings

All fittings shall be the socket type for rubber ring joints or for solvent welded joints as designated in ISO 4422 or JIS K6743.

Unless noted otherwise, materials and strength of fittings shall be the same as those of the connecting pipe.

## 4. JOINTS

Thread joints for PVC pipe shall conform to ISO 7-1.

Unless noted otherwise, all exposed joints shall be welded using solvent cement.

All joints shall be designed to have the same characteristics and strength as the connecting pipe.

Solvent cement shall be mixed in strict accordance with the manufacturer's instructions. Any impurities in the cement shall be cause for rejection. Data on the pot life of the solvent cement shall be approved by the Engineer.

Underground piping 80 mm and larger shall use push-on or coupling joints. Joints shall have rubber O-ring gaskets which shall be styrene butadiene rubber (SBR) conforming to JIS K 6353, class I-A. Reclaimed rubber shall not be used.

### 15.2.6 POLYETHYLENE PIPE

#### 1. GENERAL

All piping shall be designed for a minimum working pressure of 0.98 MPa, unless noted otherwise.

Extrusion and moulding compounds shall meet requirements specified in ISO 1872-1 and 1872-2.

The raw material shall contain no recycled compound except that generated in the manufacturers own plant from resin of the same specifications from the same raw material supplier.

Pipe and fittings shall be made from non-toxic materials and shall be certified as suitable for potable water by a testing laboratory approved by the Engineer.

#### 2. REFERENCES

The following standards are referred to:

ISO 161-1	Thermoplastic Pipes for the Conveyance of Fluids -- Nominal Outside Diameters and Nominal Pressures -- Part 1: Metric Series
ISO 1872-1	Plastics -- Polyethylene (PE) Moulding and Extrusion Materials -- Part 1: Designation System and Basis for Specifications
ISO 1872-2	Plastics -- Polyethylene (PE) Moulding and Extrusion Materials -- Part 2: Preparation of Test Specimens and Determination of Properties
ISO 3126	Plastic Pipes - Measurement of Dimensions
ISO 4065	Thermoplastic pipes - Universal wall thickness tanks

### 3. MATERIALS

#### 3.1 Pipes

The finished pipe shall be furnished in accordance with the following dimensions and limiting values.

#### OUTSIDE DIAMETER AND WALL THICKNESS OF POLYETHYLENE PIPE

NOMINAL

OUTSIDE

DIAMETER                      WALL THICKNESS

<u>(mm)</u>	<u>(mm)</u>
20	2.0
25	2.3
32	2.9
40	3.7
50	4.6
63	5.8
75	6.8
90	8.2
110	10.0
125	11.4
140	12.7
160	14.6

#### 3.2 Fittings

Fittings such as bends, tees, crosses, wyes, reducers, etc. may be injection molded or fabricated from straight pipe by butt fusing.

To eliminate the use of elbows for the slight bends pipe may be cold-bent to a minimum radius of 50

times the pipe diameter.

#### 4. JOINTS

Pipes may be jointed by:

- a. Thermal butt-fusion.
- b. Flange assembly which consists of polyethylene stub-end butt-fused to end of the pipe and metal slip-on flange.
- c. 'Victaulic' coupling with special stub-ends designed to accept the coupling butt-fused to end of the pipes.

#### 15.2.7 ASBESTOS CEMENT PIPE

Not applicable.

#### 15.2.8 REINFORCED CONCRETE PIPE

##### 1. GENERAL

Concrete and reinforcing steel shall be in accordance with the Standard and Particular Specifications titled "Concrete" and "Concrete Reinforcement" of Division 3.

The use of a dispersing agent in the concrete may be permitted subject to the specific approval of the Engineer.

The use of any other admixture will not be permitted. The 28-day compressive strength of the concrete shall be not less than that designated for the respective wall.

##### 2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

JIS A5332	Rolled Reinforced Concrete Pipes
JIS A 5371	Precast Unreinforced Concrete Products
JIS A 5372	Precast Unreinforced Concrete Products
JIS K6353	Rubber Goods for Water Works
JIS R5210	Portland Cement
JIS R5211	Portland Blast-furnace Slag Cement
JIS R5212	Portland Pozzolan Cement

JIS R5213	Portland Fly-ash Cement
BS 5911	Precast concrete pipes, fittings and ancillary products

### 3. MATERIALS

Reinforced concrete pipe shall be centrifugally cast, vertically cast or roller-suspension cast, reinforced concrete pipe fabricated by an established manufacturer and in an approved plant adapted to meet the design requirements of the pipe.

The pipe interior shall be smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind. The concrete mass shall be dense and uniform. Pipe shall conform to JIS A5372 or equivalent.

### 4. JOINTS

Joints for reinforced concrete pipe shall be the tongue and groove or modified bell and spigot type and shall be provided with a recess on the tongue for a round rubber "O-Ring" type gasket or be designed to receive a cement mortar joint. "O-Ring" type gasket shall be styrene butadiene rubber (SBR) conforming to JIS K6353 or equivalent. The bevel on the tongue and bell of the pipe shall conform to the requirements of the manufacturer of the type of gasket used. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

## **15.2.9 CAST IRON PIPE**

### 1. GENERAL

Cast iron pipe specified hereunder shall be pipe to be used for only drain service.

### 2. REFERENCES

The following standards referred to:

JIS G5501	Gray Iron Castings
JIS G5525	Cast-iron Drainage Pipes and Fittings

### 3. PIPES AND FITTINGS

Cast iron pipe shall be made of cast iron having a minimum tensile strength 147 N/mm<sup>2</sup> and cast iron shall conform to JIS G5501, class 2 FC150. The cast iron pipe shall conform to JIS G5525, Type 1. The pipes from 50 mm to 150 mm in diameter, and pipe 200 mm in diameter shall have a minimum wall thickness 6 mm and 7 mm respectively.

### 4. COATINGS AND LININGS

All exterior and interior surfaces shall have a petroleum asphalt coating, minimum 25 microns thick.

The coating shall be continuous, smooth, neither brittle when cold or sticky when exposed to the sun, and strongly adherent to the pipe and fitting.

### **15.2.10 COPPER PIPE**

#### **1. REFERENCES**

The following standards are referred to:

JIS H3300      Copper and Copper Alloy Seamless Pipes and Tubes

JIS H3401      Pipe Fittings of Copper and Copper Alloys

#### **2. MATERIALS**

##### **2.1 Piping**

Copper piping shall include all pipe and fittings. Copper piping shall be hard drawn when exposed and used in runs, and shall be annealed when used in instrument cabinets or confined area. Copper pipe shall conform to JIS H3300, C1220 or equivalent.

##### **2.2 Fittings and Joints**

Fittings shall be cast bronze and cast brass suitable for copper piping.

Soldered fitting shall conform to JIS H3401 or equivalent and compression fittings shall be flared type.

All joints shall be designed to have the same characteristics and strength as the connecting pipe.

Joints for solder-type fittings shall be made with solder composed of 95 percent tin and 5 percent antimony. Flux shall be compatible with solder.

Underground joints shall be made up using 100 percent silver solder.

Flared and compression joints will be permitted only by written approval of the Engineer.

### **15.2.11 FLEXIBLE JOINTS AND COUPLINGS**

#### **1. GENERAL**

All flexible joints and couplings shall be designed for a minimum working pressure of 0.98 MPa unless otherwise specified.

#### **2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

JIS G3101	Rolled Steel for General Structure.
JIS G3443	Coated Steel Pipes for Water Service.
JIS G3445	Carbon Steel Tubes for Machine Structural Purposes
JIS G3454	Carbon Steel Pipes for Pressure Service.
JIS G5502	Spheroidal Graphite Iron Castings.
JIS G5705	Malleable Iron Castings.
JIS K6353	Rubber Goods for Water Works Service.

### 3. MECHANICAL FLEXIBLE JOINTS

#### 3.1 General

Mechanical flexible joints shall be a closer type mechanical flexible joint or other type joint approved by the Engineer and designed to withstand designed forces or combination of the forces due to expansion and contraction, shear deflection, distortion and other forces to the pipeline.

#### 3.2 Design Requirements

Mechanical flexible joints shall be designed and manufactured to meet the operating conditions and design requirements, as enumerated and tabulated below:

- a. Two (2) meters depth of earth cover the unit weight of which is 2.0 ton/m<sup>3</sup> plus a 20 ton truck loading.
- b. Minimum shear deflection as specified below.
- c. Working pressure of 0.98 MPa.
- d. Other requirements as shown below.

MINIMUM SHEAR DEFLECTION OF 100 mm

NOMINAL DIAMETER (mm)	MAXIMUM LAYING LENGTH (mm)	MINIMUM ALLOWABLE EXPANSION (mm)	MINIMUM ALLOWABLE CONTRACTION (mm)
80 up to 250	1,150	250	80
300 up to 400	1,600	230	80
450	1,600	240	80
500 & 600	1,700	270	80
700	1,800	270	90
800 & 900	1,800	310	110
1,000	1,900	310	130
1,100	1,900	300	140
1,200	1,900	300	150
1,350	1,900	300	170
1,500	2,000	350	200
1,600	2,000	350	220
1,800	2,000	370	220
2,000 up to 2,400	2,100	380	220

MINIMUM SHEAR DEFLECTION OF 200 mm

NOMINAL DIAMETER (mm)	MAXIMUM LAYING LENGTH (mm)	MINIMUM ALLOWABLE EXPANSION (mm)	MINIMUM ALLOWABLE CONTRACTION (mm)
80 up to 250	1,900	250	80
300 to 400	2,900	200	140
450	2,900	200	140
500 & 600	3,000	200	160
700	3,000	200	180
800 & 900	3,000	240	200
1,000	3,500	240	240



1,100	3,500	240	240
1,200	3,500	240	240
1,350	3,500	260	240
1,500	3,600	300	260
1,600	3,600	320	280
1,800	3,600	340	280
2,000 up to 2,400	3,600	360	280

MINIMUM SHEAR DEFLECTION OF 300 mm

NOMINAL DIAMETER (mm)	MAXIMUM LAYING LENGTH (mm)	MINIMUM ALLOWABLE EXPANSION (mm)	MINIMUM ALLOWABLE CONTRACTION (mm)
80 up to 250	2,800	200	140
300 up to 400	3,900	200	140
450	3,900	200	140
500 & 600	3,900	200	160
700	3,900	200	180
800	4,000	240	180
900	4,000	240	200
1,000	4,400	240	240
1,100	4,400	240	240
1,200	4,400	240	240
1,350	4,500	260	240
1,500	4,500	300	260
1,600	4,600	320	280
1,800	4,600	340	280
2,000 up to 2,400	4,600	360	280

### 3.3 Construction and Materials

Mechanical flexible joints shall consist of slip pipes, a sleeve pipe, two (2) rubber rings and housings and others, and shall have flanges at both ends.

Each slip pipe shall have the continuous ring type reinforcing rib and flanged end. Slip pipes and sleeve pipes shall be fabricated from steel sheets or plates, having a minimum yield point of 215 N/mm<sup>2</sup>, conforming to JIS G 3101: SS400, JIS G 3445, STKM13A, JIS G 3454, STPG 370, or equivalent.

Rubber ring housing shall be made of ductile iron casting conforming to JIS G 5502: FCD 450-10, JIS G5705: FCMB 31-08, or equivalent. Rubber ring shall be U-type, automatic seal mechanism using internal pressure of the joints and styrene butadiene rubber (SBR) conforming to JIS K6353 or equivalent. Reclaimed rubber shall not be used.

### 3.4 Coatings and Linings

All exterior surfaces of mechanical flexible joints shall, unless otherwise specified, be painted in accordance with the Standard Specifications titled "Painting" of Section 9.1.

All interior surfaces of mechanical flexible joints and surfaces of slip pipes where they may contact with handling liquid shall be lined with an epoxy system as specified in Sub-section 5.2 Linings of Section 15.2.4 unless specifically noted.

## 4. RUBBER FLEXIBLE JOINTS

### 4.1 General

Rubber flexible joints shall be designed to withstand all the designed forces or all combination of the forces due to expansion and contraction, shear deflection, distortion and others of pipeline.

### 4.2 Design Requirement

Rubber flexible joint shall be designed and manufactured to meet the operating conditions and design requirements, as enumerated and tabulated below:

OPERATING CONDITIONS AND DESIGN REQUIREMENTS

NOMINAL DIAMETER	MINIMUM ALLOWABLE EXPANSION	MINIMUM ALLOWABLE CONTRACTION	MINIMUM ALLOWABLE SHEAR DEFLECTION
(mm)	(mm)	(mm)	(mm)
40	13	15	10
50	17	19	13
65	19	21	15
80	21	23	16
100	24	26	20
125	26	28	24
150 to 300	44	56	50

4.3 Construction and Materials

Rubber flexible joint, Type B shall consist of cylindrical reinforcement rubber body, a neck flange at both ends, and stud bolts and nuts. The joint shall be so designed that any interior ferrous surface does not contact with handling liquid in service and lined with the rubber. The rubber used in fabrication of the rubber body which will be in service with chemical or other liquid specified shall be suitable type of synthetic rubber or rubber lined with Teflon or other suitable materials as approved by the Engineer. The neck flange shall be made of steel conforming to JIS G3101: SS 400. An aluminum alloy neck flange may be used under the approval of the Engineer.

4.4 Coatings and Linings

Coatings and linings for ferrous material to be used for rubber flexible joints shall conform to the requirements specified in the previous Sub-section 3.4 of Section 15.2.11.

5. SLEEVE COUPLINGS5.1 General

Sleeve couplings shall consist of middle ring, two (2) followers, and bolts and nuts for assemblage of coupling.

5.2 Construction and Materials

Middle ring shall be of sizes to fit the pipes and fittings furnished. Middle ring and follower in sizes 300 mm and smaller shall be of steel sheets or plates conforming to JIS G3101: SS 400 or ductile iron casting conforming to JIS G5502: FCD 450-10 or other internationally accepted standards or

manufacturer's standards as approved by the Engineer. Those in sizes 350 mm and larger shall be of steel sheets or plates as specified above. Bolts and nuts for assemblage of coupling shall be of steel as specified above.

Gaskets shall be styrene butadiene rubber (SBR) conforming to JIS K6353 or other internationally accepted standards or manufacturer's standards as approved by the Engineer. Reclaimed rubber shall not be used. Bolts and nuts for the coupling shall be of the same materials as the sleeve as specified above. Length and minimum thickness of the middle ring shall conform to the following requirements.

NOMINAL DIAMETER (mm)	MINIMUM LENGTH OF MIDDLE RING (mm)	MINIMUM THICKNESS OF MIDDLE RING (mm)
150	160	7.9 ( 9.5)
200	160	7.9 (11.5)
250	160	9.5 (11.5)
300	160	9.5 (11.5)
350 to 800	177.8	8
900	177.8	8
1,000 & 1,100	200	12.5
1,200 & 1,350	250	12.5
1,500	250	12.5
1,600 to 1,800	250	12.5

Note: ( ) for iron casting middle ring

### 5.3 Joint Harnesses

Joint harnesses shall be provided on pipes or fittings where specified or shown on the drawings. Joint harnesses shall consist of stud bolts, and gusset plate with back and front plate or ring. They shall be of steel conforming to JIS G 3101: SS400 or other internationally accepted standards or manufacturer's standards as approved by the Engineer. Joint harnesses shall be shop fabricated and welded on pipes or fittings and field welding of joint harnesses will not be permitted unless otherwise specified. Maximum allowable tensile stress of 137 N/mm<sup>2</sup> shall be applied for calculation of number and size of stud bolts.

### 5.4 Coatings and Linings

All exterior surfaces of middle ring and followers with bolts shall, unless otherwise specified, be

painted in accordance with the Standard Specifications titled "Painting" of Section 9.1.

All interior surfaces of middle ring shall be lined with epoxy system specified in Sub-section 5.2 Linings of Section 15.2.4 unless specifically noted.

#### 6. VICTAULIC COUPLINGS

Victaulic couplings shall be malleable iron casting conforming to JIS G5705: FCMB 31-08 or ductile iron casting conforming to JIS G5502: FCD 450-10 or other internationally accepted standards or manufacturer's standards as approved by the Engineer and shall be designed to providing a manual connection by engaging the coupling shoulders on pipe ends which have been grooved or banded and machined to fit the coupling dimension. The coupling shall enclose a sealing gasket which will provide a water tight connection and allow for expansion and contraction of the joint and reasonable deflection. Two or more bolts shall be used to assemble the coupling. Joint harnesses shall be provided on pipes or fittings where specified or shown on the drawings and shall conform to all provisions specified in 5 Sleeve Couplings of Section 15.2.11.

Victaulic coupling in size 300 mm and smaller shall be either grooved or shouldered type and that in size 350 mm to 900 mm shall be shouldered type.

The interior and exterior corrosion protection for the surface of the coupling shall be consistent with exterior protection of the associated pipe.

#### 7. FLANGE ADAPTER

Flange Adapter shall be designed to connect plain end pipe to flanged pipe or to flanged valves and other flanged fittings. Design working pressure shall be at least 0.98 MPa. Joint harnesses shall be provided on pipe where specified or shown on the drawings and shall conform to all provisions specified in 5 Sleeve Couplings of Section 15.2.11.

Materials of major parts of flange adapter such as flanged spigot pipe, ring stopper, follower, stud bolts and bolts and nuts for assemblage of flange adapter shall be steel having minimum yield point of 215 N/mm<sup>2</sup>.

All exterior surfaces of flanged spigot pipe and follower with bolts shall, unless otherwise specified, be painted in accordance with the Standard Specifications titled "Painting" of Section 9.1.

All interior surfaces of middle ring shall be lined with epoxy system specified in Sub-section 5.2 Linings of Section 15.2.4 unless specifically noted.

### **15.2.12 JOINT COATS AND PETROLATUM CORROSION PROTECTION TAPE**

#### 1. GENERAL

Joint coats shall be heat-shrinkable sleeve and applied for corrosion protection of all field welded steel pipe joints buried under the ground unless otherwise specified.

Petrolatum corrosion protection tape shall be applied for valves, flexible joints, couplings and all other ferrous materials which will be laid under ground as specified or shown on the drawings.

## 2. REFERENCES

The following standards are referred to:

JIS K2207	Petroleum Asphalts
JIS K2220	Lubricating Grease
JIS K6911	Testing Methods for Thermosetting Plastics
JIS K6922-2	Polyethylene(PE) moulding and extrusion materials part 2
JIS K7112	Methods of Determining the Density and Relative Density of Non Cellular Plastics
JIS K7215	Method of Durometer Hardness Test for Plastics

## 3. HEAT-SHRINKABLE SLEEVE

Heat-shrinkable sleeve shall consist of outer and inner layers. The outer layer shall be cross linked polyethylene and the inner layer shall be butyl rubber based adhesive.

Length of sleeve shall be not less than 600 mm and minimum thickness of outer layer and inner layer before shrinkage shall be as follows:

APPLICABLE PIPE DIAMETER (mm)	MINIMUM THICKNESS OF OUTER LAYER (mm)	MINIMUM THICKNESS OF INNER LAYER (mm)
350 and smaller	0.6	0.6
400	0.9	0.6
450	1.2	0.6
500 and larger	1.5	0.6

Physical properties of outer and inner layers shall be as follows:

Physical Properties of Outer Layer

Specific Gravity (Min.):		0.91 (JIS K7112)
Tensile Strength	Circumferential (Min., MPa):	17.6 (JIS K6922-2)
	Axial (Min., MPa):	14.7 (JIS K6922-2)
Elongation	Circumferential (Min., %):	250 (JIS K6922-2)
	Axial (Min., %):	500 (JIS K6922-2)
Identification Hardness (Min., Shore D):		43 (JIS K7215)
Dielectric Strength (Min., kV/mm):		30(JIS K6911)
Volume Resistivity (Min., $\Omega$ cm):		1x10(JIS K6911)
Shrinkage	Circumferential (Min., %):	40 (JIS K6911)
	Axial (Max., %):	8(JIS K6911)

Note: ( ) shows standards of which the testing method is to be applied.

Physical Properties of Inner Layer

Specific Gravity (Min.):	1.0 (JIS K7112)
Consistency(Max.):	80 (JIS K2220)
Softening Point(Min. degrees C):	60 (JIS K2207)
Penetration(Max.):	90 (JIS K2207)

Note: ( ) shows standards of which the testing method is to be applied.

4. PETROLATUM CORROSION PROTECTION TAPE

Petrolatum corrosion protection tape shall be Denso type corrosion protection tape and shall be made of saturated unwoven cloth of synthetic fiber impregnated with the petrolatum compounds which consist of petrolatum, inactive inorganic and organic fillers, and organic preservative. It shall be designed to have high and long life corrosion protection with providing self-bounding, adhesiveness, electric insulation, water insulation, weather resistance, chemical resistance, anti-micro organism, etc.

After the petrolatum corrosion protection tape has been applied, its surface shall be protected with wrapping tape unless otherwise noted. The wrapping tape shall be self adhesive PVC, Polyethylene or other materials approved by the Engineer. The wrapping tape shall be a product of the same manufacturer with that of the petrolatum corrosion protection tape.

**15.2. 13 POLYETHYLENE ENCASEMENT****1. GENERAL**

Polyethylene encasement shall conform to the requirement of ISO 8180, Ductile iron pipes - Polyethylene sleeving or other internationally accepted standards. The polyethylene encasement shall be applied to underground piping of ductile cast iron pipes and fittings for the purpose of corrosion protection.

**2. MATERIALS**

Polyethylene film shall be manufactured of virgin polyethylene materials and shall not have holes, splits or any other detrimental faults, which affect its strength or impermeability.

**3. SHAPES AND DIMENSIONS**

The encasement shall be manufactured to the shape of a seamless tube with the following flat width and length.

NOMINAL DIAMETER (mm)	MINIMUM	
	FLAT	MINIMUM
	WIDTH (mm)	LENGTH (mm)
350	900	7,000
400	1,000	7,000
500	1,150	7,000
600	1,350	7,000
700	1,500	7,000
800	1,750	7,000
900	1,900	7,000
1000	2,000	7,500
1100	2,200	7,500
1200	2,500	7,500
1350	2,700	7,500
1500	2,900	7,500

Note : flat width is half of peripheral length of tube



4. ACCESSORIES

Fastening materials for polyethylene encasement shall be elastic bands and adhesive tapes conforming to the manufacturer's standards. Each elastic band shall be equipped with a set of fasteners.

5. SUPPLY OF POLYETHYLENE ENCASEMENT AND ACCESSORIES

Each encasement shall be provided with four (4) sets of elastic bands. The supplied quantities of the elastic bands shall include the allowance of 5 % to the required total quantities.

**15.2. 14 PIPE HANGERS AND SUPPORTS**

1. GENERAL

The Contractor shall provide all labor, materials, equipment, and incidentals necessary to furnish and install pipe hangers and supports, including, in general, all metallic hanging and supporting devices and all concrete piers and supports for supporting piping.

The Contractor shall submit shop drawings and schedules of pipe hangers and supports as required by the Engineer.

Shop drawings shall show size, details and shall submit shop drawings and schedules of all pipe hangers and supports.

Shop drawings shall show size, details and thickness of all materials and all installation details.

The Contractor shall submit samples of materials and items to be supplied as required by the Engineer.

Hangers and supports shall be of approved standard design where possible and shall be adequate to maintain the supported load in proper position under all operating conditions.

The minimum working factor of safety for pipe supports shall be 5 based on the ultimate tensile strength of the material assuming pipe between supports to be filled with water.

Pipe hangers and supports shall be designed based on pipe weight including water and maximum support spacing which are tabulated in the following table.

