

1,500	12.7
1,600	12.7
1,800	13.1
2,000	15.1

The Contractor shall submit proposal to the Engineer for his approval when wall thickness of the proposed pipe is smaller than the above values as a result of detailed consideration.

5304. MATERIALS OF FITTINGS

- a. Fittings shall be standard weight, steel butt-welded, shop made fittings conforming to JIS G 3451 "Fittings of Coating Steel Pipes for Water Services " and Contract Drawings, unless noted otherwise.
- b. The dimensions of steel fittings shall conform to JIS G 3451. Exterior fitting arrangements shall be four piece, long radius 90 degree bends, unless noted otherwise. Fittings shall be reinforced as shown or as required. Reinforcement shall be in the form of saddles, collars or plates, no internal bars will be permitted. The laying length of reducers shall be such that the angle between the axis of the core and the pipe wall shall not exceed ten degrees unless specifically noted otherwise.
- c. All fittings shall be designed to have the same strength as the piping and reinforcing rings or saddles shall be provided where required. Minimum wall thickness of fittings shall equal wall thickness of pipe.
- d. Screwed fittings shall be malleable iron conforming to JIS G 5702 "Blackheart Malleable Iron Castings".

5305. MATERIALS AND METHOD OF COATINGS AND LININGS

(1) Coatings inside surface of the pipes

- a. Galvanized coating on the inside and outside of pipe with zinc shall conform to JIS G3452. The size of galvanized coating pipe shall be of 300 mm and smaller, which will be used at specified place as shown in the Drawings.
- b. Unless specifically noted otherwise, all steel pipe and fittings, used as liquid carrier, shall be tar epoxy coated on the inside in accordance with JWWA K115 "Tar Epoxy Resin Coating Method for Water Services".
- c. Tar epoxy coating at welded joints in pipeline of 600 mm in internal diameter and larger shall be completed on the

inside. Coating of the joints shall be accomplished after X-ray inspection of the jointing is completed.

- d. Thickness of tar epoxy coating film shall be of 0.35 mm in total. The coating procedures except primer coating shall be divided into two layers which shall consist of prime coating with 0.20 mm thick and second coating with 0.15 mm thick, respectively.
- e. Tar epoxy coating at the welded joint shall conform to JWWA K115 "Tar Epoxy Resin Coating Method for Water Services".

(2) Coating and wrapping outside surface of the pipes

- a. Unless noted otherwise, all steel pipe and fittings except galvanized coating pipes shall be coal-tar enamel coated with glass cloth wrapping on the outside surface of pipes in accordance with JIS G3492 "Coal-Tar Enamel Protective Coatings for Steel Water Pipe".
- b. The coating and wrapping method shall conform to single coating with single wrapping in accordance with JIS G3492. The thickness of enamel coatings including glass cloth wrapping shall conform to 3.0 mm in minimum.
- c. In the case of straight pipe, enamel about 0.5 mm thick shall be coated on the wrapped surface so that the texture of wrapped materials cannot be seen from outside.
- d. All field coating and wrapping at the welded joint after completion of X-ray inspection shall conform to the method mentioned in the standard of JIS G3492.
- e. Lapping when the wrapping materials is wrapped spirally shall, in general, conform to 20 mm or more for single wound case.
- f. The inspection shall be carried out on paint, wrapping, material, steel surface before prime coating, coating and wrapping, and results of inspection shall conform to the provisions specified in JIS G3492.

5306. FITTINGS AND JOINTS

(1) Fittings

- a. Unless specified otherwise, the fitting shall conform to Class 1 on Table 1 in the standard of JIS G3451 "Fitting of Coating Steel Pipes for Water Services".

- b. The fittings shall be manufactured by welding, using as material the mill steel pipes specified in Table 2 of JIS G3451, and coated in accordance with JIS G3452 "Carbon Steel Pipes for Ordinary Pipes" or JIS G3492 "Coal-Tar Enamel Protective Coating for Steel Water Pipe" and JWWA K115 "Tar Epoxy Resin Coating Method for Water Services".

(2) Joints

- a. The joints of steel pipe work shall be of flanged, screwed, couplings and welded joints unless noted otherwise.
- b. All joints shall be designed to have the same characteristics and strength as the connecting pipe.
- c. All joints for buried pipe over 300 mm in diameter which are not flanged, or welded shall be harnessed. Harness details shall be submitted for approval including calculations for thrust. Material for buried harnesses and harnesses located in structures shall conform to the General Specifications titled "Metal Work" of Division 6.
- d. Flanges, bolts, nuts and gaskets shall conform to all aspects of JIS B2212 "Basic Dimensions of 10 kg per sq. cm Ferrous Materials Pipe Flanges". Flanges shall have raised faces on the gasket surface machined to a spired serrated finish. Flanges shall be either back-faced or spot-faced around each bolt hole. Where steel flanges are bolted to cast iron or ductile iron flanges, the steel flanges shall be plain faced. Slip-on flanges shall be double welded to the pipe with a strength fillet weld jointing the flange hub to the pipe and a seal fillet weld inside the flange at the pipe end. Welding neck flanges shall be butt-welded to the end of the pipe.
- e. Screw joints shall conform to BS21 "Pipe Threads" or equivalent standards. Joints shall be made with graphite or inert filler and oil, with an approval graphite compound or with poly-tetrafluorethylene tape.
- f. Flexible couplings shall be made with Dresser Type Expansion Joint Class 1 couplings (Slip-on type couplings) in the standard of JIS G3451 "Fittings of Coating Steel Pipes for Water Service", and Croser Type couplings as manufactured by Japan Victaulic Ltd.

Dresser Type couplings shall be designed for the same pressure rating as the connecting pipeline. Croser Type couplings shall conform to the Drawing and manufacturer's standards and recommendations. Joint harnesses shall be provided on all unanchored bends and wherever else

required. The corrosion protection of the couplings shall be consistent with that of the associated pipes.

The Contractor shall submit Shop Drawing and detailed schedule to Engineer for his approval.

- g. Welded joints shall conform to the requirements of JWWA C206 "Field Welding of Steel Pipe Joints" and have beveled pipe end in accordance with JIS G3443 "Coating Steel Pipes for Water Services". Field butt welding of steel pipes 800 mm and larger shall be made from the inside of the pipes, and the welding of steel pipe 700 mm and smaller shall be made from the outside of the pipes.