NOMINAL PIPE	PIPE WEIGHT	MAXIMUM SUPPORT SPACING		
		STEEL	DUCTILE	PVC
65	20	2.0	1.5	1.5
80	25	2.0	1.5	1.5
100	40	4.0	1.5	1.5
125	50	4.0	1.5	2.0
150	65	4.0	1.5	2.0
200	110	4.0	1.5	2.0
250	150	4.0	1.5	2.0
300	200	4.0	1.5	2.0

## 2. MATERIALS

All overhead hangers shall be provided with turnbuckles and supported by threaded hanger rods from inserts in the concrete. Overhead hangers, turnbuckles hanger rods and inserts shall be galvanized steel conforming to JIS G3101: SS 400 other internationally accepted standards or manufacturer's standards as approved by the Engineer unless otherwise specified. Hanger rods shall be machine threaded and rod sizes shall conform to the following Table.

PIPE DIAMETER (mm)	HANGER ROD DIAMETER (mm)
80 and Smaller	10
100 to 150	12
200 and 250	16
300	19

Where support is from walls or columns, welded steel brackets with U-bolts shall be provided. U-bolt sizes shall conform to the following table.

PIPE DIAMETER (mm)	U-BOLT DIAMETER (mm)
80 and Smaller	10
100 and 125	12
150 to 300	16

Wherever practicable, PVC piping and chemical feed piping shall be supported by channel supports.

Threads for all nuts, bolts and rods shall conform to ISO 68-1 "ISO General Purpose Screw Threads - Basic Profile - Part 1: Metric Screw Threads" or JIS B0205 "Metric Coarse Screw Threads".

### **15.2.15 MISCELLANEOUS**

NOT APPLICABLE

### **15.2.16 PIPE INSTALLATION**

#### **1. GENERAL**

This section covers the installation of all pipe and fittings except all pipe and fittings in the ground.

The installation of underground piping is specified in the Standard Specifications titled "Installation of Underground Piping and Fittings" of Section 2.3.

Piping shall be installed to the required lines and grades and as closely as possible to walls, ceilings, columns and other structural parts so as to occupy the minimum of space, and all offsets and fittings required to accomplish this must be furnished. All dimensioned pipes and fittings shall be installed before fitting make up pieces, and the whole shall be joined so that no stress or strain is created in the lines and associated equipment due to forcing parts into position.

When installation is not in progress, including lunchtime, the open ends of the pipe shall be closed by a watertight plug or other approved means. Flotation of pipe shall be prevented. Good alignment shall be preserved during installation. Fittings, in addition to those shown on the drawings shall be installed as required.

In the event interference develops between piping and other appurtenances the Engineer will decide which work is to be relocated regardless of which was first installed.

Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.

Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken in placing piping to prevent damage to the pipe lining or pipe coating or to adjacent structures or equipment. Supporting piers and blocking shall be in place before temporary supports and bracing are removed.

All piping shall have a sufficient number of flanged joints to allow convenient removal of piping. Threaded piping shall have a sufficient number of unions to allow convenient removal of piping.

Systems shall be arranged with low points and drains to permit complete drainage of the system. Fill connections for the purpose of testing shall also be provided on closed system when required.

Adequate air vents shall be provided at high points in all liquid carrying pipes. Interior piping shall be rigidly supported as specified under the Standard Specifications titled "Pipe Hangers and Supports" of Section 15.2.

Upon completion of installation and testing, the Contractor shall paint all exterior piping in accordance with the Standard Specifications titled "Painting" of Section 9.1.

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

## 2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

AWWA C111/A21.10	Rubber-gasket joints for ductile-iron and gray-iron pressure pipe and fittings
AWWA C600	Installation of gray and ductile cast-iron water mains and appurtenances
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings 4-Inches Through 12 Inches, for Water Distribution
AWWA C901	Polyethylene (PE) pressure pipe and tubing, 1/2 inches through 3 inches, for Water Service
AWWA MANUAL	
	Steel Pipe -- A Guide for Design and Installation (M11)
	PVC Pipe -- Design and Installation (M23)

## 3. DUCTILE IRON AND CAST IRON PIPE

### 3.1 General

All work shall be in full conformance with the manufacturer's recommendations and the requirements of AWWA C600 except as otherwise provided herein.

The lining and coating shall be protected at all times. All repairs shall be the responsibility of the Contractor.

### 3.2 Mechanical Joints

Mechanical joints at fittings and pipe shall be installed in accordance with the "Notes on Installation of Mechanical Joints under AWWA C111" and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before inserting the spigot into the bell of the joint. Bolts shall be tightened alternately on opposite ends of joint diameters and in rotation around the pipe. When properly assembled, the gland

shall be equidistant from the bell face at all points. All nuts shall be tightened with use of torque wrenches finally and confirm all nuts are tightened at the designated torque. The bolting torque for each size of bolt shall be in accordance with the manufacturer's standard but in general they are as follows:

<u>BOLT SIZE (mm)</u>	<u>STANDARD TORQUE (N-m)</u>
16	58
20	98
24	137
30	190

If effective sealing is not attained at the torque indicated above, the joint shall be disassembled, cleaned and reassembled. No overstressing of the bolts shall be allowed.

When it is desirable to deflect mechanical joint pipe in order to form a long-radius curve, the amount of deflection shall be in accordance with the instructions of the manufacturer and as directed by the Engineer.

### 3.3 Push-on Joints

The method of jointing push-on joint pipe shall be in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be installed in the groove of the bell end of the pipe, and the joint surface cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means.

Pipe that is not furnished with a depth mark shall be marked before assembly to assure that the pipe end is inserted to the full depth of the joint. Field cut ends of pipe shall be exactly same as the pipe end manufactured at the factory.

When it is desired to deflect push-on joint pipe in order to form a long-radius curve, the amount of deflection shall be as directed by the Engineer and the manufacturers instructions shall be observed.

The deflection of pipes shall be given only after complete jointing of the pipes which shall keep the pipes in a straight line.

### 3.4 Flanged Joints

After cleaning all flanged surfaces, jointing materials shall be tightened with a suitable wrench to the proper torque.

Nuts spaced at an angle of 180 degrees apart shall be tightened alternately in order to produce an equal stress on the entire surface of the flange.

All bolts and nuts for flanged-joints shall be well smeared with grease.

All nuts shall be confirmed to be tightened at the designated torque as shown below using torque wrench.

<u>BOLT SIZE (mm)</u>	<u>STANDARD TORQUE (N-m)</u>
16	58
20	88
24 and 27	170
30	323
33	323
36 and 39	490
45	568

#### 4. STEEL PIPE

##### 4.1 General

Steel pipe shall be installed in accordance with AWWA M11 or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

All work shall be in full conformance with the manufacturer's recommendations.

The lining and coating shall be protected at all times. All repairs shall be the responsibility of the Contractor.

Where steel pipe passes through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the pipe manufacturer and approved by the Engineer.

##### 4.2 Flanged Joints

Same as previous Sub-section 3.4 Flanged Joints.

##### 4.3 Screwed Joints

All threads for screw joints shall be clean, machine cut, and all pipe shall be reamed before erection. Each length of pipe as erected shall be up-ended and rapped to dislodge dirt and scale.

Screwed joints shall be made up with good quality thread compound and applied to the male thread only. After having been set up, a joint must not be backed off unless the joint is completely broken, the threads cleaned, and new compound applied. All joints shall be airtight.

No close right and left hand nipples shall be used All nipples shall be of such length that the correct size of pipe wrench can be used on them when in place.

#### 4.4 Welded Joints

Welding shall be in accordance with the specification titled "Metal Fabrication" of Section 5.3 of the Standard Specifications.

#### 4.5 Flexible Joints

During transportation, handling, storing and installation, any deflection, contraction, expansion or any other transformation of the flexible joints shall be avoided.

All flexible joints shall be installed true to the lines and levels as shown on the drawings and the Contractor shall maintain the joints in the same condition as shipped from the manufacturer. Disassembling the joints at the site shall be avoided unless otherwise directed by the Engineer. The Contractor shall not remove any protective ribs, shipping protection or other devices provided to the joints before jointing work is completed.

#### 4.6 Sleeve Couplings

For jointing sleeve couplings, the Contractor shall take account of the manufacturer's instructions and recommendations as to the methods and equipment to be used in assembling the joint.

In particular the Contractor shall render the end of each pipe perfectly smooth so as to allow the middle ring to slide freely and where necessary the pipe ends shall be recoated with the epoxy system as specified in Sub-section 5.2 Linings of Section 15.2.4.

#### 4.7 Victaulic Couplings

The method of assembling and jointing victaulic couplings shall be in accordance with the manufacturer's instructions and recommendations.

Before setting a sealing gasket, pipe ends either grooved or shouldered shall be cleaned. Sealing surfaces of pipe ends and sealing gasket shall be lubricated with the special jointing lubricant supplied by the coupling manufacturer or a good quality vegetable based lubricant.

After setting a sealing gasket, the Contractor shall set the housing properly and nuts shall be tighten equally.

### 5. PLASTIC MATERIAL PIPES

Plastic material pipes such as polyvinyl chloride pipe and polyethylene pipe shall be installed in accordance with AWWA C900, C901 and AWWA MANUAL M23 or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

All work shall be done in accordance with the manufacturer's recommendations, printed technical data and instructions.

Careful consideration must be given to the handling and storing of plastic material pipes. The pipe must be stored out of any direct sunlight. Extreme care must be made to prevent any scarring or nicking of the pipe from bearing on sharp objects. Any pipe which has any cut or bruise deeper than 10% of the wall thickness will be rejected and shall not be used in the work. The section of pipe with such a cut shall be rejected in its entirety. The pipe shall be stored in such a manner that no direct sunlight is on the pipe but ventilation is provided. Covering the pipe with a tarpaulin shall not be allowed. Stacking shall not exceed 60 centimeters in height.

Joints for PVC pipe shall be solvent welded or coupling type except flanged or threaded, where required. In making solvent welded connections, the Contractor shall clean dirt and moisture from the pipe and fittings. Care shall be taken in order that the solvent cement will not be spilled on valves or allowed to run from joints. When cuts are necessary they shall be perpendicular to the axis of the pipe and smooth.

Where plastic material pipes pass through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the pipe manufacturer and approved by the Engineer. Sealing compounds shall be applied in accordance with the manufacturer's instructions.

#### 6. CEMENT MATERIAL PIPES

Cement material pipes, reinforced concrete pipe, shall be installed in accordance with the Standard Specifications titled "Installation of Underground Piping and Fittings" of Section 2.3.

All work of asbestos cement pipe installation shall be in conformance with AWWA 603 and ISO 4482.

#### 7. COPPER PIPE

Unions shall be provided close to the main pieces of equipment and in branch lines to permit ready dismantling of piping without disturbing main pipeline or adjacent branch lines.

All tube bending shall be accomplished utilizing tube turns.

#### 8. JOINT COATS

All installation work of joint coats shall be in full conformance with the manufacturer's recommendations, printed technical data and instructions.

Careful consideration must be given to handling and storing joint coats. The joint coats must be stored out of any direct sunlight and packaging furnished shall not be opened before use at site. Extreme care must be made to prevent any scarring or nicking of the joint coats from bearing on sharp objects and to keep joint coats from heat.

#### 9. PETROLATUM CORROSION PROTECTION TAPE



All installation work of petrolatum corrosion protection tape shall be in full conformance with the manufacturer's recommendations, printed technical data and instructions.

Surface to be coated with petrolatum corrosion protection tape shall be cleaned. Burrs, rust, dirt and dust, water, oil and grease shall be removed completely from the surface to be applied.

After complete cleaning of the surface, the surface shall be covered with paste. Concave and convex parts shall be filled with filler and made to be a smooth and even surface. The said paste and filler shall be the product supplied by the manufacturer of the petrolatum corrosion protection tape.

The petrolatum corrosion protection tape shall be lapped by adding proper tension to a slightly stretched the tape. At least 150 mm overlapping of the tape shall be given. After lapping the tape, the tape surface shall be pressed by the hands in order to bond it firmly.

After the petrolatum corrosion protection tape is applied, its surface shall be protected with wrapping tape as specified unless otherwise noted.

## 10. POLYETHYLENE ENCASEMENT

### 10.1 General

Installation of polyethylene encasement shall be required when the pipe material is ductile east iron (DIP)

Polyethylene encasement shall be installed surrounding underground DIP pipes continuously along the pipelines.

The polyethylene encasement shall prevent contact between the pipe and surrounding backfill and bedding material. The installation of the polyethylene encasement shall generally be in accordance with the provisions specified in ANSI/AWWA C 105/A21.5-82, "Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids". Details for installation methods and procedures shall be in accordance with the manufacturer's instructions including use of fixtures, adhesive tapes, etc.

The polyethylene encasement will not be required for pipes and valves which are installed in the valve chamber or embedded in the concrete.

### 10.2 Method of Installation

ANSI/AWWA C105 Method A shall be applied for installation of polyethylene encasement for straight pipe using polyethylene tube. The tube shall be slipped around the pipe, centering it to provide at least 0.3 m overlap on each adjacent pipe section. Overlap shall be secured by the use of rubber bands or adhesive tape capable of holding the encasement in place until backfill is completed.

Installation of polyethylene encasement for fittings such as bends, reducers, collars other than valves, tees, crosses and other odd-shaped pieces, shall be done in the same manner as Method A.

Installation for valves, tees, crosses and other odd-shaped pieces may be Method C of ANSI/AWWA C105 or the combination of methods A and C. Detailed installation methods and procedures shall be in accordance with the instructions of the manufacturer.

For branches, blow-offs, air valves, and similar appurtenances, openings shall be provided by making an X - shaped cut in the encasement and folding back the film. After installation of the same the slack shall be taped securely between encasements and secured with tapes and rubber bands. The cut shall be repaired with tape as well as any other damaged areas.

Encasement shall be extended to the adjacent pipe beyond the connections at 0.6 m minimum. Circumference of the encasement end shall be held securely with tapes and bands.

The polyethylene encasement shall be extended into the concrete where pipe is installed penetrated into a concrete wall or in concrete encasement.

### 10.3 Backfill for Polyethylene Encased Pipe

Unless otherwise required, the encased pipe shall be backfilled with the same materials and in a same manner for those pipes without encasement. The Contractor shall exercise extreme care to prevent damage to the polyethylene encasement. Backfill materials shall be free from cinders, refuse, boulders, rocks, stone, or any other materials that could damage the polyethylene encasement.

## **DIVISION 15 MECHANICAL WORKS**

### **SECTION 15.3 VALVES, GATES AND APPURTENANCES**

#### **15.3.1 GENERAL**

##### **1. SCOPE OF WORK**

The Contractor shall provide all labor, materials, equipment and incidentals necessary to furnish and install, ready for operation, all valves with operators, accessories, paint, spare parts, tools, operating manuals and appurtenances as shown on the drawings and as specified herein. The materials and equipment shall be the product of an established and reputable manufacturer who has had experience in the manufacture of the type of equipment herein specified. The manufacturer shall demonstrate to the Engineer that his products have successfully been in operation for a minimum of five (5) years.

Before installation of any valve, the Contractor shall submit an affidavit from the manufacturer certifying that each valve meets the requirements of this specification, and a record of a specified tests, to the Engineer for approval as required. No valve shall be installed prior to approval by the Engineer.

##### **2. SHOP DRAWINGS**

The Contractor shall submit detailed working and shop drawings and schedules of required valves, accessories and appurtenances.

Shop drawings shall include but not be limited to the following:

- a. Lists and schedule of material
- b. Details of proposed joints and harnesses
- c. Names of suppliers
- d. Dates of delivery of materials to the job site

Shop drawings shall show size, details, materials and thickness of all items and all installation details.

##### **3. GENERAL CONSTRUCTION**

All valves shall be of the size shown on the drawings or in the Technical Schedules.

Major valves shall have following markings and they shall be designed cast in raised letters upon some appropriate part of the body.

- a. Name of the Employer, if specified,
- b. Name of mark of manufacturer,
- c. Year of manufacturing, 01 (means 2001)
- d. Working pressure, 0.98 (means 0.98 MPa) and

- e. Arrow direction for valves designed for one-way flow only

Valve ends shall be flanged ends except where otherwise specifically called out on the drawings or in the Technical Schedules. Where flanged ends are used, mating dimensions and drilling shall be in accordance with the flange schedule specified in Section 15.2 Piping of the Standard Specifications.

Thickness of flanges shall be determined as based on the working pressure specified and shall conform to internationally accepted standards, or the Contractor shall determine the flange thickness and shall submit his design calculation.

All materials which will be specified hereunder shall conform to JIS, ASTM, BS, DIN or other internationally accepted standards.

Valves shall be equipped with hand lever, hand wheels, chain or hand, pneumatic or electric operators as shown on the drawings or Technical Schedules. Unless otherwise specified, manual operation valves shall have hand wheels. Valves shall open by turning to the left or counter clockwise. Operators shall have arrows cast thereon to indicate the direction of rotation for opening the valve.

All pipe connection openings shall be capped to prevent the entry of foreign matter prior to installation.

Valves 50 mm in size and smaller shall be all bronze, unless otherwise specified, except for hand wheels which shall be of cast or malleable iron, provided with screw ends.

#### 4. INSTALLATION

All valves, gates and appurtenances shall be installed in accordance with manufacturer's directions at locations shown on the drawings. The installation shall be true to alignment and rigidly supported.

Pet cocks shall be installed at all points shown or called for on the drawings and at any other location where air binding of pipe lines might occur.

All valve operators shall be installed according to the manufacturer's recommendations, as shown on the drawings and as specified herein.

Before setting the items specified, the Contractor shall check all plans and figures which have a direct bearing on their locations and the Contractor shall be responsible for the proper location of these valves and appurtenances during the construction of the structures.

#### 5. TESTING

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

##### 5.1 General

The manufacturer shall notify the Engineer at least four (4) weeks prior to factory tests. The Engineer reserves the right to witness all tests.

### 5.2 Performance Tests

Each valve, gate and appurtenance shall be shop-operated three times from the fully closed to the fully opened position, and the reserve, under a no flow condition, to demonstrate that the complete assembly is workable.

### 5.3 Leakage Tests

Valves, gates and appurtenances shall be shop-tested for leaks in the closed position. With the valve in the closed position, air pressure or hydrostatic pressure as directed by the Engineer shall be supplied to one face of the disc for the full test duration at the working pressure. The length of test shall be at least 5 minutes and there shall be no indication of leakage past the valve during the test period.

### 5.4 Hydrostatic Tests

Valves specified shall be hydrostatically tested. Hydrostatic tests shall conform to the following unless otherwise specified.

With the valve disc in a slightly open position, internal hydrostatic pressure equivalent to two (2) times the specified working pressure shall be applied to the inside of the valve body of each valve for a period of 10 minutes. During the hydrostatic test, there shall be no leakage through the metal, the end joints, or the valve shaft seal; nor shall any part be permanently deformed. While undergoing testing, the valve body shall be struck with a hammer several times.

### 5.5 Field Testing

When the valves, gates and appurtenances have been completely installed and as soon as operation conditions permit, they shall be given a field test to demonstrate that they have been suitably installed, that they meet all requirements, that they are in good operating condition and that they are, in every way, adequate for the service intended.

## 6. PAINTING

Valves, gates and appurtenances as required, unless otherwise specified, shall be shop primed on the exterior in accordance with the Standard Specifications titled "Painting" of Section 9.1, unless noted otherwise.

### 15.3.2 SCHEDULE

The completeness of these schedules is not guaranteed and the omission of valves in the schedule needed to complete the work shall not relieve the Contractor from his responsibility for installation of

the work complete.

### **15.3.3 GATE VALVES**

#### **1. GENERAL**

The following gate valves shall be specified hereinafter.

- a. Gate valves (80 mm to 1,000 mm)
- b. Resilient gate valves (80 mm to 300 mm)
- c. Bronze gate valves (80 mm and smaller)
- d. Stainless steel gate valves (15 mm to 300 mm)

Unless otherwise specified, all valves except gate valves, 600 mm and larger shall be equipped with hand wheels and gate valves, 600 mm and larger shall be equipped with manual operators with hand wheels.

#### **2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS B2011	Bronze Gate, Globe, Angle and Check Valves
JIS B2031	Gray Cast Iron Valves
JIS B2062	Sluice Valves for Waterworks
JIS G5528	Epoxy-Powder Coating for Interior of Ductile Iron Pipes and Fittings
JIS H3250	Copper and Copper Alloy-Rods and Bars
JIS H5120	Copper and Copper Alloy Castings
AWWA C210	Liquid Epoxy Coating System for the Interior and Exterior of Steel Water Pipelines
AWWA C213	Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C500	Gate Valves, 3 Through 48 In. NPS, for Water and Sewage Systems
AWWA C509	Resilient-Seated Gate Valves, 3 through 12 NPS, for Water and Sewage Systems
BS 5150	Metric Specification for Cast Iron Wedge Gate Valves for Waterworks Purpose
BS 5163	Metric Specification for General Purpose Cast Iron Wedge Gate Valves

#### **3. GATE VALVES (80 mm to 1,000 mm)**

Gate valves shall be designed and manufactured in accordance with JIS B2031, JIS B2062 or AWWA

C500 or BS 5163 and BS 5150, or other internationally accepted standards. Working pressure shall be 0.98 MPa for valves 500 mm and smaller, and 0.735 MPa for valves diameter of 600 mm to 1,000 mm unless otherwise specified.

The valve body and bonnet shall be of cast iron, ductile cast iron, or equivalent.

The stuffing box shall be the same materials or the body as specified above and shall be in the open position. The depth of the stuffing box shall be not less than the diameter of the valve stem. Packing for the stuffing box shall be made of synthetic rubber or other suitable materials approved by the Engineer. Hemp or jute packing shall not be used. O-ring stem seals may be used, subject to the approval of the Engineer and these seals shall have a minimum of two (2) "O" ring seals, of which at least one (1) shall be above the stem collar and replaceable under full working pressure while the valve is in the fully open position.

Valve stem shall be cast, forged or rolled bronze or stainless steel, type 403 or 420.

#### 4. RESILIENT-SEATED GATE VALVES (80 mm to 300 mm)

Resilient-seated gate valves (hereinafter called RS type gate valve) shall be designed and manufactured in accordance with AWWA C509 or other internationally accepted standards. Working pressure shall be 0.98 MPa.

RS type gate valves shall be cast iron-body resilient-seated gate valves with non-rising stems (NRS) and outside screw-and-yoke (OS&Y) rising stems. Valves shall be designed to provide an unobstructed waterway having a diameter of not less than the full nominal diameter of the valve when in the open position.

The valve body, bonnet, gate and yoke shall be of gray cast iron or ductile cast iron. The yoke on bonnets shall be integral or of bolted-on construction of such proportions and secured in such a manner that it shall be as strong relatively to other parts of the valve. The design shall be such that a hand cannot be jammed between a yoke and the hand wheel.

For stem seals, either gland packing or O-rings including other pressure-actuated stem seals shall be provided. The stuffing box or O-ring packing plate shall be the same materials of the valve body as specified above. The depth of the stuffing box shall be not less than the diameter of the valve stem. Gland packing for the stuffing box shall be made of synthetic rubber or other suitable materials approved by the Engineer. Hemp or jute packing shall not be used. O-ring stem seals shall be designed to have a minimum of two (2) "O" ring seals, of which at least one (1) above the stem collar and replaceable under full working pressure while the valve is in the fully open position.

Valve stems shall be cast, forged or rolled bronze or stainless steel, type 403 or 420.

All valves unless otherwise specified shall be equipped with hand wheels.

Resilient seats shall be applied to the gate and shall seat against a corrosion-resistant surface. The surface shall be non-metallic, applied in a manner to withstand the action of line fluids and operation of the sealing gate under long-term service. Resilient seats shall be bonded or mechanically attached to the gate. All exposed mechanical attaching devices and hardware used to retain the resilient seat shall be of a corrosion-resistant material.

Bolts and nuts to be used for bonnet, packing plate, gland and others shall be stainless steel unless otherwise noted.