Welding shall be carried out only by welders approved by the Engineer and each welder shall identify his own work by means of a stencilled mark.

Butt welded joints where pre-jointing of straight runs of pipe outside the trench is adopted shall be full penetration strength welds executed by manual or automatic procedures to the approval of the Engineer. Butt welds shall have a throat thickness not less than the thickness of the pipe wall. All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a mechanical brush and shall be left clean and dry.

Before starting the welding of pipe joint on the site, the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength, and arrangement.

5307. INSTALLATION

(1) Exposed piping

- a. The Contractor shall furnish and install sleeves or wall castings for all pipes passing through masonry walls and concrete floors or walls and concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting these items, the Contractor shall check all plans and figures which have a direct bearing on his pipe location and he shall be responsible for the proper location of his pipes during the construction of the structures.
- b. 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.

- c. Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.
- d. 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. All supporting piers and blocking shall be in place before temporary supports and bracing are removed.
- e. Threaded piping shall have a sufficient number of unions to allow convenient removal of piping. Flanged piping shall have a sufficient number of flanges to allow for convenient removal of piping.
- f. The Contractor shall furnish and place all inserts for the support of piping installed under this Section in masonry and in concrete forms before concrete is placed, unless otherwise permitted.
- g. The lining and coating shall be protected at all times. All repairs shall be the responsibility of the Contractor.
- h. Systems shall be arranged with low points and drains to permit complete drainage of the system. Control piping may be arranged with unions or union connections at low points to permit draining. Fill connections shall also be provided on closed systems where required.
- i. Adequate air vents shall be provided at high points in all liquid carrying pipes. Interior piping shall be rigidly supported as specified under the General Specification in Section 5700 "Pipe Hangers and Supports" of this Division.
- j. In case interference develops between piping and appurtenances, the Engineer will decide which work is to be relocated regardless of which was first installed.
- k. Thrust anchors shall be installed at fittings and other locations as directed by the Engineer. Minimum anchoring requirement shall be as shown on the Drawings.
- l. Upon completion of installation and testing, the Contractor

shall paint all exposed piping in accordance with the General Specification in Section 9400 "Painting".

(2) Trench piping

- a. Unless specified otherwise or as defined hereunder, the pipes shall be installed singly and shall not be jointed until after they have been installed.
- b. Joint of steel pipes outside the trench and installation as a string of pipes will be permitted only in straight trench where all parts of the string are lowered into the trench simultaneously. Such pre-jointed lengths shall not exceed 20 m without the Engineer's written permission. Snaking into trench of a pre-jointed string of welded steel pipes will under no circumstances be permitted.
- c. The pipes and fitting shall be accurately installed to the lines level grades and positions set out by the Contractor from data obtained by him following detailed field survey.
- d. Pipes and fittings which are required to be fixed onto or built into other structures shall be positioned to suit or as approved by the Engineer. Brackets and fixing shall be coated following painting and coating manner described in the previous clauses, unless Engineer specified otherwise.
- e. The Contractor shall keep the interior of pipes clean and free from water, dirt, stones and other foreign matter as installation proceeds, and at the end of the day's work or at other times when installation work is not proceeding the open ends of pipes shall be sealed off by a wooden plug or other approved stopper.
- f. The Contractor shall provide, operate and maintain adequate systems of lighting and ventilation through any part of the pipeline where work is in progress inside the pipe.
- g. Pipes which are required to be cut to form closing pieces in any portion of the pipeline or to terminate in manhole or other parts of the works shall not be cut until after all adjacent pipes have been installed and jointed.
- h. The bottom of the trench shall be accurately graded up to the pipe bottom to be installed. The backfill, after pipes installation completed, shall be made conforming to the specified method in Division 2 "Earth Works" with suitable soils used.
- i. The trench bottom shall be clean and prepared free from stones and hard lumps. Where unsuitable material is taken out, it shall be replaced by suitable material compacted to

achieve a strength not less than that of the material used for backfill. Any small pockets or imperfection in the trench invert shall be filled with sand and tamped to ensure full contact with the pipe barrel.

- j. The Contractor shall submit his proposal on the pipe installation method and construction equipments to be used prior to commencement of the works and require the Engineer's approval.

SECTION 5400. CONCRETE PIPE

5401. REINFORCED CONCRETE PIPE IN GENERAL

Cement shall conform to TIS 15 "Portland Cement" or ASTM C150, "Portland Cement".

Concrete and reinforcing steel shall be in accordance with the General Specifications in Division 3 entitled "Concrete Works".

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 designated for the respective wall.

Pipe shall have a minimum laying length of approximately 1.0 m, except for closure and other special pieces as approved by the Engineer. The Contractor shall have available at the site of the Works sufficient pipes of various lengths to effect closures at manholes and/or structures. Maximum laying length shall not exceed 2.5 meters, but the installation of 2.5 m lengths will depend upon the ability of the Contractor to handle such lengths of pipe in the respective areas of construction. If in the opinion of the Engineer the use of 2.5 m lengths is impracticable, shorter lengths shall be used.

5402. MATERIAL OF REINFORCED CONCRETE PIPE

Reinforced concrete pipe shall be centrifugally cast, vertically cast or roller-suspension cast, reinforced concrete culvert pipe fabricated by an established manufacturer and in an approved plant adapted to meet the design requirements of the pipe. Centrifugated machine made pipe may be used, as limited below, subject to specific approval by the Engineer as based upon performance tests. Full internal diameter shall be maintained on all concrete 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 ASTM C76, "Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe", with the exceptions and additions as follows:

Unless otherwise designated on the Drawings, all pipes will be class III with a minimum D-load of 0.659. The D-load is defined as the strength test requirements in kilograms per linear centimeter per centimeter of diameter of pipe under the 3 edge bearing method that shall produce a 0.25 mm wide crack. The pipe interior shall comprise a continuous integral cement skin. The strength and absorption tests will be required. The absorption shall not exceed 6.0 percent of the dry weight. Reinforcement shall be circular for all concrete pipe, and shall be of the cross-sectional areas as specified in ASTM C76. Full bond to all reinforcing is required.

As an alternate to the foregoing, pipe may be machine-made, by variations of the "packerhead" process, provided as follows: (1) that initial fabrication be followed by supplementary densification via specific adaptations of the centrifugating or roller suspension process, (2) that the pipe fully comply with all other physical requirements of this specification and (3) that the strength and other requirements be as specified herein. Pipe shall not be shipped until the compressive strength of the concrete has attained 280 kg per sq.cm and not before 5 days after manufacture.

5403. JOINTS OF REINFORCED CONCRETE PIPE

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 "G-Ring" type gasket or be designed to receive a cement mortar joint. The bevel on the tongue and bell of the pipe shall conform to the requirements of the manufacturer of the type of gasket used. Ends of pipe shall be made true to form and dimension by casting against steel forms. When the pipe is fully home and perfectly centered, the end clearance inside and out shall not exceed 4.75 mm. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

5404. PRESTRESSED CONCRETE PIPE IN GENERAL

The Contractor may furnish either prestressed non-cylinder concrete pipe or prestressed cylinder concrete pipe.

Cement shall conform to TIS 15 "Portland Cement" or ASTM C150, "Portland Cement".

Concrete and reinforcement shall be in accordance with the General Specification titled "Concrete Works" 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.

All piping shall be designed for a minimum working pressure of 10.0 kgs per sq.cm internal pressure; and a live load equivalent to AASHO HS 20-44 (H20-S16) loading.

5405. MATERIAL OF PRESTRESSED CONCRETE PIPE

(1) Non-cylinder Prestressed Concrete Pipe

Prestressed concrete, non-cylinder pipe shall conform to ES 4625 "Prestressed Concrete Pipes".

Fittings shall conform to mill and fabricated steel pipe of Clause 5302 "Materials of Pipes."

(2) Cylinder Prestressed Concrete Pipe

Prestressed concrete cylinder pipe shall conform to JIS A 5333 "Prestressed Concrete Pipes-Core".

Fittings shall conform to these specifications for cast iron or steel pipe.

5406. JOINTS OF PRESTRESSED CONCRETE PIPE

Joints for prestressed 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. The bevel on the tongue and bell of the pipe shall conform to the requirements of manufacturer of the type of gasket used. Ends of pipe shall be made true to form and dimension by casting against steel forms. When the pipe is fully home and perfectly centered, the end clearance inside and out shall not exceed 4.75 mm. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

5407. COATINGS AND LININGS OF PRESTRESSED CONCRETE PIPE

All fittings shall be cement mortar lined on the inside as specified in these specifications for cast iron or steel fittings.

The outside of all fittings shall be coated as specified in these Specifications for steel fittings.

All pipe and fittings shall have non-toxic bituminous seal coat applied to the inside surface in accordance with AWWA C104, "Cement Mortar Lining for Cast Iron and Ductile Iron Pipe and Fittings".

5408. MATERIAL OF NON-REINFORCED CONCRETE PIPE

Cement shall conform to TIS 15 "Portland Cement" or ASTM C150, "Portland Cement".

Concrete shall be in accordance with the General Specification in Division 3 "Concrete Works".

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.

Non-reinforced concrete pipe shall be in accordance with ASTM C14, "Concrete Sewer, Storm Drain, and Culvert Pipe, Including Tentative Revision". All pipes shall be extra strength.

Perforated concrete drain pipe shall have circular, cleanly cut perforations, 6 mm in diameter, arranged in rows paralleled to the axis of the pipe. Perforations shall be approximately 7.5 cm center to center, along the rows. The ends shall be unperforated for a length equal to the depth of the socket. Rows shall be arranged in two equal groups on either side of the vertical center line of the pipe. All rows shall be located below the horizontal center line of the pipe.

5409. JOINTS OF NON-REINFORCED CONCRETE PIPE

Joints shall be bell and spigot or tongue and groove. All joints shall have the same characteristics and strength as the connecting pipe.

5410. MATERIAL OF ASBESTOS CEMENT PIPE

Asbestos cement pipe and couplings shall conform to ISO Recommendation R160, "Asbestos Cement Pressure Pipes" and/or JIS A 5301 "Asbestos Cement Water Pipes" as herein modified. All pipes shall have full internal diameter.

The Contractor will be required to furnish the Engineer with a certificate stating that all the requirements of these Specifications for asbestos-cement pipe have been met, including the section on "Sampling and Testing Methods". In addition, asbestos-cement pipe may be inspected at the factory.

5411. FITTINGS OF ASBESTOS CEMENT PIPE

Fittings shall be cast or ductile iron conforming to the fitting specification for cast or ductile iron pipe, including linings, seal coats and exterior protection, as specified in these Specifications, except ends to be modified as shown on the Drawings.

5412. JOINTS OF ASBESTOS CEMENT PIPE

Joints for asbestos cement pipe and fittings shall be sleeve type couplings or gibault type cast iron sleeves. Couplings shall meet the requirements of JIS A 5520 "Cast Iron Joints and Fittings

for Asbestos Cement Water Pipes" and JIS A 5519 "Steel Joints and Fittings for Asbestos Cement Water Pipes. All Joints shall be designed to have the same characteristics and strength as the connected pipe.

Couplings shall be sleeve type for sealing with rubber rings. The joints shall be of such design that they will provide a continuous, watertight conduit when the ends are drawn together, and will permit expansion, contraction, settlement and lateral displacement.

All surfaces upon which the rubber ring may bear shall be smooth and free from spalls, cracks, or any defects that would affect proper sealing of the joint. Couplings with two (2) or three (3) rubber rings will be acceptable.

The necessary sealing rings shall be furnished with each coupling. The rings furnished shall conform in all respects to ASTM D1869, "Rubber Rings for Asbestos-Cement Pipe" and/or equivalent.

5413. INSTALLATION

Concrete and asbestos cement pipe shall be installed in accordance with the General Specification in Section 5800 "Underground Piping and Fittings".

SECTION 5500. POLYVINYL CHLORIDE PIPE

5501. Material of Pipe

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.

Plastic pipe shall be rigid, unplasticized, polyvinyl chloride (PVC) pipe as designated in JIS K 6741 "Unplasticized Polyvinyl Chloride (PVC) Pipes". The pipe shall be suitable for field cutting, welding, bending and coupling. Plastic pipe may be supplied from suppliers manufacturing in accordance with TIS 17, "PVC for Water Service" and/or JIS K 6741.