All interior and exterior ferrous parts of the valve except for finished or seating surfaces shall be finished with fusion-bonded epoxy protective coating. Fusion-bonded epoxy coating shall be heat activated, chemically cured coating systems conforming to AWWA C213 or JIS G5528. Total dry film thickness on the interior and exterior surface shall be not more than 0.4 mm and not less than 0.3 mm respectively.

#### 5. BRONZE GATE VALVES (80 mm and smaller)

Bronze gate valves shall be designed and manufactured in accordance with JIS B2011 or approved equal. Working pressure shall be 0.98 MPa. Valves shall be equipped with either screwed ends or flanged ends.

Valves, in size 50 mm and smaller shall be bronze body, screwed bonnet, gate valves having a solid wedge, inside screw and rising stem.

Valves, in size 65 mm and 80 mm shall be bronze body, flanged bonnet, gate valves having a solid wedge, inside screw and non-rising stem.

The body shall be bronze casting conforming to JIS H5120, bronze casting class 6 CAC 406 or bronze casting having tensile strength not less than 195 N/mm<sup>2</sup>. Disc shall be bronze casting specified above or copper conforming to JIS H3250, class C3771 BD or C3771 BE or C3604 BD or C3604 BE or copper having tensile strength not less than 315 N/mm<sup>2</sup>. Stem shall be copper specified above.

#### 6. STAINLESS STEEL GATE VALVES (15 mm to 300 mm)

Stainless steel gate valves shall be solid wedge disc type valves with outside screw-and-yoke (OS&Y) rising stems and designing for handling acids. Valves shall have hand wheels and flanged ends. Working pressure shall be 0.98MPa.

Unless otherwise specified, major parts of the valve such as body, bonnet, stem, disc, gland with gland bolts and nuts, bonnet bolts and nuts and other parts which may contact with handling liquid shall be made of type 316 stainless steel and stainless steel casting.



**15.3.4 BUTTERFLY VALVES****1. GENERAL**

The following butterfly valves shall be specified hereinafter.

- a. Butterfly valves for water (80 mm to 1,800 mm)
- b. Butterfly valves for air (80 mm to 1,000 mm)
- c. Wafer butterfly valves for water (50 mm to 500 mm)
- d. Wafer butterfly valves for chemical surfaces (80 mm to 500 mm)

All valves shall be equipped with manual operators with hand wheels unless otherwise specified.

**2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS B2032	Wafer Type Rubber-seated Butterfly Valves
JIS B2064	Butterfly Valves for Water Works
JIS G5501	Gray Iron Casting
JIS G5502	Spheroidal Graphite Iron Castings
AWWA C504	Rubber-seated Butterfly Valves
ASTM A48	Specification for Gray Iron Castings
ASTM A126	Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings
ASTM A536	Specification for Ductile Iron Castings

**3. BUTTERFLY VALVES FOR WATER (80 mm to 1,800 mm)**

Valves shall be cast iron or ductile iron body, rubber-seated, tight-closure butterfly valves and shall be designed and manufactured in accordance with AWWA C504. Valves shall be designed for the maximum non-shock shutoff pressure, 0.49 MPa or 0.98 MPa. The valves shall be rated for a maximum velocity of 4.9 m/sec in the piping section upstream of the valve.

Valve bodies shall be either cast iron or ductile iron and they shall conform to these materials as specified below.

Cast iron	: JIS G 5501, FC 200 or, or ASTM A 126, Class B or ASTM A 48, Class 40 or equivalent
Ductile iron	: JIS G 5502, FCD 450 or ASTM A 536, grade 65-45-12 or equivalent

Valves shall have laying length and minimum body shall thickness as shown on the following TABLE

A unless otherwise specified.

**TABLE A LAYING LENGTH AND MIN. BODY SHELL THICKNESS**

NOMINAL DIAMETER (mm)	LAYING LENGTH (mm)	MIN. BODY SHELL THICKNESS	
		CLASS 0.49 MPa (mm)	CLASS 0.98 MPa (mm)
80	127	9.4	9.4
100	127	10.2	10.2
150	127	10.9	10.9
200	152	11.7	11.7
250	203	12.7	13.7
300	203	13.7	14.7
350	203	14.7	16.0
400	203	16.0	17.3
450	203	17.3	20.1
500	203	18.0	21.1
600	203	20.3	23.6
700	305	22.9	26.7
800	305	25.4	29.2
900	305	28.7	31.0
1,000	305	29.5	34.3
1,100	381	34.8	37.6
1,200	381	34.8	37.6
1,350	381	38.4	41.4
1,400	381	41.2	48.0
1,500	381	41.1	48.0
1,600	457	45.7	50.8
1,800	457	50.8	60.3

Note:

At no point shall the body shell thickness be more than 12.5 percent below the metal thickness shown in the above table.

Valve shafts shall be made of type 304 or 316 stainless steel or Monel metal. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which

comprises two separate shafts inserted into the valve disc hubs. If of "stub shaft" construction, each stub shaft shall be inserted into the valve disc hubs for a distance of at least 1.5 times the shaft diameter.

Valve shafts shall have a minimum diameter extending through the valve bearings and into the valve disc as specified in the following TABLE B unless otherwise specified. Valve-shaft torque capability for full-diameter portion of the shaft for valves shall meet or exceed the valves in the following Table C unless otherwise specified.

TABLE B MIN. SHAFT DIAMETER

NOMINAL DIAMETER (mm)	MIN. SHAFT DIAMETER	
	CLASS 0.49 MPa (mm)	CLASS 0.98 MPa (mm)
80	12.7	12.7
100	15.9	15.9
150	19.1	25.4
200	22.2	28.6
250	28.6	34.9
300	31.8	38.1
350	38.1	44.5
400	41.3	50.8
450	47.6	57.2
500	54.0	63.5
600	63.5	76.2
700	76.2	92.1
800	92.1	111.1
900	92.1	111.1
1,000	108.0	127.0
1,100	123.8	142.9
1,200	123.8	142.9
1,350	139.7	171.5
1,500	152.4	184.2
1,600	171.5	196.9
1,800	190.5	215.9

Note: \* : Based on the use of stainless steel, type 302,303, 304 or 316

TABLE C SHAFT TORQUE CAPABILITIES\*

NOMINAL DIAMETER (mm)	SHAFT TORQUE CAPABILITIES	
	CLASS 0.49 MPa (N · m)	CLASS 0.98 MPa (N · m)
80	24	24
100	49	49
150	84	199
200	134	285
250	285	519
300	390	674
350	674	1,070
400	857	1,600
450	1,320	2,280
500	1,910	3,120
600	3,120	5,400
700	5,400	9,520
800	9,520	16,700
900	9,520	16,700
1,000	15,300	24,900
1,100	23,200	35,500
1,200	23,200	35,500
1,350	33,200	61,400
1,500	43,100	76,100
1,600	61,400	92,900
1,800	84,200	123,000

Notes: \* Calculated with 62 MPa torsional shear stress as allowable for stainless steel type 304 and shaft diameter as shown in TABLE B.

Valves, 600 mm and smaller in diameter shall be seat-in-body.

Valves, 700 mm to 1,800 mm in diameter shall be either seat-in- body or seat-in-disc and in either case, seat shall be designed to be replaceable in-line without use of special tools.

Rubber seats shall mate with stainless steel type 304 or 316 seat surfaces.

Rubber seat for valves, 600 mm and smaller shall be clamped, mechanically secured, bonded, or vulcanized to the valve body.

Rubber seats for valves, 700 mm to 1,800 mm shall be mechanically clamped or secured to the valve body or disc.

All clamps and retaining rings for rubber seats shall stainless steel type 304 or 316. All nuts and screws used with clamps and retaining rings shall be of stainless steel type 304 or 316.

Valve discs shall be of a cast or fabricated design with no external ribs transverse to the flow. The thickness of the valve disc shall not be more than 2.25 times the shaft diameter listed in Table B. Valve discs shall be of cast iron, ductile iron, stainless steel, cast steel, fabricated steel, bronze or alloy cast iron. They shall conform to these as specified below.

Cast iron:	JIS G5501, Class 3 FC200 or ASTM A126, Class B or ASTM A48, Class 40 or equivalent
Ductile iron:	JIS G5502, FCD 450 or ASTM A536, grade 65-45-12 or equivalent
Stainless steel:	Type 304 or 316 or other type approved by the Engineer
Others:	Conform to AWWA C504 or equivalent

Shaft seals shall be provided wherever shafts project through the valve body. Shaft seals shall be designed for the use of standard split-V type packing, for standard O-ring seals or for a pull-down packing.

O-ring shaft seals shall be contained in a removable corrosion-resistant recess.

Shaft seals of the type utilizing a stuffing box and a pull down packing gland shall be designed so that the packing can be adjusted or completely replaced without disturbing any part of the valve or operator assembly except the packing gland follower. Stuffing boxes shall have a depth sufficient to accept at least four rings of packing. Packing of stuffing box shall be same materials as specified for GATE VALVES (80 mm to 1,000 mm).

#### 4. BUTTERFLY VALVES FOR AIR (80 mm to 1,000 mm)

Butterfly valves in air piping shall meet all the applicable requirements specified in the previous sub-section for butterfly valves for water except as otherwise specified herein.

Butterfly valves for air piping shall be designed to provide an air-tight seal. Rubber seats shall be synthetic rubber suitable for use with air temperature up to 115 degrees C and all other components shall be suitable for use with air temperature specified the above.

All valves shall be equipped with manual operators with hand wheels unless otherwise specified.

5. WAFER BUTTERFLY VALVES FOR WATER (50 mm to 600 mm)

Valves shall be cast iron wafer body, rubber-seated butterfly valves, and shall be designed manufactured basically in accordance with JIS B2032 and in addition shall conform to the following requirements:

Valve shall be designed to be leak tight in both directions at a maximum working pressure of 0.98 MPa and at a maximum velocity of 3.0 m/sec and for throttling service.

Laying length of valves shall conform to laying as specified in the following TABLE D unless otherwise specified. Valve bodies shall be designed to withstand the design requirements specified.

TABLE D LAYING LENGTH

NOMINAL DIAMETER	LAYING LENGTH
<u>mm</u>	<u>mm</u>
50	43
65	46
80	46
100	52
150	56
200	60
250	68
300	78
350	78
400	102
450	114
500	127
600	154

Each shaft shall be a one-piece unit extending completely through the valve disc, or of the “stub shaft” type, which comprises two separate shafts inserted into the valve disc hubs. If of “stub” construction, each stub shaft shall be inserted into the valve disc hubs for a distance of at least 1.5 times the shaft diameter.

Valve shafts shall be of high yield strength series stainless steel such as Type 403, 420, 431 and others and valves made by precipitation series stainless may be acceptable.

Valve discs shall be made of stainless steel casting and shall be of centered design with no external ribs transverse to the flow. The design of disc shall withstand full differential pressure across the

closed valve disc.

Rubber seats shall be spool shaped rubber seating applied to the body and shall be made of EPDM or Buna-N (NBR).

Allowable stress, not exceeding 20% of yield strength of cast iron or ductile cast iron and allowable stress, not exceeding 30% of yield strength of stainless steel shall be applied for design of major parts of valve.

All valves shall be equipped with manual operators with hand wheels unless otherwise specified.

#### 6. WAFER BUTTERFLY VALVES FOR CHEMICAL SERVICES (50 mm to 600 mm)

Wafer butterfly valves for chemical services shall be ductile iron wafer body, special seat ring butterfly valve.

Valves shall be designed to fit between two pipe flanges and the maximum working pressure of 0.98 MPa.

Valves shall be seat-in-body and have seat rings which shall consist of liquid contact Teflon seat and elastic rubber core.

Valve shafts shall be made of stainless steel or carbon steel and shall be coated with Teflon. Teflon bushings for valve shaft shall be provided at parts where shaft passes through the valve body.

Valve discs shall be coated with Teflon and all other parts which may contact with handling liquid shall be coated and lined with Teflon.

All valves shall be equipped with manual operators with hand wheels unless otherwise specified.

### 15.3.5 CHECK VALVES

#### 1. GENERAL

The following check valves shall be specified hereinafter.

- a. Cast iron swing check valves (50 mm to 600 mm)
- b. Bronze swing and lift check valves (50 mm and smaller)
- c. Stainless steel check valves (15 mm to 300 mm)
- d. Tilting disc check valves (50 mm to 1,500 mm)
- e. Wafer check valves (50 mm to 1,200 mm)
- f. Spring loaded lift check valves (25 mm to 400 mm)

All check valves except tilting check valves, wafer check valves and spring loaded lift check valves

mentioned above shall be constructed so that disc, seat, seat rings and other internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools and removing the valve from the line.

## 2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

JIS B2011	Bronze Gate, Globe, Angle and Check Valves
JIS B2031	Gray Cast Iron Valves
JIS H5120	Copper and Copper Alloy Castings
AWWA C508	Swing-Check Valves for Waterworks Service, 2 In. through 24 In. NPS

## 3. SWING CHECK VALVES (50 mm to 600 mm)

Swing check valves shall be cast iron body and disc, and bronze seating type. The valves shall be designed and manufactured in accordance with JIS B2031 or AWWA C508 or approved by the Engineer. Working pressure shall be 0.98 MPa.

Valves shall be suitable to operate in a horizontal or vertical position with flow upward and when fully open, valves shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Valves shall be furnished with hinge arms, levers and springs or weights and also furnished with a by-pass pipe and by-pass valve as required by the schedule.

## 4. BRONZE SWING AND LIFT CHECK VALVES (50 mm and smaller)

Bronze swing and lift check valves shall be designed and manufactured in accordance with JIS B2011 or approved equal. Working pressure shall 0.98 MPa. Valves shall be equipped with screwed ends.

Swing check valves shall be suitable to operate in a horizontal or vertical position with flow upward. Lift check valves shall be suitable to operate in a horizontal position with flow upward when fully open. Both of swing and lift check valve shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Valves shall be bronze body, screwed bonnet and disc. Valves shall be designed to have bronze seatings or resilient seating. Resilient seats shall be made of Teflon.

The body shall be bronze casting, and bonnet and disc shall be of bronze casting or copper. The said bronze casting and copper shall conform to the requirements specified in 5. Bronze Gate Valves (80 mm and smaller) of Section 15.3.3.



5. STAINLESS STEEL CHECK VALVES (15 mm to 300 mm)

Stainless steel check valves shall be straightway, swing type and designed for handling acid. Valves shall have metal to metal seating. Working pressure shall be 0.98 MPa.

Valves shall be suitable to operate in a horizontal or vertical position with flow upward and when fully open, valves shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Unless otherwise specified, major parts of the valve such as body, bonnet, disc, hinge with hinge pin and other parts which may contact with handling liquid shall be made of type 316 stainless steel casting.

6. TILTING DISC CHECK VALVES (50 mm to 1,500 mm)

Tilting disc check valves shall be cast iron or ductile cast iron body and disc, and bronze or stainless steel seating. Valves shall be designed for a working pressure of 0.98 MPa and shall be suitable for operation in a horizontal pipeline.

Body shall be two (2) piece construction bolted together. Seat rings shall be mounted on both valve body and disc and shall be made of bronze casting conforming to JIS H5120, bronze casting Class 6 CAC 406 or type 304, 403, 420 or other stainless steel. Mating surfaces of body seat and disc seats shall be machine finished. Hinge pin shall be of stainless steel specified above. Bushings of hinge pin shall be bronze casting specified above or aluminum bronze casting conforming to JIS H5120, CAC 702 or CAC 703 or equivalent.

Body shall be provided with suitable hand holes for cleaning and by-pass pipe with valve. Pivot pin housing shall be fitted with ball check grease fittings.

Dash pots shall be furnished with valves and designed to have valve opening and closing speed control devices. Dash post shall be approved by the Engineer.

7. WAFER CHECK VALVES (50 mm to 1,200 mm)

Wafer check valves shall be dual plate, two spring-loaded, semicircular plates type.

Valves shall be designed to fit between two pipe flanges and for working pressure of 0.98 MPa.

Valve body and plates shall be of cast iron, ductile iron or type 316 stainless steel. Bronze casting plates may be permitted. Hinge pin, stop pin and springs shall be of type 316 or 304 stainless steel. Valves shall have resilient seating in the valve body unless otherwise specified. Seat materials shall be Buna-N (NBR).

Valves shall be designed to have a by-pass line with by-pass valve. Unless otherwise specified, the

springs shall be high torque type.

#### 8. SPRING LOADED LIFT CHECK VALVES (25 mm to 400 mm)

Spring loaded lift check valves shall be cast iron body, spring loaded, center guided disc type with flanged ends. Valves shall be designed for a working pressure of 0.98 MPa.

The valves shall be suitable to operate in a vertical position with flow upward and shall consist of body, disc, upper guide, disc guide, reverse flow guide disc, spring and by-pass valve.

Body seat ring shall be bronze casting accurately threaded and screwed into the body. Disc shall have synthetic rubber seat bolted to the disc. Disc, upper guide, disc guide and by-pass valve shall be of bronze casting conforming to JIS H5120, CAC 406 or equivalent. Spring shall be type 304 stainless steel.

#### 15.3.6 PLUG VALVES

Plug valves shall be cast iron body, non-lubricated, resilient faced eccentric plug type valves. Valves shall be designed for a working pressure of 0.75 MPa.

Port areas of valves 500 mm and smaller shall be at least 80% of the full pipe area and shall be at least 70% for large valves.

The valve body and bonnet shall be bronze iron or ductile iron or a corrosion resistant, cast-iron alloy containing 1% to 1.5% nickel. The materials specified above shall have a minimum tensile strength of 215.6 N/mm<sup>2</sup>. If the body is cast iron, the seat shall have a welded-in overlay of not less than 90% pure nickel on all surfaces contacting the plug face. The seat face shall be machined. If the body is corrosion resistant cast-iron alloy, the raised seat shall be machine finished and protected with an approved epoxy coating.

The plug shall be cast iron as specified for the body and shall have a resilient coating to provide bubble-tight shutoff. The resilient coating shall be chloroprene (Neoprene).

Valves shall be provided with heavy duty pre-lubricated bearings of stainless steel or bronze. Stem seals shall rubber O-rings or multiple Buna-N packing rings. When packing rings are used, the packing gland and packing shall be accessible without disassembly of the valve.

All valves, 100 mm in diameter and larger shall be equipped with manual hand wheel operators with worm gear unless otherwise specified. All valves, 80 mm in diameter and smaller shall have a wrench.

#### 15.3.7 GLOBE VALVES

##### 1. GENERAL

The following globe valves shall be specified hereinafter.

- a. Angle hose valves (10 mm to 100 mm)
- b. Hose bibbs (13 mm to 25 mm)
- c. Stainless steel globe valves (15 mm to 300 mm)

All valves shall be equipped with cast iron or ductile cast iron hand wheels.

## 2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

JIS B2011	Bronze Gate, Globe, Angle and Check Valves
JIS B2061	Faucets, Ball Taps and Flush Valves
JIS H3100	Copper and Copper Alloy-Sheets, Plates and Strips
JIS H3250	Copper and Copper Alloy-rods and Bars
JIS H5120	Copper and Copper Alloy Castings

## 3. ANGLE HOSE VALVES (10 mm to 100 mm)

Angle hose valves shall be bronze body Y-Globe valves with renewable composition discs. Valves shall have rising stem and screwed ends with stainless steel replaceable quick coupling cap. Working pressure shall be 0.98 MPa. Valves shall be designed and manufactured in accordance with JIS B2011, Screwed Ends Angle Valves.

Discs shall be hard but sufficiently resilient to maintain tight seal within the pressure and temperature range and have high flexural and impact strength. Discs shall be made of Teflon or other materials approved by the Engineer.

Disc holder shall be made of bronze casting conforming to JIS H5120, CAC 406 or copper conforming to JIS H3100, Class C2600P or JIS H3250, Class C3604 or C3771 or equivalent.

## 4. HOSE BIBS (13 mm to 25 mm)

Hose bibbs shall be bronze body globe valves with renewable composition discs. Valves shall have rising stems, screw-in bonnet, screwed inlet and hose coupling outlet. Working pressure shall be 0.735 MPa. Valves shall be designed and manufactured in accordance with JIS B2061 and shall be swivel nose faucet, faucet with hose coupling or lawn faucet.

Stem with disc and disc nut shall be bronze, bronze casting or copper. Disc shall be medium soft composition as recommended by the manufacturer for the intended use.

## 5. STAINLESS STEEL GLOBE VALVES (15 mm to 300 mm)

Stainless steel globe valves shall be metal-to-metal seating type globe valves with outside

screw-and-yoke (OS&Y) rising stems and designed for handling acids. Valves shall have flanged ends and a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Unless otherwise specified, major parts of the valve such as body, bonnet, stem, disc, gland with gland bolts and nuts, bonnet bolts and nuts and other parts which may contact with handling liquid shall be made of type 316 stainless steel and stainless steel casting.

### **15.3.8 DIAPHRAGM VALVES**

Diaphragm valves shall be of the weir or straightway type as noted, with cast iron body, resilient reinforced rubber diaphragm and cast iron bonnet. They shall be fitted for spoke shaped hand wheel operation.

The valves shall be used in water, air, and weak chemical service lines.

The reinforced rubber diaphragm shall be connected to a spindle actuated compressor so that it will be lifted to provide an adequate water-way for minimum pressure loss.

Further, the diaphragm shall be forced tight against the body even when the compressor is lowered. The diaphragm shall seal the bonnet compartment and working parts from the fluid stream. The diaphragm shall be capable of ready replacement without removing the valve body from the pipeline.

The valve shall be protected against corrosion with a minimum 3.0 mm thick of neoprene lining suitable for the service intended and consistent with associated piping unless otherwise noted.

### **15.3.9 BALL VALVES**

#### **1. GENERAL**

The following ball valves shall be specified hereinafter.

- a. Stainless steel ball valves for chemical service (15 mm to 350 mm)
- b. Stainless steel ball valves for plant water line (10 mm to 50 mm)
- c. Motorized ball valves (15 mm to 50 mm)

#### **2. STAINLESS STEEL BALL VALVES FOR CHEMICAL SERVICE (15 mm to 350 mm)**

Stainless steel ball valves shall be non-lubricated and shall have stainless steel ball and body with Teflon seats. Valves shall be designed for handling chemicals and for working pressure of 0.98 MPa. Valves shall have flanged ends.

Valve ports shall be at least the area of a circle of diameter equivalent to the nominal size of the valve. Valves, 100 mm and smaller in diameter shall be wrench operated. Valves, 125 mm and larger shall be hand wheel operated through a worm gear. Port position shall be plainly visible to the operator by means of an indicator.

Unless otherwise specified, major parts of the valve such as bodies, stem, ball, gland with gland bolts and nuts and other parts which may contact with handling liquid shall be made of type 316 stainless steel and stainless steel casting.

The seats shall be reinforced Teflon and shall be easily replaceable using no special tools. The gland packing shall be reinforced Teflon and shall be adjustable while the valve is conducting flow and replaceable without removing the valve from the line.

**3. STAINLESS STEEL BALL VALVES FOR WATER LINE (10 mm to 50 mm)**

Stainless steel ball valves shall be non-lubricated and shall have stainless steel ball and body with Teflon seats. Valves shall be designed for a working pressure of 0.98 MPa and shall have screwed ends. Valves shall be wrench operated.

Major parts of the valve such as body, stem and ball shall be made of type 304 or 316 stainless steel and stainless steel casting.

**4. MOTORIZED BALL VALVES (15 mm to 50 mm)**

Motorized ball valves shall be non-lubricated, and shall have stainless steel ball and stainless steel or cast iron body with Teflon seats, and shall have integrated type electric operator. Valves shall be designed for water line and for working pressure of 0.98 MPa. Valves shall have flanged ends.

The seats and gland packing shall be reinforced Teflon and stem shall be stainless steel.

The electric operator shall be furnished with totally enclosed, waterproof construction. Motor shall be condenser motor rated at single phase, 220 V and 50 Hz. All electric components shall be designed solid state electric circuit. The operator shall be designed to provide rotary valve control with one-way rotation direction and to have built-in thermal overload protection. Open and close limit switches shall be provided. Port position shall be plainly visible to the operator. The valves shall be designed to operate by wrench.