PVC PIPE WALL SCHEDULE

Nominal Size mm. (in.)	Average O.D. mm	Minimum Wall Thickness mm
13 (3/8)	18	2.2
16 (1/2)	22	2.7
20 (3/4)	26	2.7
25 (1)	32	3.1
30 (1 1/2)	38	3.1
40 (1 1/2)	48	3.6
55 (2)	60	4.1
65 (2 1/2)	76	4.1
75 (3)	89	5.5
100 (4)	114	6.6
125 (5)	140	7.0
150 (6)	165	8.9
200 (8)	216	10.3
250 (10)	267	12.7
300 (12)	318	15.1

5502. MATERIAL OF FITTINGS

All fittings shall be the socket type for rubber ring joints or for solvent welded joints as designated in JIS A 6743, JWWA K 119 or equivalent, and shall be compatible with the pipe where installed.

Unless noted otherwise, materials and strength of fittings shall be the same as those of the connecting pipe.

5503. JOINTS

Thread joints for PVC pipe shall conform to JIS K 6743 "Pipe Threads".

Flanged joints shall conform to ANSI 125 pound requirements, except as otherwise specified herein.

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 100 mm and larger shall use push-on or coupling joints. Joints shall have rubber O-ring gaskets.

5504. INSTALLATION

The installation of PVC pipe and fittings shall be strictly in accordance with the manufacturer's technical data and printed instruction.

Joints for PVC pipe shall be solvent welded or coupling type except flanged or thread, where required. In making solvent welded connections, clean dirt and moisture from pipe and fittings and follow procedure in ASTM D2564, "Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic 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.

Expansion joints shall be used on the outside face of structures. Exterior expansion joints shall be installed within an approved sleeve to keep joint free from dirt.

Particular care shall be taken not to overstress threaded connections at sleeves. Where PVC to exterior structures passes through wall sleeves, joints shall be caulked with a sealing element equal to Expandite.

Clamps for tubing shall be stainless steel.

PVC pipe and fittings shall be carefully handled and stored to preclude direct exposure to sunlight or contact to sharp objects.

The installation of buried PVC pipes and fittings shall be in strict accordance with the General Specification of this Division.

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.

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 or pipe coating or to adjacent structures or equipment. All supporting piers and blocking shall be in place before temporary supports and bracing are removed.

All piping shall have a sufficient number of unions or flanged joints to allow convenient removal of piping.

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.

The Contractor shall furnish and place all inserts for the support of piping installed under this Section in concrete forms before concrete is placed, unless otherwise permitted.

Systems shall be arranged with low points and drains to permit complete drainage of the system. Control piping may be arranged with unions or union connections at low points to permit draining. Fill connections shall also be provided on closed systems where 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 General Specifications of this Division.

All pipes shall be sound and clean before installation.

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.

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.

Upon completion of installation and testing, the Contractor shall paint all exposed piping in accordance with the General Specification in Section 9400 "Painting". Pipe which has a uniform color that matches the selected paint color for piping need not be painted. The Contractor shall install sleeves or wall castings for all pipes passing through concrete floors or walls and concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting these items, the Contractor shall check all plans and figures which have a direct bearing on his pipe location and he shall be responsible for the proper location of his pipes during the construction of the structures.

Where PVC pipe passes through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the PVC manufacturer and approved by the Engineer. Sealing compounds shall be applied in accordance with the manufacturer's instructions.

SECTION 5600. COPPER PIPE

5601. MATERIALS OF PIPE

Copper piping shall, in general, include all copper tubing, copper pipe, red brass pipe, and fittings. Either tubing or pipe may be used, unless otherwise specified. However, all piping in one system shall be of the same type. Piping shall be of the thickness specified herein and shall be of the longest lengths commercially available. Copper tubing shall be hard drawn when exposed and used in runs, and shall be annealed when used in instrument cabinets or confined area.

Copper tubing for water service and pressure sensing shall be ASTM B88, "Seamless Copper Water Tube", type K.

Copper tubing for pneumatic service shall comply with ASTM B68 "Seamless Copper Tube, Bright Annealed", or ASTM B75, "Seamless Copper Tube".

Copper pipe shall conform to ASTM B42, "Seamless Copper Pipe, Standard Sizes", hard drawn and regular weight.

Brass pipe shall be red brass conforming to ASTM B43, "Seamless Red Brass Pipe, Standard Sizes", regular weight.

Unless noted otherwise, copper piping, inside structures, shall be type K, hard copper tubing of copper or red brass, regular grade.

5602. MATERIALS OF FITTINGS

Fittings shall be cast bronze for copper pipe; cast bronze or copper fittings for copper tubing and cast red brass for red brass pipe conforming to ASTM B-30, "Copper-Base Alloys in Ingot Form for Sand Castings", alloy No.4B.

Unions shall be brass with ground joints and shall be semi finished.

Soldered fittings shall conform to ANSI B16.18 "Cast Bronze Solder Joint Pressure Fittings, with Addenda" and compression fittings shall be flared conforming to ANSI B16.26 "Cast Bronze Fittings for Flared Copper Tubes", or flareless.

5603. JOINTS

All joints shall be designed to have the same characteristics and strength as the connecting pipe.

Joints for copper, bronze or brass solder-type fittings shall be made with solder composed of 95 percent tin and 5 percent antimony.

Underground joints shall be made up using 100 percent silver solder.

Flux shall be compatible with solder. Screw joints shall be made tight with graphite paste or other approved pipe compound. Once a joint has been made, it shall not be broken or remade without thorough cleaning of the pipe and joints.

Flared and compression joints will be permitted only by written approval of the Engineer.

5604. INSTALLATION

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 littings 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.

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 or pipe coating or to adjacent structures or equipment. All supporting piers and blocking shall be in place before temporary supports and bracing are removed.

All piping shall have a sufficient number of unions to allow convenient removal of piping.

The Contractor shall furnish and place all inserts for the support of piping installed under this Section in concrete forms before concrete is placed, unless otherwise permitted.

Systems shall be arranged with low points and drains to permit complete drainage of the system. Control piping may be arranged with unions or union connections at low points to permit draining. Fill connections shall also be provided on closed systems where 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 General Specification in Section 5700 "Pipe Hangers and Supports" of this Division.

All pipe shall be sound and clean before installation.

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.

All threads for screw joints shall be clean, machine cut, and all pipes shall be reamed before erection. Each length of pipe as erected shall be up-ended and struck to dislodge dirt and scale.

Upon completion of installation and testing, the Contractor shall paint all exposed piping in accordance with the General Specification in Section 9400 "Painting".

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.

The Contractor shall install sleeves or wall castings for all pipes passing through concrete floors or walls and concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting these items, the Contractor shall check all plans and figures which have a direct bearing on the pipe location and he shall be responsible for the proper location of his pipes during the construction of the structures.

Where copper passes 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.

Unions shall be provided close to main pieces of equipment and in branch lines to permit ready dismantling of piping without disturbing main pipe lines or adjacent branch lines.

All tube bending shall be accomplished utilizing tube turns.

SECTION 5700. PIPE HANGERS AND SUPPORTS

5701. MATERIALS

Pipe supports and hangers shall be in accordance with the Manufacturer's Standardization Society Standard Practice SP-58, "Materials and Design" and SP-69, "Selection and Application", except as noted otherwise. Hangers for copper tubing shall be copper plated.

Overhead hangers for pipe less than 100 mm in diameter shall be type 1, 7, 10 or 11. Turnbuckles shall be type 13. Hangers shall be supported by threaded rods hung from inserts in the concrete.

Overhead hangers for pipes 100 mm through 600 mm shall be single pipe rolls and sockets, type 41, supported from beam clamps or supported from inserts as shown on the Drawings. Inserts shall be type 18 or 19 and shall be capable of accommodating the rods recommended in Standard Practice SP-69 and shall be capable of carrying the working load.

Hanger rods shall be machine threaded and the strength of the hanger shall be based on root diameter. For pipe under 50 mm except support rods for channel supports (see paragraph below) the rods shall be not less than 9.5 mm in diameter. For pipes larger than 50 mm the rods shall be in accordance with the recommendation of Standard Practice SP-69.

Pipe saddle supports shall be adjustable type, type 37 with U-bolt type 24 and pipe and floor flanges for bolting to the floor. Where used under base fittings, a matching floor flange shall be substituted for saddle section.

Where support is from walls or columns, welded steel brackets, type 31, 21 and 33, shall be furnished. Additional wall bearing plates shall be provided where required for wall brackets.

Wherever practicable, PVC piping shall be supported by channel supports (see paragraph below).

Where located on the Drawings, overhead supports for chemical feed piping shall be channel supports, as manufactured by Unistrut, Burndy or Electrovert. Ladders shall be supported by vertical supports with support hooks hung from inserts in the concrete.

Structural and masonry fasteners shall be steel anchor bolts, steel shell and expanded plug, lead cinch type or malleable iron expansion case.

Threads for all nuts, bolts and rods shall conform to ANSI standards.

Where indicated on the Drawings, piping supports shall consist of concrete piers or fabricated steel supports. In these instances, materials and workmanship shall be in full compliance with the General Specifications in Division 3 "Concrete Works", and "Miscellaneous Metal" and "Structural Steel" of Division 6. Structural steel shall conform to ASTM A36, "Structural Steel", or JIS G3101, "Rolled Steel for General Structures". The class of concrete shall be class D unless noted otherwise. The top 4 cm of concrete piers shall be grouted after the pipe is in its final position, with non-shrink grout.

5702. INSTALLATION

All piping shall be rigidly supported from the structures by approved hangers, inserts, or supports with adequate provisions for expansion and contraction. Support shall be provided at changes in direction and elsewhere at a spacing no greater than the spacing recommended in Standard Practice SP-69. Piping shall not be supported from other piping or from stairs, ladders, or walkways unless specifically directed by the Engineer.

Where piping is installed on structural steel supports, blocking of pipe rolls shall be provided to arrest lateral pipe movement.

All vertical pipes shall be supported at each floor or at intervals not to exceed 3 m by approved pipe collars, clamps, brackets, or wall rests, and at all points necessary to insure rigid construction.

Each section of pipeline shall be laid out all connections (cemented, welded, screwed) made while the pipe is supported on temporary supports. After completion of connections, the pipe shall be clamped in position. When piping is correctly installed on its permanent supports, a clamped pipe connection or pipe may be loosened or removed without displacement of the pipeline.

5703. PROTECTIVE COATINGS

All metal pipe supports and hangers shall be shop primed and painted as specified in the General Specifications in Section 9400 "Painting".

Dissimilar metals shall be insulated to prevent anodic reaction. Pipe supports for copper tubing shall be copper plated.

5704. WALL AND FLOOR SLEEVES

Wall and floor sleeves and castings shall be in accordance with the details shown on the Drawings.

All sleeves and castings passing through masonry and concrete walls or floors shall be cast in place, unless otherwise specified.

All floor sleeves shall extend a minimum of 7.5 cm above the finished floor line, unless noted otherwise.

Pipe sleeves not subject to hydrostatic pressure, shall have an inside diameter, sufficiently large enough, to permit the passing of the respective pipe flange or hub, unless noted otherwise.

Wall and floor sleeves and castings, subject to hydrostatic pressure, shall have intermediate collars.

Pipe harnesses shall be in accordance with the details shown on the Drawings.

SECTION 5800. INSTALLATION OF UNDERGROUND
PIPING AND FITTINGS

5801. SCOPE OF WORK

The Contractor shall furnish and install all underground piping and fittings, specified or ordered.

This section covers the installation of all pipes and fittings in the ground. All installation shall be in strict conformance with the respective manufacturer's instructions and applicable AWWA 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. Concrete shall be class D.

All clamps, rods, bands, special couplings, nuts, bolts, etc., used to restrain pipes or for other purposes shall be given a heavy coat of a bitumastic 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 night time and lunch time when pipe laying is not in progress, the end of the pipe shall be covered or have a water tight plug inserted.

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

No pipe shall be installed so that 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. All of these specials shall be manufactured by either the pipe manufacturer or a company specializing and experienced in the production of such equipment. 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 and all necessary fittings and specials on hand prior to commencement of the tie in.