**15.3.10 PRESSURE REDUCING VALVES**

Pressure reducing valves for water service shall be cast iron body, self-contained, direct-acting, spring-loaded type. Valves shall operate at a primary pressure range of 0 to 0.98 MPa and at an adjustable secondary pressure range of 0.098 to 0.392 MPa. Valves shall have flanged ends and the working pressure shall be of 0.98 MPa.

All ports subject to wear shall be accessible for repair or replacement without removing the valve from the line. Secondary pressure of valve shall be designed to be adjustable without any use of special tools while it is in service.

In all cases of pressure reducing valves installation, suitable cast iron body strainers shall be provided

on the primary side of the valve. When directed by the Engineer, two (2) gate valves, one for the primary side and the other for the secondary side of the pressure reducing valve shall be provided and by-pass line with gate valve shall be also provided. These gate valves specified above shall be the same size as the pressure reducing valve.

Two (2) pressure gauges, one for the primary side and the other for the secondary side of the pressure reducing valve shall be provided.

### **15.3.11 AIR VALVES**

#### **1. GENERAL**

The following air valves shall be specified hereinafter.

- a. Quick type air valves (75 mm to 200 mm)
- b. Single orifice type air valves (13 mm to 25 mm)
- c. Double orifice type air valves (75 mm to 150 mm)

All air valves mentioned above shall be constructed so that internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools and removing the valve from the line. Typical installation of air valves shall be as shown on the drawings.

#### **2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS B2063      Air Valves for Waterworks

#### **3. QUICK TYPE AIR VALVES (75 mm to 200 mm)**

Quick type air valves shall be cast iron body and shall be composed of an idler valve disc and float actuated valves and shall have flanged ends. Valves shall be designed and manufactured in accordance with JIS B 2063 or other internationally accepted standards or manufacturer's standards as approved by the Engineer and working pressure shall be 0.98 MPa.

Valve shall consist of valve body, float, idler valve disc, cover plate, float guide and others.

An idler valve disc shall have small orifice and shall be designed to exhaust air in bulk through large orifice provided at cover plate and to close positively by means of upward movement of an idler valve disc assisted by float floating force with blocking small orifice by float. Under negative pressure and requirement of admission of air in bulk, an idler valve disc and float shall move downward automatically and air may enter into the valve body in bulk through the said large orifice.

Under pressure, accumulated air shall be exhausted through the said large and small orifice and the said small orifice shall be closed by the float.

Each valve shall be furnished with isolation gate valve, same size as air valve.

Valve shall be applied for pipelines 300 mm in diameter and larger unless otherwise specified.

#### 4. SINGLE ORIFICE TYPE AIR VALVES (13 mm to 25 mm)

Single orifice type air valves shall be cast iron body and single float actuated air valves with flanged ends. Valves shall be designed and manufactured in accordance with JIS B2063 or internationally accepted standards. Working pressure shall be 0.735 MPa.

Valves shall automatically operate so that they will exhaust accumulated air under pressure while the pipe is flowing full of water.

Each valve shall be furnished with bronze casting stop valve and cast iron flange, 25 mm in size.

Valves shall be applied for pipeline 250 mm in diameter and smaller unless otherwise specified.

#### 5. DOUBLE ORIFICE TYPE AIR-VALVES (75 mm to 150 mm)

Double orifice type air valves shall be cast iron body, equipped with double float actuated air valves and with flanged ends. Double orifice type air valves shall be designed and manufactured in accordance with JIS B2063 or internationally accepted standards. Working pressure or all air valves shall be 0.735 MPa.

Double orifice types shall be designed to automatically operate so that they will:

- a. positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;
- b. exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;
- c. not blow shut under high velocity air discharge; and
- d. exhaust accumulated air under pressure while the pipe is flowing full of water.

Each double orifice type air valve shall be furnished with isolation gate valve, same size as air valve.

Double orifice type air valves shall be applied for pipelines 500 mm in diameter and larger unless otherwise specified.

### **15.3.12 FOOT VALVES**

Foot valves shall be cast iron body, swing type foot valves with renewable composition disc. Valves

shall have flanged ends. Valves 100 mm in diameter and smaller shall be designed for a working pressure of 0.98 MPa. Valves 150 mm in diameter and larger shall be designed for a working pressure of 0.49 MPa unless otherwise specified.

Valves shall have cast iron strainer and valves, 300 mm in diameter and smaller shall have a valve disc knocking lever with suitable size of stainless steel chain extended to the operation floor as shown on the drawings. A net-flow area through the valve port shall be at least 75 % of the area of a circle with a diameter equal to the nominal pipe size. The valve seat shall be designed to ensure positive water tight shut-off at low head pressure.

Disc shall be cast iron and shall have a rubber seat mounted on disc by retaining plate. The retaining plate with bolt and hinge pin shall be type 304 stainless steel.

### **15.3.13 SOLENOID VALVES**

Solenoid valves shall be direct acting or pilot valve acting, multi port solenoid operated valves for pneumatic power systems. Valves shall be designed and manufactured in accordance with the following standards or accepted by the Engineer.

- a. JIS B8373            2-Port Solenoid Operated Valves for Pneumatic Use
- b. JIS B8374            3-Port Solenoid Operated Valves for Pneumatic Use
- c. JIS B8375-1        5-Port Directional Control Valves - Part 1
- d. JIS B8375-2        5-Port Directional Control Valves - Part 2
- e. JIS B8375-3        5-Port Directional Control Valves - Part 3

Valves shall be rated at 220 V x 50 Hz and voltage variation shall be  $\pm 10\%$  of rated voltage.

Valves shall be designed for working pressure of 0.98 MPa and to operate at 5 to 50 degrees C ambient temperature and working air temperature.

Valves shall have such construction that valve can be operated manually from the outside of the valve without excitation.

Unless otherwise specified for operation of solenoid valves, valves shall be housed in valve box and this valve box shall be provided with switch bottoms with signal lamps for each valve. These bottoms with signal lamps shall be mounted on the front of the valve box. The valve box shall be shop assembled and factory tested.

### **15.3.14 SLUICE GATES**

#### **1. GENERAL**

Sluice gates shall be furnished as indicated in the Technical Schedules, and the drawings, and as



further described in these specifications. The gates shall be the product of a manufacturer having five (5) or more years' experience in the manufacture of similar sized sluice gates of the design head as required by this application.

The work shall be completed with operating stem, electric motorized or hand operated floor stand, whichever is indicated or specified, and all other incidental appurtenances and accessories.

## 2. DESIGN

All sluice gate parts, including the structural elements of the lift mechanism, shall be designed for the heads shown, with a minimum safety factor of five (5) stems, the safety factor of five shall also apply in respect to the material's ultimate compressive and shearing strength. The compressive strength of stems shall be determined by the  $1/r$  ratio i.e. buckling strength. The sluice gates shall be designed and manufactured basically in accordance with AWWA C501, "Cast Iron Sluice Gates" or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

## 3. WORKMANSHIP

All work shall be performed in accordance with best modern practice for the manufacture of high grade machinery.

All parts shall have accurately machined mounting and bearing surfaces so that they can be assembled without fitting, chipping or re-machining. All parts shall conform accurately to the design dimensions and shall be free of all defects in workmanship or material that will impair their positions to the layout indicated on the shop drawings. The sluice gates shall be completely shop assembled to insure the proper fit and adjustment of all parts.

## 4. MATERIALS

All materials used in the construction of the gates and appurtenances shall be the best suited for the application and shall be allowable materials under AWWA C501 or equivalent unless otherwise noted herein.

## 5. CONSTRUCTION AND MATERIALS

Sluice gates shall be the square opening, rising stem and conventional closure type. The sluice gates shall consist of frames, gate slides, wedging devices, stems and stem couplings, stem guides and lifting devices. The sluice 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 heads to be encountered. Seating, and unseating conditions shall be found in the Schedule. Head conditions shall be measured from the bottom of the gate.

### 5.1 Frames

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

#### 5.2 Gate Slides

Slides shall be made of cast iron, one piece with strengthening ribs where required, and reinforced section to receive the seating faces.

#### 5.3 Seating Faces

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

#### 5.4 Wedging Devices

Sluice gates shall be equipped with adjustable side-wedging devices to provide contact between the slide and frame facing when the gate is in close position. Wedges shall be fully adjustable and so designed that they will remain in the fixed position after adjustment.

#### 5.5 Stem and Stem Couplings

The operating stems shall be of 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.

#### 5.6 Manual Lifting Mechanisms

Manual lifting mechanisms shall be hand wheel operated or crank operated type and shall be either a single or double gear type. Manual lifting mechanism shall have a lift nut threaded to fit the operating stem and ball or roller bearings shall be provided above and below the flange on the lift nut to take the thrust developed in opening and closing gate with a force of 135 N-m on the crank or hand wheel.

Gears shall be machined accurately with cut teeth to provide smooth, proper operation for lifting mechanism. Suitable shafts shall be installed with sleeve, ball or roller bearings of appropriate size. All gears and bearings shall be enclosed in housings. Fittings shall be provided so that all gears and bearings can be lubricated periodically.

Lifting 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. The mechanism shall be geared in such a manner as to permit the slide operation with an effort of not more than 65 N-m on the lifting device after the slide is unseated from its wedges based on the operating head specified.

Crank shall be removable and fitted with a corrosion-resistant rotating handle. The maximum crank radius shall be 380 mm or the maximum hand wheel diameter shall be 760 mm.

The direction of wheel or crank rotation to open the gate shall be indicated on the lift mechanism.

Each rising-stem unit shall be provided with stem guard. The stem guard shall be galvanized seamless steel pipe conforming to JIS G3454, "Carbon Steel Pipes for Pressure Service", STPG 370, Schedule 40 or equivalent. The guard shall be of sufficient diameter and length to permit full travel of the threaded stem without obstruction. The top of the guard shall be closed with galvanized steel cap.

Each rising-stem unit shall be provided with a position indicator to show the position of the gate at all times. The indicator shall be attached to the mechanism and shall read in percent (0-100%) with minimum graduation of 5%.

Pedestal shall be of cast iron with sufficient section to withstand the full load encountered in the gate operation, maintaining the safety factor specified.

#### 5.7 Motor Operated Lift Mechanisms

Motor-operated lift mechanisms shall include, but not be limited to, the electric motor, reduction gearing, stem nut, pedestal, space heaters, torque and limit switches, reversing magnetic starters, shop wiring, gear case and a declutch hand wheel to allow manual operation of the gate. The motor lift mechanism shall be limitorque SMB type or other type approved by the Engineer.

Motor-operated lift mechanisms shall be adequately sized to operate the gate against load, the full operating differential head plus all other anticipated forces resulting from friction and sticking of sluice gate.

Gear case shall be of cast iron. Flanges for motor attachment and pedestal attachment shall be integrally cast, fully machined, and template drilled.

Pedestal shall be of cast iron with sufficient section to withstand the load specified above, maintaining a structural safety factor of five (5) with regard to tension, compression, or shear.

Reduction gearing shall consist of helical gears, spur gears, or worm gears of the proper ratio for transferring the full torque of the motor to the stem nut and for operating the gate. Helical and spur gears shall be of alloy steel accurately machined. Torque requirements shall be computed on the basis of an efficiency of not greater than 50 percent.

Roller bearings shall be provided on the stem nut to endure thrust developed during opening and closing of the gate under maximum operating conditions. All other gears and shafting shall be mounted on antifriction bearings throughout.

All parts of the motor-operated lift mechanism shall be designed to move the gate slide at a rate of

minimum 300 mm per minute under maximum operating conditions unless otherwise specified.

All shall be high torque, with sufficient power to operate the gate through one complete cycle, open-close-open or close-open-close under the maximum specified unbalanced head when voltage to motor terminals is within  $\pm 10$  percent of specified voltage. The motors shall be totally enclosed, non-ventilated and wired for 3 phase, 50 Hertz, 380 volts electrical supply. They shall be capable of a running torque equal to 40 percent of the maximum motor torque required, without exceeding a temperature rise of 75 degrees C over a 40 degrees C ambient.

Operator shall include an adjustable torque or thrust-limited switch capable of stopping the power to the motor when the gate has reached the stops in the open or closed position or when an obstruction has been encountered in either direction of travel. Torque switches shall be factory set to satisfy the calculated value corresponding to the maximum operating conditions.

Limit switches shall be geared to the drive mechanism and in step at all times whether the unit is operated electrically or manually. The switches shall be of the adjustable type capable of being set to trip at the fully open and fully closed gate positions or at any point between. All electrical interconnections between limit switches, torque switches, and so forth, shall be factory-wired and ready for operation. All gearing used in connection with limit switches shall be factory-lubricated.

Operator shall be provided with a position indicator to show the position of the gate at all times. The indicator shall read in percent (0-100%) with a minimum graduation of 5%.

Operators shall be equipped with a hand wheel for manual operation. The hand wheel shall be connected so that operation of the motor will not cause the hand wheel to rotate and the operation of the hand wheel shall not cause the motor rotor to rotate. The hand wheel shall be engaged by an exterior lever or an automatic clutch. The action of the lever shall also declutch the motor if there is no device to accomplish this automatically when the power supply to the motor ceases. Should the power return to the motor while the hand wheel is in use, the design of the unit shall prevent the power from being transmitted to the hand wheel. The hand wheel shall require an effort of no more than 65 N-m to lift the gate after the slide is unseated from its wedges under maximum operating conditions. An arrow and the word "open" and "close" shall be placed on the hand wheel to indicate direction of resultant gate movement. The words shall be in Russian.

### **15.3.15 BACKFLOW PREVENTERS**

Backflow preventer shall be reduced pressure principle type consisting a mechanical, independently operating, hydraulically dependent relief valve located between two loaded check valves which, in turn, are located between two tightly closing shut off isolation valves.

Backflow preventers shall be designed and manufactured in accordance with AWWA C506, Backflow Prevention Devices-Reduced Pressure Principle and Double Check Valve Types. Working pressure

shall be 0.98 MPa. The isolation valves shall be supplied separately.

The maximum allowable pressure loss at any rate of flow, from zero up to and including the maximum rated flow for the indicated size, shall not exceed the valves shown in the following Table.

NOMINAL DIAMETER	RATED * FLOW	MAX. ALLOWABLE PRESSURE LOSS AT RATED FLOW
(mm)	(l/min)	(MPa)
13	45.4	0.152
20	113.5	0.138
25	189.1	0.124
32	283.7	0.124
40	378.2	0.109
50	605.1	0.109
65	851.0	0.109
80	1,210.2	0.102
100	1,891.0	0.096
150	3,782.0	0.096
200	6,051.2	0.096
250	8,698.6	0.096

Note \* Maximum recommended operating flow rate for which pressure loss is calculated.

### **15.3.16 VALVE OPERATORS**

#### **1. GENERAL**

Operators shall be capable of seating, unseating and rigidly holding the valve disc in any intermediate position under the maximum design unbalanced head and water velocity noted.

Means for holding the valves in intermediate positions shall be furnished.

The operating mechanism of plug valve and ball valve operators shall incorporate worm gears of bronze and worms of hardened steel operating in a lubricating bath totally enclosed in a sealed water tight gear case. The operating mechanism of butterfly valve shall be lever type unless otherwise specified.

All valves shall be equipped with adjustable mechanical stop-limiting devices to prevent over travel of the valve disc in the open or closed position.

Operator housing, supports and connections to the valve shall be designed with a minimum safety factor of five (5) based on the ultimate strength, or three, based on the yield strength, of the material used.

Extension stem for valves shall be galvanized seamless steel pipe conforming to JIS G3454, "Carbon Steel Pipes for Pressure Service", STPG 370, Schedule 80 with pinned coupling or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Support housing for extension stem shall be seamless steel pipe specified above, schedule 40 with reinforcing steel ribs if required.

Each rising-stem unit shall be provided with stem guard. The stem guard shall be galvanized seamless steel pipe specified above, Schedule 40. The guard shall be of sufficient diameter and length to permit full travel of the threaded stem without obstruction. Top of the guard shall be closed with galvanized steel cap.

The stem guide shall be so constructed that when properly spaced they will hold the stem in alignment and yet allow it enough play to permit easy operation.

The guides shall be spaced in accordance with the manufacturer's recommendations for each stem size. The  $l/r$  ratio shall not be greater than 200. The guides shall be adjustable with respect to the bracket to provide proper concentric alignment with the stem, and shall be so designed that alignment will be maintained after adjustment. Brackets shall be attached to the wall by sufficient anchor bolts to prevent twisting or sagging under load.

Each floor stand unit shall be provided with a position indicator to show the position of the valve disc at all times. The indicators of rising-stem floor stand and non-rising-stem floor stand shall be attached to the operator and floor stand respectively. The indicator shall read in percent (0-100%) with minimum graduation of 5%.

Manual operators shall require an input force of not greater than 175 N pull on either hand wheel or crank. Hand wheels shall be of cast iron, clearly marked with an arrow and the work "open" and "close" cast in relief on the rim. Hand wheels shall be of the spoke type only. Webbed or disc type shall not be used.

Pedestal shall be cast iron with sufficient section to withstand the full load encountered in the valve operation, maintaining the safety factor specified.

Manually operated buried valves shall be operated by "T" wrenches, from ground level. Two (2) "T" wrenches shall be provided with each standard size of operating nut.

Buried butterfly operators shall be of the totally enclosed worm and gear type. They shall have stainless steel input shaft and special seals to prevent corrosion. They shall be rated tight when

subjected to 15 meters of water head for 72 hours. The worm and gear unit shall be permanently lubricated with grease. A stem nut shall be provided on the input shaft and it shall have a cap to center the valve box used to guide the entrance and location of the operating wrench.

All gate valves buried in the ground shall be provided with suitable heavy pattern valve boxes of proper dimensions to fit over the valve bonnets and to extend to such elevation, at or slightly above the finished ground surface, as directed by the Engineer. The barrel shall be not less than the diameter shown. The upper section shall have a flange at the bottom having sufficient bearing area to prevent settling and shall be complete with cover and shall be adjustable. A cap shall center and guide the entrance and location of the operating wrench.

All operators, whose pipe centerline is less than 2.0 meters above the operating level shall be of the hand wheel type, unless noted otherwise.

All operators, whose pipe center line is more than 2.0 meters above the operating level, shall be of the chain operated type with chain sufficiently long to reach to 0.9 meters above operating level, unless noted otherwise.

## 2. MANUAL OPERATORS

### 2.1 Manual Operators for Gate Valves (500 mm and smaller)

Manual operators for gate valves, 500 mm and smaller including resilient-seated gates, non-rising-stem (NRS) type shall be wrench nuts and hand wheels type without gear ratio. OS & Y rising stem type resilient-seated gate valves shall be equipped with hand wheels without gear ratio. Wrench nuts and hand wheels shall be made of cast iron or ductile cast iron. The wrench nuts shall be 32 mm square at the top, 38 mm square at the base, and 70 mm high. The outside diameter of hand wheels shall be not less than those given in the following Table.

VALVE NOMINAL DIAMETER	MINIMUM OUTSIDE DIAMETER OF HAND WHEEL
mm	mm
80	180
100	250
125	280
150	300
200	350
250	400
300	400
350	450
400	500
450	600
500	600

### 2.2 Manual Operators for Gate Valves (600 mm to 1,000 mm)

Manual operators for gate valves, 600 mm to 1,000 mm shall be bevel gear type, totally enclosed operators. Operators shall be equipped with hand wheel and liner position indicator which shall read in percent (0-100%) with minimum graduation of 5%. The hand wheel shall be cast iron or ductile cast iron, and spoke type of suitable size. Operators shall be designed so that a pull of not more than 175 N on a hand wheel which will produce an output torque equivalent to the maximum valve shaft torque required to operate the valve under actual line pressure and velocities.

### 2.3 Manual Operators for Butterfly Valves and Ball Valves

Manual operators for butterfly valves and ball valves shall be essentially an integral part of a butterfly valve. The rated torque capability of each operator shall be sufficient to seat, unseat, and rigidly hold in any intermediate position the valve disc it controls under the maximum operating condition. All valves shall be equipped with an adjustable mechanical stop-limiting devices to prevent over travel of the valve disc or ball in the open and closed positions. Operators housings, supports, and connections to the valve shall be designed with a minimum safety factor of five (5), based on the ultimate strength, or three (3), based on the yield strength, of materials used.

Each manual operator shall have all gearing totally enclosed. Operators shall be designed to produce the specified torque with a maximum rim pull of 355 N on hand wheel or chain wheel operators and a maximum input of 205 N-m on operating nuts. Stop-limiting devices shall be provided in the operators



for the open and closed positions. All operators components between the input and these stops shall be designed withstand, without damage, a pull of 880 N for hand wheel or chain wheel operators and an input torque of 402 N-m for operating nuts.

All gears operators shall be self-locking and designed to transmit two (2) times the required operator torque without damage to the faces of the gear teeth. Each manual operator shall be equipped with a position indicator which shall read both in percent (0-100%) with minimum graduation of 5% and in degrees (0-90 degrees) with minimum graduation of 5 degrees. The graduation shall be engraved on operator cover plate.

#### 2.4 Gearing

Gears shall be of ductile iron, steel, or bronze, accurately machined with cut teeth, and smooth running with suitable shafts in bronze sleeve bearings or roller bearings of ample size.

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. For remotely operated valves, the operator shall be supplied with a cast-iron pedestal, machined and drilled to receive the gear housing and drilled for bolting to the operating floor.

### 3. ELECTRIC VALVE OPERATORS

#### 3.1 General

Two (2) types of electric valve operators such as Type A, integral control type, and Type B, standard type, shall be specified hereinafter.

Each type electric valve operators shall be furnished in weatherproof construction. The motor shall operate on 380 volt, 3-phase, 50 Hertz, service for open-close service.

Each type electric valve, operator shall be mounted by the valve manufacturer, tested and adjusted prior to shipment. All electric valve operators shall be Limitorque SMB type or other type approved by the Engineer.

##### 3.1.1 Type A Integral Control Type

Electric valve operator, Type A, shall be integral control type and shall include, but not be limited to, the electric motor, reversing magnetic starter, limit switches, torque switches, space heaters, valve position potentiometer if specified, pushbutton station, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

The valve control units shall have pushbutton stations furnished in enclosures suitable for flush panel mounting or field mounting as required. The stations shall include pushbuttons, status lights, and a selector switch all as required.

### 3.1.2 Type B Standard Type

Electric valve operator, Type B shall be standard type and include, but not be limited to, the electric motor, reversing magnetic starter, limit switches, torque switches, space heaters, valve position potentiometer if specified, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

### 3.2 Electric Valve Operators for Gate Valve

Electric valve operators for gate shall conform to all requirements specified in 5.7 Motor-operated Lift Mechanisms of Sub-section 15.3.14.

### 3.3 Electric Valve Operators for Butterfly Valve and Plug Valve

Gear case shall be of cast iron. Flanges for motor attachment and pedestal attachment shall be integrally cast, fully machined, and template drilled.

Motors for electric valve operator shall be capable of producing not less than 1.5 times the required operator torque.

Any gearing in direct association with the electric motor drive shall be totally enclosed and shall operate in a lubricant.

Operator shall include an adjustable torque or thrust-limited switch capable of stopping the power to the motor when the valve has reached the stops in the open or closed position or when an obstruction has been encountered in either direction of travel. Torque switches shall be factory set to satisfy the calculated value corresponding to the maximum operating conditions.

Limit switches shall be geared to the drive mechanism and in step at all times whether the unit is operated electrically or manually. The switches shall be of the adjustable type capable of being set to trip at the fully open and fully closed valve positions or at any point between. All electrical interconnections between limit switches, torque switches, indicator lights, and so forth, shall be factory-wired and ready for operation. All gearing used in connection with limit switches shall be factory-lubricated.