5802. CAST IRON AND DUCTILE IRON PIPE

The reference AWWA specification for the installation of cast-iron and ductile-iron is AWWA C-600, "Installation of Cast Iron Water Mains".

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 ends. 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, except where designated on the Drawings. Granular material shall be placed in 20 centimeter layers on both sides of the pipe and compacted by hand tools. This filling shall be carried up to the crown of the pipe. 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 shall be rubber gasket mechanical or flanged. Joints for all pipes 400 mm and greater in diameter shall be harnessed.

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

Mechanical joints shall be in accordance with the "Notes on Method of Installation" under ANSI A21.11. 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 joint diameters and in rotation around the pipe. When properly assembled, the gland shall be equidistant from the bell face at all points.

Flanged joints shall be made up with a rubber gasket of 3 mm thickness.

5803. STEEL PIPE

The pipe shall be handled and installed in accordance with applicable sections of AWWA C600, "Standard Specifications for Installation of Cast Iron Water Mains" and the requirements described herein.

The ends of the pipe shall have wooden stiffeners installed inside the pipe at quarters 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 pipes shall not be occupied by workmen for any purpose. Stocking of 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. Modifications to this bedding shall only be as indicated on the Drawings. Granular material shall be placed on both sides of the pipe and compacted with hand tools in 20 centimeter layers up to the crown of the pipe. No blocking will be allowed under the pipe. Bedding shall be in accordance with the details shown on the Drawings.

Joints for steel pipes 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 full conformance with AWWA C206, "Field Welding of Steel Water Pipe Joints". Pipes and fittings 600 mm and larger shall be double welded with the lower half made from the inside and the upper half from the outside. After the welds have been inspected and approved by the Engineer the cement

lining and exterior coating shall be repaired as described in AWWA C205, "Cement Mortar Protective Coatings for Steel Water Pipe".

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

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

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. Care shall be taken not to damage the coating or lining of the pipe.

5804. REINFORCED CONCRETE PIPE

(1) General

The pipe shall be stored, 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 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 in the trench and the pipe shall be firmly bedded in this material to conform accurately to the line and grade shown on the Drawings. No blocking under pipe will be permitted.

Bedding is indicated on the Drawings.

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.

(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 crowbars 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. If motion at joints can be detected, a greater amount of backfill shall be placed before pressure is released.

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

(3) Cement Mortar Joints

If used for drainage pipe, 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. Saturate the jointing surfaces with water and fill the annular opening with mortar. Form a 45 degree fillet bead of mortar all around from spigot to top of 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. 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.

All locations to be determined in the field, tapping couplings and/or tapping saddles shall be installed. These taps shall be in full accordance with the pipe manufacturer's recommendations.

5805. PRESTRESSED CONCRETE PIPE

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

Fittings and mechanical joints shall be cast iron, ductile iron, or steel and shall have either restrained mechanical joints or flanged joints.

At crossings over streams and ditches, the pipe shall be steel with welded joints. At the junction of the steel to the concrete pipe and 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 provide a continuous even bearing for the entire length of the pipe.

The joints of the pipes 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 rubber gasket immediately before being inserted. 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 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 inserted 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. 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 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, sand 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.

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.

All pipe 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 floatation. 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 joint 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.

5806. 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.

5807. ASBESTOS CEMENT PIPE

All work shall be in full conformance with the manufacturer's recommendations and the requirements of AWWA C603 "Standard Specifications for the Installation of Asbestos Cement Water Pipe" except as otherwise provided herein.

Fittings for use with asbestos cement pipe shall be cast iron or ductile iron and shall have a rubber gasket type joint. Flanged joints shall be used where required.

At crossings over streams and ditches the pipe shall be steel with welded joints. Details and limits of steel pipe are shown on

the Drawings. At the juncture of steel pipe to asbestos cement pipe adaptor coupling shall be installed.

The pipe shall be bedded as shown on the Drawings. The bed shall provide a continuous even bearing for the entire length of the pipe.

The pipe shall be joined in accordance with the manufacturer's recommendations. The rubber rings or gaskets and pipe bells shall be kept clean and dry. The pipe shall be pushed into the coupling with bars or by means of a jack or come-along. Care shall be taken to protect the end of the pipe from damage while it is being pushed home. After the joint has been made, the pipes shall be separate by 5 mm to allow for expansion of the pipe. In no cases shall the pipe be left with ends solidly butted together. The final position of the rubber rings or gaskets shall be carefully checked around the entire circumference of the joint by a feeler gauge. Any improper seating of the joint shall be rectified by pulling the joint apart and rejoining the pipe as described above.

Joints shall be left exposed until the lines has been successfully pressure and leakage tested. The Engineer may choose to waive this requirement if traffic conditions warrant. Exposed joints shall be protected by wooden boxes or some other suitable method. Joints at thrust blocks shall not be left exposed.

Alignment shall be preserved and deflections at the joints shall not exceed the limits recommended by the pipe manufacturer.

Fittings other than those shown on the Drawings may be required to suit conditions at the time of construction. All fittings shall have thrust blocks of the sizes and shapes indicated on the Drawings. The Engineer may require that the size of these blocks be increased or otherwise modified.

All locations to be determined in the field, tapping couplings and/or tapping saddles shall be installed. These taps shall be in full accordance with the pipe manufacturer's recommendations.

Any field cuts in the pipe shall be made by an approved cutting device. Cut ends shall be smooth and at right angles to the centerline of the pipe. Tapering of cut ends shall also be made with an approved device and shall conform to the manufacturer's recommendations.

During times when pipe 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 Contractor shall adequately protect the pipe to preclude floatation.

5808. POLYVINYL CHLORIDE PIPE

Careful consideration must be given to the handling and storage of polyvinyl chloride pipe and fittings. 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 Works. 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 in a 20 centimeter depth of granular material. The same material shall be placed alongside the pipe and compacted in 20 centimeter layers up to the crown of the pipe. 30 centimeters of the same material shall be placed over the pipe and shall be carefully compacted in two layers.

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 centimeters in 30 meters 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.

5809. COPPER PIPE

Copper pipe shall be installed in a trench 30 centimeters wide and shall have a minimum cover of 50 centimeters. The pipe shall have 10 centimeters of bedding.