Operator shall be provided with a position indicator to show the position of the valve at all times. The indicator shall read in percent (0-100%) with minimum graduations of 5%.

Operator shall be equipped with a hand wheel for manual operation. The hand wheel shall be connected so that operation of the motor will not cause the hand wheel to rotate and the operation of the hand wheel shall not cause the motor rotor to rotate. The hand wheel shall be engaged by an exterior lever or an automatic clutch. The action of the lever shall also declutch the motor if there is no device to accomplish this automatically when the power supply to the motor ceases. Should the power

return to the motor while the hand wheel is in use, the design of the unit shall prevent the power from being transmitted to the hand wheel.

An arrow and the word “open” and “close” shall be placed on the hand wheel to indicate direction of resultant valve movement. Lettering shall be in Russian language.

**4. PNEUMATIC VALVE OPERATORS**

Pneumatic valve operators shall be cylinder type with pressure maintained on the cylinder piston at each end of its stroke. Pneumatic cylinders shall comply with the following requirements:

- a. Cylinder bodies shall be hard-drawn brass or centrifugally cast bronze with the inside diameter honed to at least a 0.0004 mm finish or of steel bored, honed, chromium plated, and re-honed to at least 0.0004 mm finish.
- b. Cylinder head and cap ends shall be of corrosion-protected ferrous material.
- c. Cylinder pistons shall be of chromium-plated steel or cadmium-plate cast iron.
- d. Cylinder piston rods shall be of stainless steel having a 0.0001 to 0.0002 mm finish with a surface of hard chrome plating approximately 0.013 mm thick.
- e. Piston rod bushings shall be of bronze and shall be pilot-fitted into the cylinder head.
- f. Cylinders shall be equipped with a dirt wiper to clean the piston rod before it enters the cylinder.
- g. Cylinders shall be equipped with rod seals of a non-adjustable wear-compensating type.
- h. Rod seals, rod wiper, and piston cups shall be of neoprene, “Buna-N”, or other equal material for air service.
- i. Cylinders shall be equipped with adjustable cushions at each end of the stroke.
- j. The structure of the cylinder shall have a safety factor of at least five (5), based on the working pressure. When cast iron is used, this safety factor shall be at least ten (10).
- k. Cylinders shall require not more than the pressure listed in the following Table to be cycled a complete stroke in each direction before they are connected to the valve.

**PRESSURE REQUIRED TO MOVE CYLINDER**

CYLINDER BORE	PRESSURE
mm	MPa
50	0.0343
50 – 125	0.0275
125	0.0206

**15.3.17 STRAINERS AND SIGHT GLASSES**

**1. GENERAL**

The following strainers and sight glasses shall be specified hereinafter.

- a. U-type strainers
- b. Y-type strainers
- c. Sight glasses

## 2. U-TYPE STRAINERS

U-type strainers shall be quick open-and-close type strainers. Strainers shall consist of body, removable body cover plate, mesh cage and yoke with bolt. Strainers shall be constructed so that mesh cage shall be readily accessible, removable, and replaceable without use of special tools and removing the strainer from the line. Removable body cover plate shall have air vent plug and be fixed to the body by means of yoke and bolt. Body shall have drain plug. Mesh cage shall consist of inner mesh cage and outer perforated metal cage. Unless otherwise specified, inner mesh size shall be 40. Mesh cage diameter and length shall conform to the following Table. The strainers shall have flanged ends, and working pressure shall be 0.98 MPa for nominal size 50 mm and smaller and 0.735 MPa for nominal size 65 mm to 150 mm.

NOMINAL SIZE mm	MINIMUM MESH CAGE DIAMETER mm	MINIMUM MESH CAGE LENGTH mm
15	20	50
20	30	75
25	40	85
32	45	90
40	50	100
50	60	120
65	100	160
80	100	160
100	130	200
125	170	260
150	220	320

Unless otherwise specified, body, cover plate and yoke with bolt mesh case shall be type 316 stainless steel and stainless steel casting. Body, cover plate and yoke with bolt shall be type 304 stainless steel and stainless steel casting or cast-iron, and mesh cage shall be type 304 stainless steel unless otherwise specified.

### 3. Y TYPE STRAINER

Y-type strainer shall consist of body, removable body cover plate, mesh cage. Strainers shall be constructed so that mesh cage shall be readily accessible, removable, and replaceable without use of special tools and removing the strainer from the line. Removable body cover plate shall be screwed type for nominal size 50 mm and smaller and flanged type for nominal size 65 mm to 200 mm. Mesh cage shall consist of inner mesh cage and outer perforated metal cage.

Unless otherwise specified, inner mesh size shall be 40. Mesh cage diameter and length shall conform to the following Table. The strainer shall have flanged ends and working pressure shall be 0.98 MPa.

NOMINAL SIZE	MINIMUM MESH CAGE DIAMETER	MINIMUM MESH CAGE LENGTH
mm	mm	mm
15	18	45
20	23	50
25	30	60
32	39	70
40	44	75
50	56	90
65	78	120
80	88	150
100	110	180
125	140	200
150	170	240
200	210	300

Unless otherwise specified, body, cover plate and mesh cage shall be type 316 stainless steel and stainless steel casting. Body and cover plate shall be type 304 stainless steel and stainless steel casting or cast-iron, and mesh cage shall be type 304 stainless steel unless otherwise specified.

#### 4. SIGHT GLASSES

Sight glasses shall consist of flanged body and two sight glasses with glass holders. Sight glass shall have colored plastic balls unless otherwise specified. Working pressure shall be 0.98 MPa.

Body for chemical service and for general purpose shall be type 316 and 304 stainless steel casting respectively.

**DIVISION 15 MECHANICAL WORKS****SECTION 15.4 MAJOR PUMPING UNITS****15.4.1 GENERAL****1. SCOPE OF WORK**

The work specified herein includes the furnishing and installing, in a satisfactory operating condition, electric motor driven pumping units as required in the Particular Specifications, together with motor control panels and all other necessary and desirable accessory equipment and auxiliaries and appurtenances, whether specifically mentioned in this specification or not, as required for an installation incorporating the highest standards for the type of service, and including field testing of the entire installation and instruction of the regular operating personnel in the care, operation and maintenance of all equipment.

The following types of pumps shall be specified hereinafter.

- a. Double suction volute pumps.

**2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS B 1452	Flexible Flanged Shaft Couplings
JIS B 1453	Geared Type Shaft Couplings
JIS B 8301	Rotodynamic Pumps - Hydraulic Performance Acceptance Tests - Grade 1 and 2
JIS B 8302	Measurement Methods of Pump Discharge
JIS B 8322	Double Suction Volute Pumps
JIS G 4051	Carbon Steels for Machine Structural Use
JIS G 5501	Gray Iron Casting
JIS H 5120	Copper and Copper Alloy Castings

**3. SCHEDULE OF MAJOR PUMPING UNITS**

Schedule of major pumping units will be specified in the Particular Specifications.

**4. GENERAL ARRANGEMENTS****4.1 General**

The Contractor shall be responsible for the design of the complete electric motor driven pumping units,

and shall guarantee the complete units to be free from harmful torsional or other vibration stresses throughout the entire operating range of speed and loads.

#### 4.2 Data Submittal

Literature, pump characteristic curves showing head, capacity, horsepower, efficiency and required NPSH, detail drawings including materials, construction and parts list to indicate full conformance with the detail specifications and to show installation details shall be submitted to the Engineer.

#### 4.3 Nameplate

There shall be a metal nameplate on each pump with the serial number, size type or model, design head, capacity and speed stamped into the plate. There shall also be an arrow indicating the direction of forward rotation.

#### 4.4 Shop and Field Painting

The pumps, couplings, motors and bed plates shall have shop and field coats. All interior ferrous and nonmachined surface of casings shall be shop painted with epoxy resin paint, Paint System D1 unless otherwise specified.

Painting shall conform to the requirements as specified in the Standard Specifications titled "Painting" of Section 9.1 unless otherwise specified.

#### 4.5 Anchor Bolts

The Contractor shall furnish all anchor bolts and other necessary bolts and nuts for the complete pump installation.

### 5. MATERIALS AND WORKMANSHIP

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, and of the classification and grades designated. Material not specifically described shall conform to the manufacturer's standard for the applicable part in the service intended.

All materials, supplies, and articles, not manufactured by the Contractor, shall be the products of recognized reputable manufacturers. The products of firms other than those specified herein will be accepted when it is proved to the satisfaction of the Engineer that they are equal in strength, durability, usefulness, and convenience for the purpose intended.

The Contractor shall furnish to the Engineer for his approval the names of the manufacturers of all machinery and other equipment which he contemplates incorporating in the work, together with performance capacities and other relevant information pertaining to the equipment. Samples of materials shall be submitted for approval when so directed. Equipment, materials, and articles installed



or used without such approval shall be at the risk of subsequent rejection.

Workmanship shall be of the highest grade and in accordance with the best modern standard practice.

#### **15.4.2 DOUBLE SUCTION VOLUTE PUMPS**

##### **1. GENERAL**

The pumps shall be single stage, double suction, horizontally split case type, centrifugal pumps suitable for continuous heavy-duty service. The construction of the pumps shall be such that no damage will occur to the pump, attached motor or controls if reverse rotation takes place. Mechanical brakes or ratchets shall not be permitted. No non-metallic materials will be allowed in the inside of the pump casing or impellers.

Pump speed, head-capacity characteristics shall conform to the requirement listed in the Particular Specifications.

Unless otherwise noted, relation between pump suction diameter, 500 mm in diameter and smaller and pole number of the drive motor shall be as specified in the following table.

The pump, suction diameter 500 mm and smaller shall be designed and manufactured in accordance with JIS B 8322 unless otherwise specified.

POLE NUMBER OF DRIVE MOTOR	PUMP SUCTION DIAMETER mm
4	200, 250 and 300
6	300, 350, 400 and 500
8	500

Rated discharge flow of the pump, suction diameter 500 mm in diameter and smaller shall be as specified in the following Table.

PUMP SUCTION DIAMETER mm	RATED DISCHARGE FLOW m <sup>3</sup> /min
200	2.5 to 5.0
250	4.0 to 8.0
300	6.3 to 12.5
350	8.0 to 16.0
400	10.0 to 20.0
500	16.0 to 31.5

At any total head between shut-off head and run out head or capacity specified in the Particular Specifications, the required NPSH shall not exceed the available NPSH based on the pump suction piping and suction pool low water elevation indicated on the drawings.

In no case shall the efficiency at the specified rated operation point be less than the value specified in the Particular Specifications.

Pumps of equal head-capacity characteristics shall have identical features of construction and parts shall be interchangeable. Unless otherwise specified, the pump casing design pressure shall be their shut-off pressure plus 10.0 m and the pump casing shall be hydrostatically tested to 150 percent of their casing design pressure. Minimum length of hydrostatic test shall be 3 minutes.

All essential and desirable indicators, lubrication devices, and other accessories for the pumping units shall be provided.

## 2. CONSTRUCTION AND MATERIALS

### 2.1 Casing

The casing shall be horizontally split on the centerline of the shaft with suctions and discharge connections cast integrally in the lower half to permit removal of the complete rotating element by

removal of the upper half casing, the bearing caps, and coupling bolts.

The faces of the upper and lower halves shall be accurately machined and doweled for tight and accurate fit. The bearing brackets shall be cast separately and bolted to the lower half of the casing. The suction and discharge flanges shall conform to the Flange Schedule specified in Section 15.2 Piping.

There shall be a 10 mm pipe tap connection in each flange. The upper half of the casing shall be fitted with eyebolts. There shall be at least two (2) 25 mm pipe tap connections, one at the bottom of the lower casing as a drain and the other at the top of the upper casing as an air vent.

Additional tapped connections shall be provided at any other high points in the upper casing. The drain shall be fitted with a gate valve. The top of the upper casing shall be fitted with a gate valve and a priming sight glass with water level detector if required.

Both the exterior and the interior surfaces shall be finished smooth. No plugging, welding, or other repairs to casting will be permitted. The casing shall be of cast iron conforming to JIS G5501: FC200 or better. Minimum casing thickness of the pumps, suction diameter, 500 mm and smaller shall be as specified in the following Table.

PUMP SUCTION DIAMETER	MINIMUM CASING THICKNESS
mm	mm
200	6
250	6
300	8
350	8
400	10
500	12

## 2.2 Impeller

The impeller shall be of the enclosed double suction type, of one-piece construction, finished smooth, and statically and dynamically balanced. The impeller shall be tightly mounted on the pump shaft with a key so that it will not become loose due to rotation either in the forward or in the reverse direction.

The impeller shall be of bronze casting conforming to JIS H5120, CAC402, or better unless otherwise specified. Minimum thickness of impeller, except tip of inlet and outlet of impeller, shall be 4 mm for pumps, suction diameter 300 mm and smaller, and 5 mm for pumps, suction diameter 350 mm to 500 mm.

### 2.3 Wearing Rings

Unless otherwise specified, removable wearing ring shall be provided on the pump casing. If specified, removable wearing rings shall be provided on both of pump casing and impeller. The wearing rings shall be of bronze casting conforming to JIS H5120, CAC 406 or better.

### 2.4 Shaft and Sleeves

The pump shafts shall be of heat-treated carbon steel conforming to :

- a. JIS G4051: S30C or better, for pumps of suction diameter, 500 mm and smaller
- b. JIS G4051: S35C or better for pumps of suction diameter, 600 mm and larger.

The pump shafts shall be ground and polished over the entire length. Shafts shall be of ample size and rigidity to ensure low working stress under all conditions of operation.

For the pumps of suction diameter, 500 mm and smaller, the minimum size of the shaft shall be determined by the following formula.

$$d = K (L/n)^{1/3}$$

$$L = 0.163 \times SG \times Q \times H \times 1/EF$$

Where:

- d: Minimum shaft diameter of any under cut, mm
- L: Required shaft power, kW
- n: Pump rotational speed, rpm
- SG: Specific gravity of handling liquid, 1.0
- Q: Rated discharge flow, m<sup>3</sup>/min
- H: Rated head, m
- EF: Pump efficiency at rated operation point
- K: Co-efficient, K = 125 with shaft materials of JIS G4051, Class S30C. When high class materials will be used, K may be modified based on the following formula and the minimum K shall be 110 with any materials proposed.  $K = 125 (48/TS)$
- TS: Tensile strength of proposed material, kg/mm<sup>2</sup>.

For the pumps of suction diameter 600 mm and larger, the combined shear stresses on the shaft shall not exceed 33 N/mm<sup>2</sup> at the smallest diameter.

The shaft shall be protected from wear and corrosion by removable sleeves. The sleeves shall extend from the impeller to the outside of the stuffing boxes. Sleeves shall be of bronze casting or stainless steel. Bronze casting shall conform to JIS H5120, CAC 406 or better. Type of stainless steel shall be

304, 420 or others.

## 2.5 Bearings

The bearings shall be of heavy-duty antifriction ball, or spherical roller type or sleeve type, or a combination of the two types.

For pumps of suction diameter 500 mm and smaller, lubrication shall be by oil or grease and a direct reading bearing temperature indicator shall be provided on each bearing unless otherwise specified. A suitable guard for each indicator shall be provided. For the pumps of suction diameter 600 mm and larger, regardless of the type of bearing provided, lubrication shall be by oil. Grease lubrication will not be acceptable. Constant-level oilers and temperature detectors shall be provided by the pump manufacturer. Bearing temperature detectors shall be provided on each bearing and designed for both remote indication and direct reading local indication.

There shall be a water deflector fastened to the shaft at the inner end of each bearing housing.

## 2.6 Stuffing Boxes

Stuffing boxes shall be large and deep and shall be provided with square packing rings and a lantern ring. Number of square packing rings shall be as specified in the following Table.

<u>PUMP SUCTION</u> <u>DIAMETER</u>	<u>MINIMUM NUMBERS</u> <u>OF SQUARE PACKING RING</u>
500 and smaller	5
600 and larger	6

Packing glands shall be bronze casting conforming to JIS H5120, CAC 406 split horizontally to provide for installing packing.

Unless otherwise specified, piping with gate valves shall be provided for sealing water to each stuffing box from a tapping on each side of the discharge volute casing.

## 2.7 Bed Plate

Bed plates shall be fabricated steel or cast iron box with web reinforcing so designed that they can be grouted after alignment and leveling.

## 2.8 Shaft Coupling

Coupling between pump and drive shall be the flexible type and shall have sufficient capacity to develop the full strength of the shafting which they connect.

For pumps of suction diameter 500 mm and smaller, the shaft coupling shall be a flexible flanged shaft

coupling conforming to JIS B1452.

For the pumps of suction diameter 600 mm and larger, the shaft coupling shall be of forged steel and shall transmit torque by means of external gears on hubs engaging internal gears on the coupling sleeves, or by means of a steel grid fitted into grooves in the peripheries of the coupling hubs. The former shaft coupling mentioned above shall conform to JIS B1453. The couplings shall be enclosed and sealed to retain the lubricant and exclude dust and moisture from the contact surfaces of the torque-transmitting members. Couplings shall be provided with guards.

### 2.9 Pressure Gauges and Connections

There shall be provided not less than 10 cm diameter pressure gauge for both the suction and discharge side of each pump. The gauge ranges shall be selected such that they will be roughly double the maximum vacuum gauges. The gauges shall have brass case and ring, finish black and phosphor bronze Bourdon tube. The ranges selected shall be submitted to the Engineer for approval. The gauges shall be mounted on a 3.20 millimeter steel panel supported on a free-standing steel angle frame by each pump. The gauges shall have bottom connection with shut-off valves mounted on the front of the gauge panel.

### 3. MOTORS

The motors for the driven pumps shall have sufficient rating to operate the pump at any point on its characteristic curve without overloading and in addition shall have a service factor of at least 1.15 at the rated operation point.

Output of motors shall be not less than kilowatt rating specified.

Unless otherwise specified, motors which are rated at 30 kW and smaller shall be the totally enclosed, fan cooled type and motors of output 37 kW and larger shall be the open dripproof type. All motors shall be as hereinafter specified under Section 16.17 Motors.

### 4. FACTORY PERFORMANCE TESTS

Unless otherwise specified, all pumps shall be tested at the manufacturer's plant to demonstrate complete compliance with these specifications. The tests shall be in full compliance with the applicable provisions of JIS B8301 and JIS B8302, and as herein noted.

Unless waived in writing by the Engineer, all tests shall be witnessed by a duly authorized representative of the Engineer. The Contractor shall provide 30 days notice to the Engineer in writing prior to conducting factory tests.

The tests shall cover the entire range of total head from shut-off to the minimum total head at which the pump can operate without cavitations, noise, or vibration with suction pool water level indicated

on the drawings as low water elevation. The minimum head shall be equal to or less than the run out head specified for each pump. Data shall be recorded for not less than five points between shut-off and the minimum total head for suction pool low water elevation. After factory performance tests, the Contractor shall submit six (6) copies of test reports.

If the pump fails to meet the specified head, capacity, and efficiency requirements or indicate cavitation or damaging noise or vibration in the total head range between shut-off and specified run out heads, the pump shall be modified or newly manufactured until acceptable tests are completed.

#### 5. INSTALLATION

The Contractor shall install all pumps specified herein. All handling and placing of the pumps including leveling and alignment shall be done by the Contractor. Final checking of leveling and alignment of each pump shall be done by a supervisor from the pump manufacturer.

#### 6. FIELD TESTS

As soon as convenient after the equipment is installed, each unit shall be field tested to determine that the units have been properly installed, to verify factory tests, and to demonstrate that the complete units will operate continuously without over heating and that the drives are not overloaded.

The portion of the test to demonstrate satisfactory continuous operation shall be for five (5) continuous hours. During the field test operation the total head shall be as near the condition point total head as conditions at the site will permit.

Reading off all essential data shall be taken and recorded at 30 minute intervals. All instruments required for the readings shall be acceptable calibrated devices furnished by the Contractor at no additional cost to the Employer. Readings required include, but are not limited to, voltage, amperage, power factor, RPM, suction and discharge pressure, flow, temperatures and vibration. Full details of test procedures will be as determined or approved by the Engineer based on conditions existing in the field at the time of the tests. The Contractor shall submit six (6) copies of all results arranged and neatly presented for the approval of the Engineer.

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

#### 7. SPARE PARTS AND TOOLS

The following spare parts shall be furnished for each pump.

- a. One (1) Complete set of sleeve
- b. One (1) Complete set of bearings
- c. One (1) Complete set of wearing rings

- d. Two (2) Complete sets of all gaskets
- e. Three (3) Complete sets of all packing required for the pump
- f. Two (2) Lantern rings
- g. Two (2) Complete sets of all special bolts, screws and nuts
- h. One (1) Complete set of special tools required for maintenance of the pump

**8. CERTIFICATION**

The Contractor shall submit a certificate to the Engineer from the manufacturer stating that the installation of the equipment is satisfactory; that the units are ready for operation; and that the operating personnel have been suitably instructed in the operation, lubrication and care of the units.



**DIVISION 15 MECHANICAL WORKS****SECTION 15.5 MISCELLANEOUS PUMPING UNITS****15.5.1 GENERAL****1. SCOPE OF WORK**

Provide all labor, materials, equipment and incidentals necessary to furnish, install and test the miscellaneous pumping units as specified herein and as shown on the drawings.

The following types of pumps shall be specified hereinafter and the units shall be complete with electric motors, or engines, starters, automatic controls where specified or shown, floor plates and all other necessary appurtenances.

- a. End Suction Centrifugal Pumps
- b. Multi-Stage Centrifugal Pumps
- c. Horizontal Peripheral Pumps
- d. Vertical Centrifugal Sump Pumps

**2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

JIS B 1452	Flexible Flanged Shaft Couplings
JIS B 1521	Rolling Bearings - Deep Groove Ball Bearings
JIS B 1522	Rolling Bearings - Angular Contact Ball Bearings
JIS B 1523	Rolling Bearings - Self-aligning Ball Bearings
JIS B 1533	Rolling Bearings - Cylindrical Roller Bearings
JIS B 8301	Rotodynamic Pumps – Hydraulic Performance Acceptance Tests – Grade 1 and 2
JIS B 8302	Measurement Methods of Pump Discharge
JIS B 8313	End Suction Centrifugal Pumps
JIS B 8319	Small Size Multi-Stage Centrifugal Pumps
JIS G 4051	Carbon Steel for Machine Structural Use
JIS G 5501	Gray Iron Castings
ISO 2858	End-suction centrifugal pumps (rating 16 bar) - Designation, nominal duty point and dimensions
ISO 3069	End-suction centrifugal pumps - Dimensions of cavities for mechanical

seals and for soft packing

### 3. SCHEDULE OF MISCELLANEOUS PUMPING UNITS

Schedule of miscellaneous pumping units will be specified in the Particular Specifications.

### 4. GENERAL ARRANGEMENTS

#### 4.1 Design of Pumps

Pumps shall be designed for the specified performance and shall operate without overheating, excessive vibration, or strain.

All parts shall be so designed and proportioned as to have liberal strength, stability, and stiffness and to be especially adapted for the work to be done.

#### 4.2 Data Submittal

Literature, pump characteristic curves showing head, capacity, horsepower, efficiency and required NPSH, detail drawings including materials, construction and parts list to indicate full conformance with the detail specifications and to show installation details shall be submitted to the Engineer.

#### 4.3 Nameplate

Brass or stainless steel nameplates giving the name of the manufacturer, the rated capacity, head, speed, model and serial number and other pertinent data shall be attached to each pump.

Similar nameplates giving pertinent motor data shall be attached to each electric motor.

#### 4.4 Shop and Field Painting

The pumps, couplings, motors and bed plates shall have shop and field coats. All interior ferrous and non-machined surface of casings shall be shop painted with tar epoxy paint, either Paint System E1 or E2.

Painting shall conform to the requirements as specified in the Standard Specifications titled "Painting" of Section 9.1 unless otherwise specified.

#### 4.5 Factory Performance Tests

Unless otherwise specified, all pumps shall be tested at the manufacturer's plant to demonstrate complete compliance with these specifications. The tests shall be in full compliance with the applicable provisions of the following standards.

- a. JIS B 8301 Rotodynamic Pumps – Hydraulic Performance Acceptance Tests – Grade 1 and 2
- b. JIS B 8302 Measurement Methods of Pump Discharge

Six (6) copies of test data shall be submitted for approval prior to shipment.

#### 4.6 Field Tests

As soon as convenient after the equipment is installed, each pump shall be field tested to determine that the units have been properly installed, to verify factory tests, and to demonstrate that the complete units will operate continuously without over heating and that the drives are not overloaded.

The tests on each unit shall be four (4) continuous hours. During the operation the total head shall be as near the specified head as conditions at the site will permit.

If required, readings of all essential data shall be taken and recorded at minute intervals. All instruments required for the readings shall be furnished by the Contractor at no additional cost.

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

#### 4.7 Motors

The motors for the driven pumps except horizontal peripheral pumps shall have sufficient rating to operate the pump at any point on its characteristic curve without overloading and in addition shall have a service factor of at least 1.15 at the rated operation point.

The motors for the driven horizontal peripheral pump shall have sufficient rating to operate the pump at any point on its characteristic curve without overloading.

Output of motors shall be not less than kilowatt rating specified in the Particular Specifications.

Unless otherwise specified, motors which are rated at 30 kW and smaller shall be the totally enclosed, fan cooled type and motors of output 37 kW and larger shall be the open drip-proof type. All motors shall be as hereinafter specified under Section 16.17, Motors.

#### 4.8 Spare Parts and Tools

All spare parts for each pump specified hereinafter, shall be furnished.

For each station, one (1) set of special tools for maintenance shall be supplied in painted steel cases and identified on the outside with an itemized list of contents.

### **15.5.2 END SUCTION CENTRIFUGAL PUMPS**

#### 1. GENERAL

Pumps shall be horizontal, end suction, top vertical discharge, centrifugal pumps, directly connected to the motor with a flexible coupling and complete with shaft seals and bearings. Each pump and motor unit shall be mounted on a steel or cast iron common base plate. Suction and discharge of the pump

shall be flanged end.

The pumps shall be designed and manufactured in accordance with JIS B8313 and ISO 2858 or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

Unless otherwise specified, relation between pump suction diameter and pole number of drive motor shall be as specified in the following Table.

<u>POLE NUMBER OF DRIVE MOTOR</u>	<u>PUMP SUCTION DIAMETER mm</u>
2	50, 65, 80, 100 and 125
4	40, 50, 65, 80, 100, 125, 150 and 200

Rated discharge flow of the pump shall be as specified in the following Table unless otherwise specified.

PUMP SUCTION DIAMETER	RATED DISCHARGE FLOW	
	2POLE DRIVE MOTOR	4 POLE DRIVE MOTOR
mm	m3/min	m3/min
40	-	Less than 0.16
50	0.1 to 0.32	0.1 to 0.32
65	0.2 to 0.63	0.2 to 0.63
80	0.4 to 1.25	0.4 to 1.25
100	0.8 to 2.5	0.63 to 2.0
125	1.25 to 6.3	0.80 to 3.15
150	-	1.6 to 5.0
200	-	2.5 to 10.0

Pumps of equal head-capacity characteristic shall have identical features of construction and parts shall be interchangeable. Unless otherwise specified, the pump casing design pressure shall be their shut-off pressure plus 10.0 m and the pump casing shall be hydrostatically tested to 150 percent of their casing design pressure. Minimum length of hydrostatic test shall be 3 minutes.

All essential and desirable indicators, lubrication devices, and other accessories for the pumping units shall be provided.

## 2. CONSTRUCTION AND MATERIALS

### 2.1 Casing

The casing shall be of cast iron conforming to JIS G 5501: FC 200 or better, with smooth waterway and fitted with wearing rings. The wearing rings shall be of bronze casting conforming to JIS H 5120: CAC 406 or better.

### 2.2 Impeller

The impeller shall be enclosed, accurately machined, and statically and dynamically balanced. The impeller shall be made of the following materials.

- a. Bronze casting conforming to JIS H 5120: CAC 406 or better, or
- b. Cast iron conforming to JIS G 5501: FC 200 or better, or
- c. Stainless steel, type 304

### 2.3 Shaft

The pump shaft shall be of carbon steel conforming to JIS G 4501: S30C or better, precision-ground, and provided with renewable bronze or stainless steel sleeve where it passes through the stuffing box and is in contact with water.

The minimum shaft diameter shall be determined by the formula as specified in previous sub-section 2.4 Shaft and Sleeves, Section 15.4, Major Pumping Units.

The shaft shall be rigidly supported by at least two (2) sets of heavy-duty antifriction ball bearings conforming to JIS B 1521 or B 1522. Lubrication of bearings shall be oil or grease and in case of oil lubrication, appropriate provisions for oil level checking and an oil drain shall be provided.

#### 2.4 Stuffing Box

The stuffing box shall be of such design and size as to ensure tight packing without excessive wear or friction on the shaft sleeve. Dimensions of stuffing box shall conform to ISO 3069 or other internationally accepted standards or manufacturer's standards as approved by the Engineer.

The stuffing box shall be provided with at least three (3) square packing rings with a lantern ring. An easily removable gland shall be provided for the stuffing box. The gland shall be of bronze casting, stainless steel or cast iron.

#### 2.5 Shaft Coupling

The shaft coupling between pump and motor shall be the flexible type and shall conform to JIS B1452, couplings shall be provided with guards.

### 3. ACCESSORIES AND SPARE PARTS

#### 3.1 Accessories

For each pump, all essential and desirable accessories for an installation and operation shall be furnished and installed, which shall include but not be limited to the following:

- a. One (1) Set of common base plates
- b. One (1) Set of anchor bolts and nuts
- c. One (1) Set of couplings with guard
- d. One (1) Set of casing drain valves
- e. One (1) Set of priming funnel with valve
- f. Two (2) Sets of pressure gauges with cocks for pump suction and discharge

#### 3.2 Spare parts

The following spare parts shall be furnished for each pump.

- a. One (1) Complete set of sleeve, if any
- b. One (1) Complete set of bearing
- c. Two (2) Complete sets of gland packing
- d. One (1) Complete set of oil seals
- e. One (1) Complete set of gasket

### **15.5.3 MULTI-STAGE CENTRIFUGAL PUMPS**

#### **1. GENERAL**

Pumps shall be a horizontal, end suction top vertical discharge, multi-stage centrifugal pump, directly connected to the motor with flexible coupling and complete with shaft seals and bearings. Each pump and motor unit shall be mounted on a steel or cast iron common base plate. Suction and discharge of the pump shall be flanged end.

The pump shall be designed and manufactured in accordance with JIS B 8319 and the number of poles of the driven motor shall be 4.

Rated discharge flow of the pump shall be as specified in the following Table unless otherwise specified.

PUMP SUCTION DIAMETER	RATED DISCHARGE FLOW
mm	m <sup>3</sup> /min
40	Less than 0.20
50	0.16 to 0.32
65	0.25 to 0.50
80	0.40 to 0.80
100	0.63 to 1.25
125	1.00 to 2.00
150	1.60 to 3.15

Pumps of equal head-capacity characteristics shall have identical features of construction and parts shall be interchangeable. Unless otherwise specified, the pump casing design pressure shall be their shut-off head plus 10.0 m and the pump casing shall be hydrostatically tested to 150 percent of their casing design pressure. Minimum length of hydrostatic test shall be 3 minutes.

All essential and desirable indicators, lubrication devices, and other accessories for the pumping units shall be provided.

## 2. CONSTRUCTION AND MATERIALS

### 2.1 Casing

The casing shall be cast iron conforming to JIS G 5501: FC 200 or better, with smooth waterway and each split casing shall be fitted with wearing rings. The wearing ring shall be of bronze casting conforming to JIS H 5120, CAC 406 or better.

### 2.2 Impellers

The impellers shall be enclosed, accurately machined, and statically and dynamically balanced. The impeller shall be made of bronze casting as specified above.

### 2.3 Shaft

The pump shaft shall be carbon steel conforming to JIS G 4051: S30C or better, precision-ground, and provided with renewable bronze sleeves where it passes through the stuffing box and is in contact with water, if any.

The minimum shaft diameter shall be determined by the formula as specified in the previous sub-section 2.4 Shaft and Sleeve, Section 15.4, Major Pumping Units.

Both sides of the shaft shall be rigidly supported by heavy-duty antifriction ball, roller or sleeve type bearings. Ball bearings shall conform to JIS B1521, 1522 or 1523. Roller bearings shall conform to JIS B 1533. Lubrication for ball or roll bearings shall be grease or oil and for sleeve type bearing shall be oil. In case of oil lubrication appropriate provisions for oil level checking and an oil drain shall be provided.

### 2.4 Stuffing Box

The stuffing box shall be of such design and size as to ensure tight packing without excessive wear or friction on the shaft sleeve.

The stuffing box shall be provided with at least three (3) square packing rings with a lantern ring. An easily removable gland shall be provided for the stuffing box. The gland shall be of bronze casting.

### 2.5 Shaft Coupling

The shaft coupling between pump and motor shall be the flexible type and shall conform to JIS B 1452. Couplings shall be provided with guards.

## 3. ACCESSORIES AND SPARE PARTS

Requirements shall be the same as specified in previous sub-section 3. Accessories and Spare Parts, Section 15.5.2, End Suction Centrifugal Pumps.



## **15.5.4 HORIZONTAL PERIPHERAL PUMPS**

### **1. GENERAL**

Pumps shall be the horizontal single stage, peripheral multivane turbine impeller type, directly connected to the motor with flexible coupling and complete with shaft seals and bearings. Each pump and motor unit shall be mounted on a steel or cast iron base plate. Suction and discharge of the pump shall be flanged end.

All essential and desirable indicators, lubrication devices, and other accessories for the pumping units shall be provided.

### **2. CONSTRUCTION AND MATERIALS**

The pumps shall be split vertically and shall have a removable casing cover so designed that the pump can be entirely disassembled for repairs or inspection without disturbing discharge or suction piping. Front and back casing guide rings shall be provided. Casing and casing cover shall be of cast iron conforming to JIS G 5501: FC 200 or better. Casing guide rings shall be of leaded tin bronze castings conforming to JIS H 5120.

The impeller shall be bronze casting conforming to JIS H 5120: CAC 406 or stainless steel.

The shaft shall be stainless steel having a stainless steel sleeve and supported by two (2) sets of ball bearings with grease or oil lubrication.

The stuffing box shall be of such design and size as to ensure tight packing without excessive wear or friction on the shaft sleeve. The stuffing box shall be provided with at least five (5) square packing rings with a lantern ring. An easily removable gland shall be provided for the stuffing box. The gland shall be of bronze casting, stainless steel or cast iron.

The shaft coupling pump and motor shall be the flexible type and shall conform to JIS B 1452. Couplings shall be provided with guards.

### **3. ACCESSORIES AND SPARE PARTS**

#### **3.1 Accessories**

Requirements shall be the same as specified in the previous sub-section 3. Accessories and Spare Parts, Section 15.5.2, End Suction Centrifugal Pumps

#### **3.2 Spare Parts**

The following spare parts shall be furnished for each pump.

- a. One (1) Complete set of sleeve

- b. One (1) Complete set of bearing
- c. One (1) Complete set of casing guide ring
- d. Two (2) Complete sets of gland packing
- e. One (1) Complete set of oil seals
- f. One (1) Complete set of gasket

### **15.5.5 VERTICAL CENTRIFUGAL SUMP PUMPS**

#### **1. GENERAL**

Pump shall consist of an electric motor directly connected, by means of an enclosed shaft, to a vertical centrifugal type pump having a bottom suction and a separate steel discharge pump column to a flanged side outlet near the motor. Bearing guiding to enclosed shaft shall be oil or grease lubricated.

The pump units shall be mounted in pairs on a common sump cover plate which shall be rigid enough to support the units and not to allow any vibration over the full operating range. Each pump unit shall be individually removable from the said common base plate without interrupting the operation of the other.

#### **2. CONSTRUCTION AND MATERIALS**

##### **2.1 Casing**

The casing shall be cast iron accurately machined to provide uniform clearance for impeller and rigid connection to the supporting plate through a steel pipe to ensure positive alignment. A strainer of corrosion resistant material shall be securely attached to the suction side of the casing. Strainers shall have 14 mm. diameter holes. Casing shall be provided with bronze wearing rings. Casing and wearing rings shall conform to JIS G 5501: FC 200 and JIS H 5120: CAC 406 respectively.

##### **2.2 Impeller**

The impeller shall be cast iron of either the open or semi-enclosed non-clogging type, accurately machined and finished to produce high efficiency. Impeller shall be capable of passing any solids which can pass through the strainer and shall be securely attached to the drive shaft by a key and lock nut with provision for easy removal and replacement.

##### **2.3 Shaft**

The shaft shall be of carbon steel, turned and ground and of sufficient diameter to transmit the power of the motor and operate at maximum speed without vibration. Suitable oil seal or stuffing box shall be provided where the shaft passes through the pump supporting plate.

##### **2.4 Bearings**

The upper bearing shall be a combined radial and thrust type antifriction bearing, grease lubricated. The lower bearing shall be bronze or leaded tin bronze casting bushing and lubrication for lower bearing shall be oil or grease. Suitable oiler or grease cup shall be provided.

### 2.5 Pump Support Plate

Each pump shall be supported from a steel plate mounted on the sump cover plate. The pump discharge shall pass through and be rigidly supported by the supporting plate.

### 2.6 Sump Cover Plate

The square sump opening shall be provided with a steel angle frame and steel cover plate of the dimensions indicated. Sump cover plate shall be provided with manhole and cover plate and holes for installation of the pumps and studs for bolting down the pump supporting plates and manhole cover plate. Sump cover plate shall be bolted down to the angle frame with stainless steel nuts on stainless steel studs welded to the angle frame.

## 3. SUMP PUMP OPERATION

Operation of two (2) sump pumps shall be automatically controlled through mercury type level switches with an associated relay and switches which shall start each pump successively if the water continues to rise above predetermined levels in the sump pit and shut them all off when the water has been lowered to a predetermined level. In normal operation, one pump will be operated for pumping, and the 2nd pump is only started in the case that a flow to the sump pit exceeds the pumping capacity of one pump operation, and water level of the sump pit reaches the water level as determined for the 2nd pump starting. An automatic alternate pump starting system shall be provided.

## 4. MERCURY TYPE LEVELS SWITCHES

Level switches shall consist of a PVC encased, rigid, eccentrically - weighted float housing for a mercury switch actuator, of design which can withstand occasional submergence under 20 meters of water. Float-and-rod actuated switches shall not be permitted. Mounting brackets and anchor bolts shall be stainless steel. Number and configuration of level switches shall be as required for the control system specified above, and shall be suited for installation in the sump pit of dimensions shown.

## 5. ACCESSORIES AND SPARE PARTS

### 5.1 Accessories

For each pump, all essential and desirable accessories for an installation and operation shall be furnished and installed, which shall include but not be limited to the following:

- a. One (1) Set of pump support plate
- b. One (1) Set of bolts and nuts for sump cover plate and pump support plates

- c. One (1) Set of couplings
- d. One (1) Set of pressure gauges with cocks for pump discharge

## 5.2 Spare Parts

The following spare parts shall be furnished for each pump.

- a. One (1) Complete set of bearings including upper and lower bearings
- b. Two (2) Complete sets of gland packing (if gland packing system will be applied)
- c. Two (2) Complete sets of oil seals
- d. One (1) Complete set of gaskets

## **DIVISION 15 MECHANICAL WORKS**

### **SECTION 15.6 CONVEYING SYSTEM**

#### **15.6.1 GENERAL**

##### **1. SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals required to provide and install and make ready for operation conveying system as specified in the Particular Specifications, and as indicated on the drawings.

The following equipment shall be specified hereinafter.

- a. Double beam motorized bridge cranes
- b. Single beam motorized bridge cranes
- c. Single beam hand-operated bridge cranes
- d. Motorized wire hoists
- e. Motorized chain hoists
- f. Hand-operated chain hoists
- g. Miscellaneous systems
  - Gantry "A" frames
  - Jib cranes
  - Portable pulley blocks

##### **2. REFERENCES**

The following standards are referred to.

JIS B 8801	Electric Overhead Travelling Cranes
JIS B 8802	Manually Operated Chain Hoists
JIS B 8812	Link Chains for Chain Hoists
JIS B 8815	Electric Chain Hoists
JIS C 9620	Electric Wire Rope Hoists
JIS G 3101	Rolled Steel for General Structure
JIS G 3192	Dimensions, Mass and Permissible Variations of Hot Rolled Steel Sections
JIS G 3454	Carbon Steel Pipes for Pressure Service

##### **3. SCHEDULE OF CONVEYING SYSTEM**

Schedule of conveying system will be specified in the Particular Specifications.

#### 4. GENERAL ARRANGEMENTS

##### 4.1 General

Each equipment shall be fabricated by a manufacturer regularly engaged in the production of cranes of similar requirements for at least five (5) years.

The crane shall be of such design and constructed so that it will fit the available space without alteration of the building and without change to the location of the crane rails. Clearances between the crane and building construction shall be not less than the following:

- a. Between highest part of crane and lowest member of roof structure 50 mm.
- b. Between bridge and trucks and nearest wall or column 40 mm.

The limitations for highest position of hook, hook travel, hook approach to centerline of rail and elevation of lowest part of bridge are shown on the drawings or provided in the Particular Specifications.

Unless otherwise specified, runway beams and crane rails with stoppers shall be supplied and installed by the Contractor.

##### 4.2 Shop Drawings

Submit for approval complete shop drawings and descriptive literature showing details of fabrication and erection of all material and equipment furnished under this Section.

The shop drawings shall include but not be limited to the following data :

- a. Length of bridge crane span
- b. Overhang of bridge trucks relative to crane rail
- c. Bridge wheel tread diameter and wheel base
- d. Limits of hook travel in relation to walls of structure
- e. Speeds of bridge drive, trolley and hoist
- f. Horsepower, full load amperes and number of motors
- g. Hoist capacity and length of lift
- h. Number and type of hoist brakes
- i. Length of track
- j. Installation of runway beams and crane rails
- k. Electric power supply and wiring

1. Others

#### 4.3 Installation

All equipment specified herein shall be installed in full accordance with the manufacturer's recommendations, by mechanics skilled in the installation of this type of work, and in addition all motorized bridge cranes and motorized monorail system shall be installed under the supervision of the manufacturer's representative.

#### 4.4 Shop Tests

The manufacturer shall furnish the following shop tests for equipment specified.

##### 4.4.1 Motorized bridge crane and motorized monorail system

Load test of 125 % rated load with operation of lifting up and down, travelling and cross travelling, and other tests shall be carried out in accordance with following standard.

- a. JIS B 8801,
- b. JIS B 8815 and
- c. JIS C 9620

##### 4.4.2 Hand-operated bridge crane and monorail system

Load test with following rated load with operation of lifting up and down, travelling and cross travelling and other tests shall be executed in accordance with JIS B 8802.

RATED CAPACITY	TEST LOAD
Ton	Ton
0.5	0.75
1.0	1.50
1.5	2.36
2.0	3.00
3.0	4.75
5.0	7.50
8.0	10.00
10.0	12.50

#### 4.5 Field Tests

Upon completion of the equipment, the Engineer may order a full load operating test on the equipment. The Contractor shall furnish the labor and materials required for such tests and shall at his own expense correct defects in the fabrication and erection.

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

#### 4.6 Shop and Field Painting

All ferrous surfaces requiring painting shall be shop and field coated in accordance with the Standard Specifications titled "Painting" of Section 9.1.

#### 4.7 Anchor Bolts

The Contractor shall furnish all anchor bolts and other necessary appurtenances for the complete equipment installation. Anchor bolts and appurtenances shall be installed under the supervision of the manufacturer's representative.

#### 4.8 Certification

The Contractor shall submit a certificate from the manufacturer stating that the installation of the equipment is satisfactory, that the unit is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of the unit.

### **15.6.2 DOUBLE BEAM MOTORIZED BRIDGE CRANES**

#### 1. GENERAL

The crane shall be motor operated double girder, travelling bridge crane with motor driven trolley and



hoist, controls and all appurtenances necessary to operate the crane.

Design and manufacturing the crane with all structural steel members, welding, mechanical and electrical materials and assemblies of the bridge crane shall conform to JIS B 8801.

Steel to be used for all structural steel member shall be JIS G 3101: SS 400 or better.

All members of the crane shall have a minimum safety factor of 5 based on the ultimate strength of materials. Maximum deflection of the bridge shall be 1/800 of the span with given rated load.

The double beam motorized bridge crane shall be complete, including but not limited to the following.

## 2. CONSTRUCTION AND MATERIALS

### 2.1 Bridge

The bridge shall be double beam, top running, floor control type with motorized drive, push button control, single travel speed of 10 meters per minute, externally adjusted brake, double flanged induction hardened forged steel wheels with sealed roller bearing, and forged steel shafts.

Rubber type end bumpers shall be provided at each end of the crane girders.

### 2.2 Hoist Trolley

The hoist trolley shall be top running, floor controlled type with motorized drive, upper and lower limit switches, overload weight trip, double reeving for vertical plumb hook travel with wire rope cable and hook, two (2) independent brake systems (one a rectified D.C., short stroke, low maintenance electric motor brake on a solenoid operated disc brake and one a mechanical load brake or approved equal). The hoist trolley shall have a main hoist and auxiliary hoist. Main hoist shall have two lifting speeds of 2 meters per minute and 1 meter or less per minute. If auxiliary lifting is specified, speed of auxiliary hoist lifting shall be approximately 0.5 meter per minute. Hook shall be swivel type with safety latch. Trolley shall have a single travel speed of 10 meters per minute.

### 2.3 Rails and Runway Beams

Crane rails shall be of the size recommended by the crane manufacturer. The rails shall be installed with staggered splices, appropriate pairs of anchor bolts with rail clips every 60 cm and a continuous strip of 5 mm neoprene between the rails and the runway beam. Rails shall have sliding splice to provide for expansion joints in concrete.

Heavy duty, high impact, rubber faced bumper stops shall be provided at each end of the runway rails.

Runway beams shall be of a standard steel type I or H beam conforming to JIS G3192. Maximum deflection of runway beams shall be 1/1000 span with given maximum wheel load. The runway beams shall be installed on concrete brackets as shown on the drawings.

## 2.4 Electric Conductors

The electrical conductor for the runway and bridge shall be PVC enclosed conductor system, 100 ampere vertical mount, safety enclosed conductor. The current collectors shall be made of reinforced fibber glass plastic and shall have spring loaded carbon brushes maintaining uniform contact pressure with copper conductors with 60 amperes in the runway and 30 amperes in the bridge. All accessories for the proper mounting of conductors and collectors shall also be provided.

## 2.5 Power Supply System for Hoist Trolley

The power supply system for the hoist trolley shall be a heavy duty festooned cross conductor system and shall be designed to store cabtyre cable in uniform scallops. Messenger wire or guide bar and cable hanger with accessories shall be stainless steel.

## 2.6 Controls

The controls shall be an eight (8) button pendant with a dust tight case, ballast resistor speed control and a pilot circuit to reduce the voltage at the push button to 24 volts. The pendant shall be suspended from a festoon roller track on the bridge.

## 2.7 Cable Reel

The cable reel shall have the electro-magnetic spring pressure multiple disc brake steeples height adjustment and shall be capable of lifting 14 meters of cable puls pendant and storing 12 meters of pendant cable. Total pendant cable length shall be 14.0 meters.

The cable shall be wound onto the drum of cable reel by means of depressing a button of pendant and shall be drawn down manually.