The entire trench and bedding shall be granular material. 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 centimeter space provided between the edges of the pipes. Pipe joints shall be soldered except for unions which shall be screwed.

5810. CONNECTIONS OF EXISTING PIPE

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 modification 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. 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 tool 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. 250 grams of calcium hypochlorite shall be deposited in the branch pipe prior to final fit up. As soon as the assembly has been installed and braced the Authority shall reopen the valves on the existing pipe. The branch valve shall be installed in a vertical position.

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 operation until a successful leakless installation has been made.

5811. 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 tender price. Where the Contractor elects to use a sleeve for installation this shall be done at no increase in cost to the Employer.

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 delay 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 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 the 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 of facility.

If any movement or settlement occurs which causes or might cause damage to structures, over, along or adjacent to the Works, 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

The size and wall thickness of the casing (sleeve) to be jacked to accommodate the contract pipeline shall conform to the Drawing shown. 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 safety or to the correct line the work shall be discontinued until agreement is reached on how to proceed.

(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 6. METALS WORKS

SECTION 6000. STRUCTURAL STEELWORK

6001. GENERAL

This Section covers all structural steelwork to be furnished by the Contractor. In addition, the Contractor shall furnish all labor, materials, equipment and incidentals required to erect the structural framing as shown on Drawings.

6002. DETAILING

The Contractor shall submit complete sets of detailed working and shop drawings and schedules of all structural steelwork in accordance with the Contract Drawings.

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 requirement. 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.

6003. MATERIALS

Materials, used in the Works, shall meet the following requirements of those hereinafter specified under the particular item:

Structural shapes, plates and bars unless otherwise noted	ASTM A36 "Structural Steel"	JIS G3101 "Rolled Steel for General Structures"
Corrosion resistant structural shapes, plates and bars	ASTM A242, "High Strength Low-Alloy Structural Steel"	JIS G3106 "Rolled Steel for Welded Structures"
Square steel columns	AISI C1015	
Welding rods	AWS Spec. for Arc Welding	
High Strength steel bolts	ASTM A325, "High Strength Bolts for"	

Shear connector studs	Structural Steel Joints"
- 4 in. long	ASTM A354, "Quenched and Tempered Alloy Steel
Steel pipe (medium weight)	Bolts and Studs"
	BS 1387, "Steel JIS G3452 "Carbon Steel Pipes for Ordinary Piping"
	Tubes and Tubulars

6004. WORKMANSHIP

Unless otherwise specified, structural steel shall be fabricated in accordance with the requirements of the AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings. 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.

Workmanship shall be in accordance with the General Specifications in Section 6200, "Metal Fabrication".

Materials for welding shall be in accordance with the recommendations of the manufacturer of the material to be welded and in accordance with AWS Standard. 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 assembly of field connections shall be reamed and the pieces match marked before disassembly. Drift pins shall be used only for bringing members into position and not to enlarge or distort holes. Any piece, weakened by reaming to compensate for eccentricity to a point where the strength of the joint is impaired, shall be rejected and a new and satisfactory piece shall be provided by the Contractor. Slotted holes and washers shall be provided for trueing up lintels and other steel requiring accurate alignment. During erection, approved temporary bracing shall be installed as required to prevent distortion or damage to the framework due to wind or erection forces.

6005. WELDING

Welding shall be in accordance with the General Specification in Section 6200 "Metal Fabrication".

The Contractor may substitute field bolting where field welding is shown, provided bolting details have Shop Drawing approval.

6006. BOLTING

High-strength bolts shall conform to the Specifications for the Assembly of Structural Joints using High-Strength Steel Bolts, as approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation.

Anchor bolts shall be of mild steel with hexagonal nuts. Threads shall be clean cut and conform to ANSI, B1, 1, "Unified Screw Threads", coarse thread UNC, class 3A. 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. The Contractor may substitute wooden templates in lieu of screed plates upon written approval.

Anchor bolts with pipe sleeves shall be in accordance with the details shown on the Drawings.

Bolt anchors shall be of the cinch, rawl or slug-in type. Anchors shall be minimum two unit type.

Bolt and nut threads, to be galvanized, shall conform to ANSI B1.1, Class 2A.

6007. PAINTING

(1) Shop Painting

All structural steel shall be given shop primer after fabrication and cleaning but before shipping in accordance with the General Specification in Section 9400 "Painting".

All steelwork 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 General Specification in Section 9400 "Painting".

SECTION 6100. MISCELLANEOUS METALS

6101. GENERAL

This Section covers 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.

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 Works. The certification shall contain the results of chemical and physical tests required by the specifications for the materials.

The Contractor shall submit three (3) samples of all materials to be supplied under this Section for approval.

6102. COORDINATION

The Contractor shall completely coordinate the Works of this Section with other contracts. The Contractor shall verify, at the site, both the dimensions and work of other contractors which adjoin his materials before installation of items herein specified. Field measurements shall be taken at the site and incorporated in the Shop Drawings.

The Contractor shall furnish all necessary templates and patterns required by other Sections. He shall also furnish to the pertinent contractor, all items included under this Section, that are to be built into the work of other contracts, and shall supervise and be responsible for the proper location and installation of such.

6103. MATERIALS

Materials used in the Works shall conform to the following requirements:

Ductile iron	ASTM A536 (grade 60-4-18) "Ductile Iron Castings"	JIS G5502, "Spheroidal Graphite Castings"
Structural steel bars and shape	ASTM A36 "Structural Steel"	"Graphite Castings"

Mild steel for railing, posts, flanges and sleeves (standard strength unless noted otherwise)	ASTM A53 "Welded and Seamless Steel Pipe"	JIS G3454 "Carbon Steel Pipes for Pressure Service"
Steel pipe (medium weight)	BS 1387 "Steel Tubes and Tubu- lars Suitable for Screwing to BS 21 Pipe Threads"	JIS G3452 "Carbon Steel Pipes for Ordinary Piping"
Cast iron	ASTM A48 (class 30) "Gray Iron Castings"	JIS G5501, "Gray Iron"
Bolts and nuts	ASTM A307 "Low Carbon Steel Externally and Internally Treaded Standard Fasteners"	
Cast steel	ASTM A27 "Mild-to-Medium-Strength Carbon-Steel Castings for General Application"	JIS G5101, "Carbon Steel Castings"
Stainless steel pipe	ASTM A269, type 304 "Seamless and Welded"	JIS G3463 "Stainless Steel Boiler and Head"
steel pipe nuts	ASTM A269, type 304 "Seamless and Welded Austenitic Stainless Steel Tubing for General Service"	JIS G3463 "Stainless Steel Boiler and Head Exchanger"
Stainless steel plate and sheet	ASTM A480, type 304 "General Requirements for Delivery of Flat- rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip"	
Stainless and shapes	ASTM A276, type 304 "Stainless and Heat- Resisting Steel Bars and Shapes"	