## 2.8 Platform

Steel platforms shall be provided at each end of the crane and a connecting steel walkway along the girder with tubular handrails. Suitable gate shall be provided to provide access to the platform from the fixed wall ladder.

### **15.6.3 SINGLE BEAM MOTORIZED BRIDGE CRANES**

#### 1. GENERAL

The crane shall be a motor operated single girder, overhead or underhung travelling bridge crane with motorized trolley and hoist, controls and all appurtenances necessary to operate the crane.

Design and manufacturing the crane with all structural steel members, welding, mechanical and electrical materials and assemblies of the bridge crane shall conform to JIS B 8801 and JIS C 9620.

Steel to be used for all structural steel members shall be JIS G 3101: SS 400 or better.

All members of the crane shall have a minimum safety factor of 5 based on the ultimate strength of materials. Maximum deflection of the bridge shall be 1/800 of the span with given rated load.

The single beam motorized bridge crane shall be complete, including but not limited to the following.

## 2. CONSTRUCTION AND MATERIALS

### 2.1 Bridge

The bridge shall consist of steel girder carried by end trucks. The girder shall be designed to safely carry the full rated load and proportioned to resist all vertical, lateral and torsional forces within conservative limits. End trucks shall be built up from structural shapes and plates welded to form a rigid section. Trucks shall be precision bored to provide accurate alignments of wheel bearing assemblies. Wheels shall be finished to equal diameters in pairs and be double flanged hardened forged steel etc. Single travel speed of 10 meter per minute shall be provided. Each wheel shall be provided with anti-friction bearings and a sealed self-lubrication system.

### 2.2 Bridge Drive

Each end truck shall be provided with the bridge drive unit having a completely sealed reduction gear and brake motor. The bridge drive shall be designed to ensure a smooth start and sudden stop and all gearing shall be totally enclosed and in an oil bath.

Rubber type end bumpers shall be provided at each end of the end trucks.

### 2.3 Motorized Trolley and Wire Hoist

Motorized trolley and wire hoist unit shall be low head type or normal head type specified in the Particular Specifications and shall be designed and manufactured in accordance with JIS C 9620.

The trolleys shall have motorized drive, single speed specified, push button control, four flanged induction hardened forged steel wheels with sealed ball or tapered roller bearing, thrust brake and forged steel fittings.

The hoists shall have a lift as required in the Particular Specifications or on the drawings, motorized drive, single speed or dual speed as specified in the Particular Specifications, upper and lower limit switches, push button control, two independent brake systems (one a solenoid operated motor brake and one a mechanical load brake, or approved equal), double reeving for plumb vertical movement of hook with wire cable and swivel safety latch hook.

### 2.4 Rails and Runway Beams

#### 2.4.1 Overhead Traveling Bridge Type

Crane rails shall be of the size recommended by the crane manufacturer. The rails shall be installed with staggered splices, appropriate pairs of anchor bolts with rail clips every 60 cm and a continuous strip of 5 mm neoprene between the rails and the runway beam. Rails and runway beams shall have sliding splice to provide for expansion joints in concrete structure.

Heavy duty, high impact, rubber faced bumper stops shall be provided at each end of the runway rails.

Runway beams shall be of a standard type I steel or H beam conforming to JIS G 3192. Maximum deflection of runway beams shall be 1/1000 span with given maximum wheel load. The runway beams shall be installed on concrete brackets as shown on the drawings.

#### 2.4.2 Underhung Traveling Bridge Type

Crane rails shall be a standard I beam conforming to JIS G 3192 with non-peening rolling surface and maximum deflection of 1/1000 span with given maximum wheel load.

Rails shall be installed in a structural concrete beam in an appropriate manner. Heavy duty, high impact, rubber faced bumper stops shall be provided at each end of the rails.

#### 2.5 Electric Conductors

The electrical conductor for the runway and bridge shall be a PVC enclosed conductor system, 100 ampere vertical mount, safety enclosed conductor. The current collectors shall be made of reinforced fiber glass plastic and shall have spring loaded carbon brushes maintaining uniform contact pressure with copper conductors with 60 amperes in the runway and 30 amperes in the bridge. All accessories for the proper mounting of conductors and collectors shall also be provided.

#### 2.6 Power Supply System for Motorized Trolley and Hoist

The power supply system for motorized trolley and hoist shall be a heavy duty festooned cross conductor system and shall be designed to store cable in uniform scallops. Messenger wire or guide rail and cable hanger with accessories shall be stainless steel. All accessories for proper mounting of the festooned conductor system shall be provided.

#### 2.7 Controls

The controls shall be push button pendant with a dust tight case, ballast resistor speed control and a pilot circuit to reduce the voltage at the push button to 24 volts. The pendant shall be suspended from the motorized Trolley and hoist to the elevation indicated on the drawings.

### **15.6.4 SINGLE BEAM HAND-OPERATED BRIDGE CRANES**

#### 1. GENERAL

The crane shall be a hand-operated single girder, overhead or underhung travelling bridge crane with

hand-operated geared trolley type chain hoist.

Design and manufacturing the crane with all structural steel members, welding, mechanical and assemblies of the bridge crane shall conform to JIS B 8801 and JIS B 8802.

Steel to be used for all structural steel member shall be JIS G 3101: SS 400 or better.

All members of the crane shall have a minimum safety factor of 5 based on ultimate strength of materials. Maximum deflection of the bridge shall be 1/800 of the span with given rated load.

## 2. CONSTRUCTION AND MATERIALS

### 2.1 Bridge and Bridge Drive

The bridge shall consist of steel girder carried by end trucks. The girder shall be designed to safely carry full rated load and proportioned to resist all vertical, lateral and torsional forces within conservative limits. End trucks shall be built up from structural shapes and plates welded to form a rigid section. Trucks shall be precision bored to provide accurate alignment of wheel bearing assemblies. Wheels shall be finished to equal diameters in pairs and shall be double flanged hardened forged steel wheels. Each wheel shall be provided with anti-friction bearings and a sealed self-lubrication system.

The bridge shall be driven by pulling on an endless hand chain. The hand chain wheel shall be secured to a cross shaft which shall rotate the driving wheels through gear drive or dual belt drive arrangement at each end truck.

### 2.2 Trolley and Hoist

The geared trolley shall be gear drive type with 4 ball-bearing pressed steel wheels, equipped with life-time lubrication and hardened threads with a geared travel mechanism. Chain hoist shall have a malleable iron casting forming the body casing and main frame. The reduction gears shall provide a positive drive between the driving shaft and the load. The chain hoist shall be manufactured in accordance with JIS B 8802 and shall conform to the requirements specified following Section 15.6.7, Hand-Operated Chain Hoists.

### 2.3 Rails and Runway Beams

Rails and runway beams shall conform to the requirements as specified in the previous sub-section 2.4 Rails and Runway Beams, Section 15.6.3, Single Beam Motorized Bridge Cranes.

## 15.6.5 MOTORIZED WIRE HOISTS

### 1. GENERAL

Motorized wire hoist, in all their parts, shall be of sufficient capacity to move the load indicated in the

Particular Specifications, or on the drawings, and shall be wired for electrical service.

Design and manufacturing the motorized wire hoist shall conform to JIS C 9620. All appurtenances necessary to operate the motorized wire hoist shall be provided.

The motorized wire hoist shall be complete, including but not limited to the following.

## 2. CONSTRUCTION AND MATERIALS

### 2.1 Trolley

The trolleys shall have motorized drive, single speed specified in the Particular Specifications, push button control, four flanged induction hardened forged steel wheels with sealed ball or tapered roller bearings, thrust brake and forged steel fittings.

### 2.2 Motorized Wire Hoist

The hoists shall have a lift as required in the Particular Specifications or on the drawings, motorized drive, single speed or dual speed as specified in the Particular Specifications, upper and lower limit switches, push button control, two independent brake systems (one a solenoid operated motor brake and one a mechanical load brake, or approved equal), double reeving for plumb vertical movement of hook with wire cable and swivel safety latch hook.

### 2.3 Truck

Monorail truck shall be a standard I beam conforming to JIS G 3192 with non-peening rolling surface and maximum deflection of 1/1000 span with given maximum wheel load. Heavy duty, high import rubber faced bumper stops shall be provided at each end of truck.

### 2.4 Electric Conductor

Electric conductor system shall be enclosed conductor or festooned conductor system as specified under the Particular Specifications.

#### 2.4.1 Enclosed Conductor System

The electrical conductor shall be PVC enclosed conductor system, 100 ampere vertical mount, safety enclosed conductor. The current collectors shall be made of reinforced fiber glass plastic and shall have spring loaded carbon brushes maintaining uniform contact pressure with copper conductors with 60 ampere capacity. All accessories for proper mounting of conductors and collectors shall also be provided.

#### 2.4.2 Festooned Conductor System

The electrical conductor shall be heavy duty festooned conductor system and shall be designed to store

cabtyre cable in uniform scallops. Messenger wire or guide rail and cable hanger with accessories shall be stainless steel. All accessories for proper mounting of the festooned conductor system shall be provided.

## 2.5 Controls

The controls shall be push button pendant with a dust tight case, ballast resistor speed control and a pilot circuit to reduce the voltage at the pushbutton to 24 volts. The pendant shall be suspended from the hoist to the elevation indicated on drawings.

## **15.6.6 MOTORIZED CHAIN HOISTS**

### 1. GENERAL

Motorized chain hoist, in all their parts, shall be of sufficient capacity to move the load indicated in the Particular Specifications or on the drawings, and shall be wired for electrical service.

The motorized chain hoist shall be complete, including but not limited to the following.

### 2. CONSTRUCTION AND MATERIALS

#### 2.1 Motorized Chain Hoist

The hoists shall have a lift as required in the Particular Specifications or on the drawings, motorized drive, single speed or dual speed as specified in the Particular Specifications, upper and lower limit switches, push button control, two independent brake systems (one a solenoid operated motor brake and one a mechanical load brake, or approved equal), flanged load sheave with chain guide and guide rollers, single or double reeving for plumb vertical movement of hook with and built-in bearing swivel safety latch hook.

Each hoist shall be provided with suitable metal chain storing box which shall be cable of storing lifting chain of specified lift length and shall have drain hole.

#### 2.2 Chain

All chains shall be electrically welded, hardened alloy steel, polished and accurate to pitch. Dimension and strength of the chains shall conform to JIS B 8812.

#### 2.3 Others

Trolley, truck, electric conductor and controls for the motorized chain hoist shall conform to the requirements as specified in previous Section 15.6.5, Motorized Wire Hoist.

## **15.6.7 HAND-OPERATED CHAIN HOISTS**

### 1. GENERAL

Hand-operated chain hoist shall be plain or geared trolley with chain hoist. Design load and lifts shall be specified in the Particular Specifications or on the drawings.

Chain hoist shall be designed and manufactured in accordance with JIS B8802.

## 2. CONSTRUCTION AND MATERIALS

Chain hoist shall consist of frame, casing, reduction gear and flanged load sheave with precision roller bearings, load and operation chain, overload limiter, mechanical brake and safety latch hook.

The reduction gears shall be ample proportion and provide a positive drive between the driving shaft and the load. Pinions and spur wheels shall be made from high-grade heat-treated alloy steel, and have precision machine cut-teeth.

The brake shall be of the screw and disc type where the brake pressure and the sustaining power increases in proportion to the load on the hook. Screwed brake sleeve shall be high grade steel and mounted on a splined driving shaft.

All chains shall be electrically welded steel, heat treated, polished and accurate to pitch. Dimensions and strength of the chains shall conform to JIS B 8812.

The geared trolley shall be the gear drive type with 4 ball-bearing pressed steel wheels, equipped with life-time lubrication and hardened threads with a geared travel mechanism.

The push and plain trolley shall be of the hung-in travelling type with a forged steel bar held between the side plates of the trolley. The push and plain trolley shall have 4 ball-bearings pressed steel wheels equipped with lifetime lubrication.

Monorail truck shall conform to the requirements specified in previous Section 15.6.5, Motorized Wire Hoist.

### 15.6.8 MISCELLANEOUS SYSTEMS

#### 1. GANTRY "A" FRAMES

Gantry "A" frames shall consist of monorail truck and specially designed gantry leg assemblies. The monorail truck shall be mounted and firmly fixed on gantry legs by means of bolts and plates. The gantry "A" frames shall be capable of completely dismantling for easy storage and transporting, and shall be equipped with heavy duty industrial casters with anti-friction bearing wheels and ball type thrust bearing swivels. The gantry "A" frames shall be fabricated from seamless steel pipe conforming to JIS G 3454, STPG38 minimum Schedule of 40. Monorail truck shall be a standard I beam conforming to JIS G 3192 with non-peening rolling surface and maximum deflection of 1/800 span with given rated load.



Span and load condition of gantry "A" frames shall be specified in the Particular Specifications or the drawings.

## 2. JIB CRANES

The cranes shall be the full revolving self supporting jib crane type and consist of monorail truck boom, mast with base plate, upper and lower bearings and others.

Monorail truck boom shall be a standard I beam conforming to JIS G 3192 with non-peening rolling surface and shall be provided with trolley stops at both ends of boom.

Floating action mast head assembly shall be weld connected to the mast on the pipe sleeve principle. Mating surfaces shall be carried on upper and lower bearings permitting the head to rotate freely through 360 degrees.

Upper bearings shall be lifetime lubricated sealed ball bearings mounted in a finely machined receptacle. Lower roller bearings shall be designed to have a row of continuous two-surface roller type bearings recessed into a heavy wearing ring welded to the mast head assembly.

The mast assembly shall be made from seamless steel pipe conforming to JIS G 3454 STPG38, minimum schedule of 40. The mast shall be provided with a heavily gusseted structural steel base.

## 3. PORTABLE PULLEY BLOCKS

Portable hand operated pulley blocks of the hoist capacity indicated shall be furnished for use with the push type trolleys herein before specified.

Frame shall be malleable iron castings forming the body casing and main frame. The castings shall be accurately machined and bolted together to form a rigid frame.

**DIVISION 15 MECHANICAL****SECTION 15.7 VACUUM AND COMPRESSED AIR SYSTEM****15.7.1 GENERAL****1. GENERAL**

Provide all labor, materials, equipment and incidentals necessary to furnish, install and test the vacuum and compressed air system as specified herein and as shown on the drawings.

The following equipment shall be specified hereinafter and units shall be complete with electric motors, starters, automatic controls where specified or shown, floor plates and all other necessary appurtenances.

- a. Vacuum pumps
- b. Air compressor units

**2. REFERENCES**

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS B 8270	Pressure Vessels (General Standard)
JIS B 8340	Testing Methods for Turbo Blowers and Compressors
JIS B 8341	Displace Compressors - Test Method
JIS B 8342	Small-size Reciprocating Air Compressors
JIS G 4051	Carbon Steel for Machine Structural Use
JIS G 5501	Gray Iron Castings
JIS H 5120	Copper and Copper Alloy Castings

**3. SCHEDULE OF VACUUM AND COMPRESSED AIR SYSTEM**

Schedule of vacuum and compressed air system will be specified in the Particular Specifications.

**4. GENERAL ARRANGEMENTS****4.1 General**

The contract drawings indicate the extent and general arrangement of the systems. Equipment and piping shall fit into the space allotted and shall allow adequate acceptable clearances for installation, replacement, servicing and maintenance. All necessary anchor bolts shall be furnished and installed.

**4.2 Data Submittal**

The Contractor shall submit the following for all equipment to the Engineer for approval:

Shop drawings describing the equipment in sufficient detail, including capacities, materials of construction and parts lists to indicate conformance with the specifications and to show installation details.

#### 4.3 Capacity

Capacities of all equipment and materials shall be not less than those indicated in the Particular Specifications or the drawings.

#### 4.4 Nameplates

Brass or stainless steel nameplates giving the name of the manufacturer, the rated capacity, pressure, speed, model and serial number and other pertinent data shall be attached to each pump.

Similar nameplates giving pertinent motor data shall be attached to each electric motor.

#### 4.5 Safety Requirements

Belts, pulleys, chains, gears, couplings, projecting set screws, keys and other rotating parts, so located that personnel can come in close proximity thereto, shall be fully encased or properly guarded.

#### 4.6 Materials and Equipment

Materials and equipment shall be the products of manufacturers regularly engaged in the manufacture of such products. Items of equipment shall essentially duplicate equipment that has been in satisfactory use at least five (5) years.

#### 4.7 Shop and Field Painting

The vacuum pumps, compressor units, coupling air receiver tanks, motors and bed plates shall have a shop and field coats. Painting shall conform to the requirements as specified in the Standard Specifications titled "Painting" of Section 9.1 unless otherwise specified.

#### 4.8 Factory Performance Tests

Unless otherwise specified, all pumps shall be tested at the manufacturer's plant to demonstrate complete compliance with those specifications. The tests shall be in full compliance with the applicable provisions of the following standards.

- a. JIS B 8340,
- b. JIS B 8341 and
- c. JIS B 8342

Three (3) copies of test data shall be submitted for approval prior to shipment.

#### 4.9 Field Tests

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

##### 4.9.1 Piping Tests

Air piping shall be tested and proved tight at a pressure equal to 150 percent of the specified operating pressure. Vacuum piping shall be tested and proved tight at a vacuum of 620 mm of mercury.

##### 4.9.2 Operating Tests

Operating tests shall be performed on each piece of equipment to demonstrate compliance with these Specifications. Operating tests shall start with air tanks at atmospheric pressure and shall be continuous until specified pressure are reached in the tanks after which the pressure shall be relieved below the set starting point at least three times to check the automatic starting and stopping operation.

#### 4.10 Motors

The motors for vacuum pumps and air compressors shall have sufficient rating to operate units at any point on its characteristic curve without overloading.

Unless otherwise specified, motors which are rated at 30 kW and smaller shall be totally enclosed, fan cooled type and motors, output 37 kW and larger shall be open drip-proof type. All motors shall be as hereinafter specified under Section 16.17 Motors.

#### 4.11 Spare Parts and Tools

All spare parts for each unit specified hereinafter shall be furnished.

For each unit, one (1) set of special tools for maintenance shall be supplied in painted steel cases and identified on the outside with an itemized list of contents.

### 15.7.2 VACUUM PUMPS

#### 1. GENERAL

Vacuum pumps shall be a single or double suction, single-stage, positive displacement, nonpulsating, liquid sealed rotary vacuum pump, complete with direct connected motor, coupling, guard, base, suction check valve, strainer, gate valve, vacuum relief valve, vacuum gauge and, seal water, suction and discharge piping. The pump shall be capable of accepting sludge of water in the suction line without damage.

Each pump and motor unit shall be mounted on a steel or cast iron common base plate. Suction and

discharge of the pump shall be flanged end.

Handling air temperature range shall be - 15 degrees C to +40 degrees C with normal humidity and normal concentration of dust.

Unless otherwise specified, relation between pump suction diameter, minimum motor output, maximum negative pressure and suction air flow shall be as specified in the following table.

For each pump, suction air flow shall be measured under following five (5) points at factory in accordance with JIS B 8340.

- a. Maximum negative pressure
- b. In between maximum negative pressure and negative pressure 400 mm Hg
- c. Negative pressure 400 mm Hg
- d. Negative pressure 200 mm Hg
- e. Atmospheric pressure

Each pump shall be hydrostatically tested with at least 0.196 MPa of water pressure and minimum length of hydrostatic test shall be 3 minutes.

MINIMUM SUCTION AIR FLOW

SUCTION DIAMETER	MAXIMUM* <sup>1</sup> NEGATIVE PRESSURE	UNDER	UNDER	UNDER	MINIMUM
		ATMOSPHERIC PRESSURE	NEGATIVE PRESSURE	NEGATIVE PRESSURE	OUTPUT (MOTOR POLE NUMBER)
mm	mm Hg	m <sup>3</sup> /min	200 mm Hg* <sup>2</sup> m <sup>3</sup> /min	400 mm Hg m <sup>3</sup> /min	kW
20	560	0.25	0.18	0.10	0.75(4 or 2)
25	600	0.56	0.40	0.22	1.5 (4 or 2)
32	600	0.90	0.63	0.35	2.2 ( 4 )
40	600	1.60	1.12	0.63	3.7 ( 4 )
50	630	2.50	1.80	1.00	5.5 ( 4 )
65	630	3.55	2.50	1.40	7.5 ( 4 )
80	630	5.60	4.00	2.24	11.0 (4 or 6)
100	630	8.00	5.60	3.15	15.0 (4 or 6)
100	630	10.00	7.10	4.00	18.5 (6 or 8)
125	630	12.50	9.00	5.00	22.0 (6 or 8)
150	630	18.00	12.50	7.10	30.0 (6 or 8)
150	630	23.50	16.00	9.00	37.0 (8 or 10)

Note: \*1 : Maximum negative pressure shall be kept under shut off suction air flow and for at least 1.0 minute.

\*2 : mm Hg means mm mercury

2. CONSTRUCTION AND MATERIALS

Casing shall be cast iron conforming to JIS G 5501: FC 200 or better and shall have port liner or port plate which shall be cast iron specified above or bronze casting conforming to JIS H 5120: CAC 406 or better.

Impeller shall be bronze casting or cast iron specified the above. Shaft shall be carbon steel conforming to JIS G 4051: S35C or better or stainless steel. The minimum shaft diameter shall be determined by the formula as specified in the sub-section 2.4 Shaft and Sleeves, Section 15.4, Major Pumping Units.

The stuffing boxes shall be provided where the shaft is through the casing and of such design and size as to ensure tight packing without excessive wear or friction. Each stuffing box shall be provided with at least three (3) square packing rings with a lantern ring. An easily removable gland shall be provided for the stuffing box.

A stainless steel water tank shall be furnished and installed beside the vacuum pumps if specified. The tank shall have air vent, level gauge, automatic float valve, connections for plant water supply, seal water supply, vacuum pump discharge drain and overflow connection. An effective capacity of the tank shall be indicated in the Particular Specifications or on the drawings.

### 3. ACCESSORIES AND SPARE PARTS

#### 3.1 Accessories

For each pump, all essential and desirable accessories for an installation and operation shall be furnished and installed, which shall include but not be limited to the following:

- a. One (1) Set of common base plates
- b. One (1) Set of anchor bolts and nuts
- c. One (1) Set of couplings with guards
- d. One (1) Set of casing drain valve
- e. One (1) Set of priming funnel with valve
- f. One (1) Set of vacuum relief valve and vacuum gauge

#### 3.2 Spare Parts

One (1) complete set of gland packing shall be furnished for each pump.

### 15.7.3 AIR COMPRESSOR UNITS

#### 1. GENERAL

Air compressor units shall consist of compressor, motor, V-belt drive, horizontal or vertical air tank(s) and regulation, and necessary accessories as shown on the drawings.

Handling air temperature range shall be +0 degrees C to +40 degrees C with normal humidity and normal concentration of dust.

Air cooled, single stage, reciprocating air compressors having motors of output 5.5 kW and smaller with maximum working pressure 0.294 to 0.98 MPa shall be designed and manufactured in accordance with JIS B 8342.

Air compressor units specified above and larger units shall be hydrostatically tested at 180 and at least

150 percent of the specified maximum working pressure with water respectively and the minimum length of the hydrostatic test shall be 3 minutes.

## 2. AIR COMPRESSOR UNITS

The air compressor units shall be single-stage or two-stage air-cooled, reciprocating type.

All components of air compressor units shall be designed with liberal service factors to ensure quiet, vibration-free operation for continuous service as well as intermittent service. All moving parts shall be enclosed in protective guards.

Frame shall be cast iron or aluminium alloy casting, completely sealed and shall have a large oil sump to ensure at least 48 hours continuous service without lubricant supply.

Cylinders shall be separately cast from each other and bolted to the frame for ease of maintenance. Each cylinder shall have deep radial fins to help remove the heat of compression: Each piston shall be provided with at least three (3) piston rings and recesses for the piston ring shall be finished with precision. If non-lubricated oil-free type specified, Teflon rings shall be provided on each piston.

Valves shall be readily accessible. Connecting rods shall be of the solid-end, non-adjustable type.

## 3. AIR TANKS

All air tanks for the compressed air system shall be designed and manufactured in accordance with JIS B 8270, and shall be fabricated of steel plate of a minimum thickness of 6.00 mm.

Air tanks, maximum working pressure of 0.294 MPa and smaller shall be hydrostatically tested at 200 percent of specified working pressure with water.

Air tanks maximum working pressure of 0.303 MPa and larger shall be hydrostatically tested at 130 percent of the specified maximum working pressure plus 0.294 MPa with water.

Minimum length of the hydrostatic test shall be 3 minutes.

## 4. SELF-CONTAINED AND SEPARATE TYPE

### 4.1 Self-Contained Type

Self-contained type shall be horizontal air tank mounted type, vertical or V-type, single or two-stage, non lubricated, oil-free type or lubricated type, V-belt drive with motor, air compressor. Interconnecting piping between the compressor, air tank and regulation, and necessary accessories shall be included. Typical self-contained type shall be as shown on the drawings and completely shop assembled

### 4.2 Separate Type



Separate type shall include vertical air tank(s) and vertical or V-type, single or two-stage, non-lubricated, oil-free type or lubricated type, V-belt drive with motor, air compressor. Interconnecting piping between the compressor, air tank(s) and regulation, and necessary accessories shall be also included. The compressor and motor shall be mounted on cast iron or steel fabricated common base plate. Typical separate type shall be as shown on the drawings.

## 5. CONTROL

### 5.1 Pressure-Control System

Pressure control system shall be automatically controlled through pressure switches with an associated relay and switches which start and stop the compressor automatically to maintain the pre-set pressure in the air tank.

### 5.2 Automatic Unloader System

Automatic unloader system shall be controlled through pressure switches with an associated relay and switches which hold the compressor suction valve off or on its seat to maintain the pre-set pressure in the air tank during continuous operation of the compressor.

## 6. ACCESSORIES AND SPARE PARTS

### 6.1 Accessories

For each type of compressor unit, all essential and desirable accessories, for an installation and operation shall be furnished and installed but not to be limited to those shown on the drawings.

In addition, for each separate type compressor unit, the following accessories shall be furnished.

- a. One (1) Set of base plates
- b. One (1) Set of anchor bolts and nuts for base plate and air tank(s)

### 6.2 Spare Parts

The following spare parts shall be furnished for each compressor.

- One (1) Set of pressure relief valves
- Two (2) Complete sets of V-belts
- One (1) Complete set of pressure switches

## **DIVISION 15 MECHANICAL**

### **SECTION 15.8 AIR CONDITIONING SYSTEM**

#### **15.8.1 GENERAL**

##### **1. SCOPE OF WORK**

Provide all labor, materials, equipment, and incidentals necessary to furnish, install, test and place in operation the air conditioning systems.

The systems shall be complete with all ductwork piping, insulation and controls as indicated on the drawings and herein specified.

##### **2. REFERENCES**

The following standards are referred to, JIS A9504 Man Made Mineral fiber Thermal Insulation Materials.

##### **3. SCHEDULE OF EQUIPMENT**

Schedule of equipment will be specified in the Particular Specifications and/or the drawings.

##### **4. GENERAL ARRANGEMENT**

###### **4.1 General**

The Contract drawings indicate the extent and general arrangement of the air conditioning systems. Equipment, ductwork, and piping arrangements shall fit into the spaces allotted and shall allow adequate acceptable clearance for installation, replacement, entry, servicing, and maintenance.

###### **4.2 Data Submittal**

The Contractor shall submit the following for approval for all the equipment.

Shop drawings describing the equipment in sufficient detail, including materials of construction, capacities, part lists and dimensions to indicate conformance with the drawings and specifications. Operating and maintenance manuals shall also be provided.

###### **4.3 Capacities**

Capacities of all equipment and material shall be not less than those indicated.

###### **4.4 Name Plates**

Each major item of equipment shall have the manufacturer's name, address, serial and model numbers on a plate securely attached to the item.

#### 4.5 Safety Requirements

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts shall be located so that they are fully enclosed or properly guarded from any person coming in close proximity thereto.

#### 4.6 Verification of Dimensions

The Contractor shall be responsible for the coordination and proper relation of his work to the building structure and to the work of all trades.

### 5. MATERIALS AND EQUIPMENT

#### 5.1 General

Materials and equipment shall conform to the requirements specified herein and as shown on the drawings and shall be the products of manufacturers regularly engaged in the manufacture of such products. Items of equipment shall essentially duplicate equipment that has been in satisfactory use for at least two (2) years and shall be supported by a service organization, that is, in the opinion of the Engineer reasonably convenient to the site.

#### 5.2 Compressors

Air-conditioning compressors having less than 2 years service record specified above, will be acceptable when a certified record of satisfactory field operation under normal operating conditions for not less than 6,000 hours can be shown. Types that have been shown to have operated satisfactorily for these periods may have modifications, provided it can be clearly shown that the modifications will not increase maintenance and operating costs and will not decrease the life of the machine. Modifications of the following descriptions will definitely require compliance with the full 2-year or 6,000 hours satisfactory experience requirement.

- a. Increase in rotative speeds in excess of 20 percent
- b. Reduction in metal thickness in sections subject to high pressures or vacuum
- c. Change of refrigerant.
- d. Change in lubricating system and bearings.

### 6. INSULATION

#### 6.1 General

Fire hazard classification and flame spread rating for insulating and acoustical materials, vapor barrier, covering and wrapping materials permanently attached or installed separately shall not exceed 25, and the smoke developed rating shall not exceed 50, when tested in accordance with ASTM Specification

E84, "Test for Surface Burning Characteristics of Building Materials".

## 6.2 Duct Insulation

Duct insulation shall be fiberglass block, board, blanket or felt with vapor barrier facing conforming to JIS 9504. The thermal conductivity, K value, shall not be greater than 0.046 W/m•k at 70 . The vapor barrier shall consist of a lamination of aluminum foil, reinforced scrim, and Kraft paper.

## 6.3 Pipe Insulation

Pipe insulation shall be closed cell plastic foam insulation and 19 mm thick with a K factor of not more than 0.043 W/m•k at 70 . All joints in pipe insulation shall be sealed with a weatherproof adhesive.

## 7. PIPE AND FITTINGS

### 7.1 Refrigerant Piping

Refrigerant piping shall be annealed or hard drawn copper tubing of thickness required for the applicable pressure. Fittings for copper tubing shall be wrought copper or forged brass.

### 7.2 Drain Piping

Drain piping shall be polyvinyl chloride (PVC) pipe. Fittings shall have solvent welded joints.

## 8. VALVES

Valves for refrigerant service shall be of the type and design suitable for the application.

## 9. WORKMANSHIP

All materials and equipment shall be installed in accordance with the approved recommendations of the manufacturer to conform with the contract documents.

## **DIVISION 15 MECHANICAL WOEPS**

### **SECTION 15.9 PLUMBING**

#### **15.9.1 GENERAL**

##### **1. SCOPE OF WORK**

The Contractor shall provide all labor, equipment, and materials necessary to furnish and install complete plumbing systems as described herein or as shown on the drawings.

The following systems shall be included in their entirety:

- a. Roof and floor drainage pipe systems.
- b. Sanitary and waste water drain and vent systems.
- c. Building water service systems including piping to equipment plumbing fixtures and faucets.
- d. Plumbing fixtures, hose faucets and valves.

In general the cleaning, testing and disinfection of plumbing shall be done in conformance with the Standard Specifications, Division 1 titled "General Requirements" and as herein specified.

##### **2. GENERAL ARRANGEMENT**

###### **2.1 Piping**

The general arrangement of the plumbing shall be as indicated. Detailed drawings of proposed departures due to actual field conditions or other caused shall be submitted for approval. The Contractor shall carefully examine the drawings and shall be responsible for the proper fitting of materials and equipment in each building, as indicated without substantial alteration. Material and equipment installed in the plumbing system shall be suitable for the pressures encountered.

Water piping shall start at the flanged tees on the main distribution header or as otherwise shown. Sanitary piping shall be extended outside the building to the septic tank, unless otherwise indicated. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown.

All piping shall be designed for a minimum working pressure of 0.98 MPa unless noted otherwise.

###### **2.2 Cross Connections and Interconnections**

No plumbing fixture, device, equipment, or pipe connection shall be installed that will provide a cross connection or interconnection between a potable water supply and any source of non-potable water, such as a drainage system, a sanitary or waste water pipe.

###### **2.3 Connection to Equipment and Fixtures**

The Contractor shall provide all necessary material and labor to connect to the plumbing connections, which are specified in other Sections of these Specifications. All connections to the sanitary drainage system shall be trapped. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with an integral stop, shall be equipped with a cut-off valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures.

#### 2.4 Drawings

All offsets, fittings, and accessories that may be required may not be indicated on the drawings. The Contractor shall carefully investigate the structural and finish conditions affecting all his work and shall arrange such work accordingly, furnishing such fittings, traps, valves, and accessories as may be required to meet such conditions.

#### 2.5 Cutting and Repairing

The work shall be carefully laid out in advance, and no excessive cutting of construction will be permitted. Damage to buildings, piping, wiring, equipment or appurtenances as a result of cutting for installation shall be repaired by mechanics skilled in the trade involved.

#### 2.6 Protection to Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical injury. Upon completion of all work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated. Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts located so that any person may come in close proximity thereto shall be fully enclosed or properly guarded.

### **15.9.2 MATERIAL, FIXTURES AND EQUIPMENT**

Materials, fixtures, and equipment shall be as hereinafter specified below, and as shown on the drawings. Fixtures and equipment shall be the products of manufacturers regularly engaged in the manufacture of such products.

### **15.9.3 SANITARY AND WASTE WATER, DRAIN AND VENT PIPING**

#### 1. GENERAL

Pipe materials shall be Polyvinyl Chloride (PVC) plastic drain, waste and vent pipe conforming to the requirements of the Standard Specifications titled "Piping" of Division 15. Fittings on dry vents shall be regular-pattern type. Fitting on PVC pipe shall be PVC socket type and shall be installed by the solvent weld method using approved solvent cement.

#### 2. INSTALLATION

## 2.1 Drainage and Vent Pipes

Horizontal waste and drain pipes shall have a slope of 20 mm per meter. When authorized by the Engineer horizontal piping may be installed with a slope not less than 10 mm per meter. Vent pipes in roof spaces shall be run as close as possible to the underside of the roof without forming traps in pipes, using fittings as required. Vent and branch-vent pipes shall be so sloped and connected as to drip back to the vertical stack by gravity.

## 2.2 Fittings

Changes in pipe size, on sanitary, waste water and drain lines, shall be made with reducing fittings. Use of bushings will not be permitted. Changes in direction shall be made by the appropriate use of 45-degree wyes, long or short-sweep 1/4, 1/6, 1/8, or 1/16 bends, or by a combination of these or equivalent fittings. Sanitary tees and 1/4 bends or elbows may be used in drainage lines only where the direction of flow is from horizontal to vertical, except elbows may be used in lines 50 mm or less in diameter. Short sweeps not less than 80 mm in diameter may be used where the change in direction of flow is either from horizontal to vertical or from vertical to horizontal, and may be used for making necessary offsets in vertical lines.

## 2.3 Union Connections

Slip joints shall be permitted only in trap seals or on the inlet side of the traps.

## 3. JOINTS

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Threaded joints conform to ISO 7-1, "Pipe Threads where Pressure-tight Joints are made on the Threads -- Part 1: Dimensions, Tolerances and Designation". Joints shall be made with an approved graphite compound or with polytetrafluoroethylene tape applied to the male threads only.

### 15.9.4 FLASHING

Pipes passing through roofs shall be flashed using lead or copper flashing with an adjustable integral flange of adequate size to extend not less than 200 mm from the pipe in all directions and flashed into the roofing to provide a watertight seal.

### 15.9.5 TRAPS

Each fixture and piece of equipment, except fixtures or equipment having an integral trap or seal, requiring connections to the sanitary drainage system shall be equipped with a trap. Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped. Traps installed on PVC pipe shall be PVC. Traps installed on lavatory wastes shall be brass recess-drainage pattern, or

brass-tube type, chrome plated.

### **15.9.6 FLOOR DRAINS**

#### **1. GENERAL**

Floor drains shall have cast iron bodies with double drainage flange, weep holes and bottom outlet. Outlets shall be inside caulked or screwed.

#### **2. LAVATORY ROOMS**

Shower and toilet room drains shall have adjustable chrome plated brass strainers with free strainer area equal to not less than one and one half times the connecting pipe size.

#### **3. INDUSTRIAL AREAS**

Pump room, equipment room, and area drains shall have antitilting slotted cast iron grate of not less than 150 mm diameter.

### **15.9.7 DOWN SPOUTS**

Down spouts for roof drainage shall be the size indicated on the drawings, fabricated of light gage galvanized steel. All offsets and bends shall be made with 1/8 bends and no skewed joints or bowed down spouts will be permitted. Down spouts shall be supported with galvanized steel straps as noted on the drawings. Steel pipe overflows shall be installed as noted using galvanized medium class pipe.

### **15.9.8 WATER PIPE, FITTINGS AND CONNECTIONS**

#### **1. WATER PIPE**

Water pipe to the structure and water piping within the structure shall be galvanized steel pipe. Exposed cold and hot water supply piping to fixtures shall be chrome plated brass pipe, or chrome-plated copper tube.

#### **2. FITTINGS**

Fittings for copper tubing shall be flared brass or solder-type bronze or wrought copper. Fittings for galvanized steel pipe shall be galvanized malleable iron. Fittings for brass pipe shall be brass.

#### **3. INSTALLATION**

##### **3.1 General**

The piping shall be extended to all fixtures, outlets, and equipment. The water piping system shall be installed so as to be drained. Drainage shall be accomplished using 12 mm plugged or capped fittings at each low point, except where a drain valve or hose faucet is shown.



Pipes shall be cut accurately to measurements established at the building by the Contractor and shall be worked into place without springing or forcing. Care shall be taken not to weaken structural portions of the building. Exposed piping shall be run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using such crossover fittings as may be required by structural or installation conditions. Pipes, valves, and fittings shall be kept at a sufficient distance from other work and other pipes to permit not less than 25 mm between pipes and other work and between pipes. No water pipe shall be buried in floors, cast in concrete walls, unless specifically indicated or approved. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted. Change in direction shall be made with fittings.

### 3.2 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of pipe. Sufficient flexibility shall be provided on all branch runouts from mains to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that the piping will spring enough to allow for expansion without straining.

### 3.3 Air Chambers

Air chambers shall be provided where indicated. Air chambers shall consist of a 30 cm length of pipe of the same diameter as the branch supply, capped.

## 4. JOINTS

Joints in steel piping may be screwed or flanged, except where flanged joints are indicated on the drawings. Joints in PVC piping shall be socket type. Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations.

Mitering of joints for elbows and notching of straight runs of pipe for tests will not be permitted. Threaded joints shall conform to ISO 7-1. Joints shall be made with polytetrafluoroethylene tape applied to the male threads only. Unions shall be provided where required for disconnection.

### **15.9.9 VALVES**

Valves shall be provided on supplies to equipment and fixtures. No valve shall be installed on any line with its stem below the horizontal. All valves shall be gate valves, unless otherwise specified or indicated. Valves shall conform to Standard Specifications titled "Valves, Gates and Appurtenances" of Section 15.3.

### **15.9.10 UNIONS**

Unions on PVC pipe shall be PVC with socket type ends. Unions shall be installed in easily accessible

locations. Gaskets for flanged unions shall be of the best quality fiber, plastic, or leather. Unions shall not be concealed in walls, ceilings, or partitions.

### **15.9.11 HOSE FAUCETS**

Hose faucets shall be brass with 13 mm inlet threads, hexagon shoulder, unless otherwise indicated. Hose faucets installed on exterior walls of buildings shall have integral wall flange which shall be securely anchored to the wall to prevent any strain on the supply pipe when attaching or disconnecting hose. Anchors shall use brass or bronze bolts or screws with expansion shields in the concrete or masonry wall.

### **15.9.12 PIPE SLEEVES, HANGERS AND FIXTURE SUPPORTS**

#### **1. GENERAL**

The materials shall be furnished and set, and the Contractor shall be responsible for their proper and permanent location.

#### **2. PIPE SLEEVES**

Pipes passing through concrete or masonry walls or concrete floors shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be steel pipe. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush, except sleeves in toilet room floors shall extend 25 mm above the finished floor. Unless otherwise indicated, sleeves shall be of such size as to provide a minimum of 6.3 mm all around clearance between bare pipe and sleeves. The annular space between pipe and sleeve shall be packed and caulked watertight.

#### **3. PIPE HANGERS, INSERTS, AND SUPPORTS**

Material shall conform to the Standard Specifications titled "Piping" of Section 15.2 The location of hangers and supports shall be coordinated with the structural work to assure that the structural members will support the intended load.

#### **4. FIXTURE SUPPORTS**

##### **4.1 General**

Wall-hung fixtures shall be fastened to the wall by 10.0 mm through bolts where appearance of the bolts is not objectionable. Exposed bolt heads in finished areas shall be hexagonal and painted. Exposed nuts shall be chromium-plated hexagonal cap nuts. Washers shall be painted or chromium-plated to match bolts heads or nuts.

##### **4.2 Solid Masonry**

For solid masonry and where through bolting is objectionable, fixtures shall be fastened with 10.0 mm

machinebolt expansion shields or 10.0 mm stud-type expansion bolts.

#### 4.3 Cellular Masonry

For cellular-masonry construction, where through bolting is objectionable, fixtures shall be fastened with 10.0mm toggle bolts. Toggle bolts shall extend into the cell of the masonry unit and shall be of the gravity or spring-swing type. Lavatories mounted on pipe chases shall be installed with one or two steel backup plates as required. The backup plates shall be 3.2 mm thick, 100 mm wide, and not less than the width of the fixture. Urinals mounted on pipe chases shall be installed with one to two steel backup plates as required, as specified for lavatories. Backup plates shall be suspended on the inner side of the chase by two 3.2 mm thick metal clips placed in the mortar joint. The metal clips and through bolts shall be tack-welded to each plate. The plates shall be installed horizontally and fastened to the top and bottom of the lavatory or urinal as required.

### **15.9.13 TYPES OF FIXTURES AND FIXTURES TRIMMINGS**

#### 1. GENERAL

Material specified herein shall be furnished and installed complete with all trimmings and fittings, unless otherwise specified.

#### 2. GENERAL REQUIREMENTS

Generally, all fixtures, except water closets and shall have the water supply above the rim. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock shield, loose-key pattern stops for supplies shall be furnished and installed with fixtures. Exposed traps and supply pipes for all fixtures and equipment shall be connected to the rough piping systems adjacent to the fixtures where rough piping is exposed and at the wall where concealed. Floor and wall escutcheons shall be provided where pipes enter walls or floors. Exposed fixture trimmings and fittings shall be chromium-plated on nickel-plated brass with polished, bright surfaces.

#### 3. FIXTURE CONNECTIONS

Where space conditions will not permit standard fittings in conjunction with the cast iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and sanitary pipe shall be made absolutely gastight and watertight with a closet-setting compound or with a neoprene gasket and seal. Use of natural-rubber gaskets or putty will not be permitted for these connections. Bolts shall be not less than 6.0 mm in diameter and shall be equipped with chromium-plated nuts and washers.

Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

#### 4. FLUSH VALVES

Flush valves shall be of the non-hold-open type.

#### 5. FIXTURES

##### 5.1 General

Sanitary wares shall be manufactured in accordance with JIS A5207 “Sanitary Wares”.

##### 5.2 Water Closets

Water closets shall be vitreous china similar and equivalent to type C 1210 of JIS A5207, completed with close-coupled tank, tank fittings, seat and cover.

##### 5.3 Lavatory-Wall Hung Lavatories

Wall hung lavatories shall be vitreous china with single faucet, back overflow, anti-splash front rim, flat shelf top, soap depression, chainstay with rubber stopper and chain.

##### 5.4 Countertop Lavatories

Countertop Lavatories shall be vitreous china, front or back overflow, single faucet, soap depression, chainstay with rubber stopper and chain.

##### 5.5 Urinals

Urinal shall be wall hung, vitreous china, top inlet similar and equivalent to type U 410R of JIS A5207 completed with flush valve and trap.

##### 5.6 Service Sinks

Service sink shall be wall hung with rolled rim, vitreous china, 33 cm minimum height, back splash single faucet, concealed hanger, and S-trap to floor similar and equivalent to type S210 of JIS A5207.

##### 5.7 Shower Heads

Shower heads shall be stainless steel of the adjustable spray type with ball joint connection. Shower piping shall be exposed.

### **15.9.14 TESTS AND STERILIZATION**

#### 1. TESTS FOR PLUMBING SYSTEMS

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

1.1 General

Sanitary, waste, vent, and water piping shall be tested by the Contractor and approved before acceptance. Underground sanitary and waste piping shall be tested before backfilling. Equipment required for tests shall be furnished by the Contractor.

1.2 Drainage and Venting System Piping

Piping shall be tested with water before the fixtures are installed. After the plumbing fixtures have been set and their traps filled with water, the entire drainage and venting system shall be submitted to a final test with smoke or peppermint.

1.3 Water Test

Water testing shall be applied to the drainage and venting system either in its entirety or in sections. If the entire system is tested, all openings in the pipes shall be tightly closed except the highest opening, and the system shall be filled with water to the point of overflow. If the system is tested in sections, each opening except the highest opening of the section under test shall be tightly plugged, and each section shall be filled with water and tested with at least a 3 meter head of water. The water shall be kept in the system, or in the portion under test, for at least 15 minutes before the inspection starts; the system shall then be tight at all joints.

1.4 Final Test

When the smoke test is employed, the smoke shall be produced by a smoke machine, and a pressure equal to 25 mm water column shall be maintained for 15 minutes before inspection starts. When the peppermint test is used, 2 ounces of peppermint shall be introduced into each line or stack.

2. WATER SYSTEM

When the roughing-in is completed and before fixtures are set, the entire water piping systems shall be tested at a hydrostatic pressure of not less than 0.686 MPa, and proved tight at this pressure for not less than 30 minutes in order to permit inspection of all joints. Where a portion of the water-piping system is to be concealed before completion, this portion shall be tested separately as specified for the entire system.

3. DEFECTIVE WORK

If inspection or tests show defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests repeated. Repairs to piping shall be made with new materials. No caulking of screwed joints or holes will be acceptable.

4. CLEANING AND ADJUSTING

Equipment, pipes, valves, fittings, fixtures and appurtenances shall be cleaned of grease, metal cuttings, and sludge that may have accumulated from operation of the system during the test. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building, due to the Contractor's failure to properly clean the piping system, shall be repaired by the Contractor. Flush valves and automatic control devices shall be adjusted for proper operation.

## 5. DISINFECTION

After pressure tests have been made, the entire water system shall be thoroughly flushed with water until all dirt and mud have been removed before introducing chlorinating material shall provide a dosage of not less than 50 parts per million and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe long enough to destroy all non-spore-forming bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 10 ppm of chlorine at the extreme end of the system at the end of the retention period. All valves in the system being sterilized shall be opened and closed several times during the contact period. The system shall then be flushed with clean water until the residual chlorine is reduced to less than 1.0 p.p.m. During the flushing period all valves and faucets shall be opened and closed several times. From several points in the system the Engineer may take samples of water in properly sterilized containers for bacteriological examination. Disinfection shall be repeated until tests indicate the absence of pollution for at least 2 full days.

The system will not be accepted until satisfactory bacteriological results have been obtained. The rate of discharging flushed, chlorinated water shall be controlled in an approved manner.

### 15.9.15 FURNISHINGS

Lavatory accessories shall be installed where indicated on the drawings and as specified in the Particular Specifications.