Aluminum for structural shapes	ASTM B221, alloy 6061, temper T6 "Aluminum - Alloy Extruded Bars, Rods, Shapes, and Tubes"	
Architectural aluminum	ASTM B221, alloy 6063, temper T5	
Rolled steel	ASTM A283 C "Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality"	JIS C3101 "Rolled Steel for General Structures"
Square steel columns	AISI C1015	

6104. 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 of welds 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.

Pipe railing panels shall be straight and true to dimensions. Adjacent railing panels shall align with a variation of not to exceed 1.5 mm. Joints shall be match marked.

6105. FINISHES

All steelwork 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 General Specification in Section 9400 "Painting". 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 not be painted, unless noted otherwise.

Castings shall receive a coat of coal-tar pitch varnish before shipments. The varnish shall present a smooth finish and shall be tough but not brittle.

Cadmium coatings and chromium coatings shall conform to the General Specification in Section 6200 "Metal Fabrication".

Galvanizing shall conform to the General Specification in Section 6300 "Galvanizing".

All aluminum exposed surfaces shall have satin finish, free from die markings, scratches, welding discolorations, "leave-off marks", or other surface blemishes. Unless otherwise specified, aluminum shall be given an anodic oxide treatment in accordance with the Aluminum Association Specification AA-C22-A31. Aluminum, which after installation, will be exposed to severe corrosive conditions or wearing, shall have a finish equal to the Aluminum Association AA-C22-A41. A coating of methacrylate lacquer shall be applied to all aluminum before shipment from the factory.

All exposed stainless steel surfaces shall have a ASTM A240, "Stainless and Heat-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet and Strip for Fusion-Welded Unfired Pressure Vessels", No.4, polished finish, free from die markings, welding discolorations or other surface blemishes.

6106. INSTALLATION

The Contractor shall install all items furnished including items to be embedded in concrete.

Items, to be attached to concrete after such work is completed, shall be installed in accordance with the details shown on the Drawings. Fastening to wood plugs in concrete will not be permitted. The Contractor may use plastic or fiber covered lead inserts.

All aluminum surfaces to come in contact with concrete shall receive a heavy protective coating of bitumastic applied in a neat manner. All aluminum surfaces to come in contact with dissimilar metals shall receive a heavy brush coat of zinc - chromate primer followed by two coats of aluminum paint and a fabric separator.

6107. BOLTS AND NUTS

Unfinished bolts shall have hexagonal heads and hexagonal nuts. The bolts shall be long enough to extend entirely through the nut but

not more than four (4) threads beyond. Washers under nuts shall be furnished, but will not be required under the heads of bolts unless required by the Drawings.

Treads for all nuts and bolts shall comply with ANSI B1.1. "Unified Screw Threads", coarse thread, UNC class 3A.

Anchor bolts, with or without pipe sleeves, shall be in accordance with the details shown on the Drawings and include washers and hexagonal nuts.

Galvanized bolts shall be of the hot dip galvanized type.

Screw and bolt anchors, that are not shown, shall be cinch anchors, rawl or of the slug-in type. Anchors shall be minimum "two unit" type. Toggle bolts shall be of the size indicated and shall be galvanized.

Bolt and nut threads, to be galvanized shall be conformed to ANSI B1.1, Class 2A.

6108. HAND RAILINGS

Hand railings indicated to be steel pipe shall be constructed pipe conforming to BS 1387 "Steel Tubes and Tubulars Suitable for Screwing to BS 21 Pipe Threads" Medium class. Railings shall be black steel unless called for to be galvanized. Joints shall be welded in conformance with the details shown on the Drawings except railings required to be galvanized shall have galvanized socket joints.

Railings shall be of the two rail or one rail type with vertical posts or wall anchorage all as indicated on the Drawings.

Fasteners for joining rails will only be permitted at removable sections, expansion joints, or as indicated.

Railing posts may be set in boxed out sleeves, or pipe sleeves. Posts shall be grouted in using cement mortar and a steel coverplate. Attachments to vertical surfaces shall be as shown on the drawings. Galvanized chains shall be installed across opening in railings where indicated. One end of each chain shall be provided with a hook and eye for attachment purposes.

6109. GRATINGS

Floor grating shall be mild steel and of the type, depth and thickness shown on the Drawings. Grating subject to vehicular traffic shall be designed for a minimum live load equal to AASHO HS-20-44, unless noted otherwise.

Bearing bars shall span the shorter dimension, unless indicated otherwise. 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 shall be field attached with approved clips and anchors. Grating, in the final position, shall have all surfaces firmly bearing.

6110. NON-SLIP TREAD NOSING

Non-slip tread nosings shall be provided in all concrete and terrazzo stairs, including each tread, edge of each intermediate landing, and edge of each top platform; unless noted otherwise. Nosings shall be brass or aluminum. Brass nosings shall conform to the Shop Drawings. Aluminum nosings shall be embedded with silicon carbide abrasives.

6111. STAIRS

Steel stairs shall be mild steel and conform to the Shop Drawings. Attachments for pipe railing shall be provided. Stairs shall be of the open riser type, unless noted otherwise.

6112. LADDERS

(1) General

Ladders shall be mild steel and be of the type shown in the Drawings. Ladders 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 in the Drawings. Attachments for pipe railings shall be provided.

(3) Vertical Ladders

Stringers and rungs shall be as shown in the Shop Drawings. Stringers shall be drilled and the rungs plug welded with the ends flush with the outside of the stringer.

Vertical ladders, over 4.5 m in height, shall be provided with continuous safety cages. Safety cages shall start 2.2 m above the floor ground and continue to the top of the stringers. Cages shall have equally spaced, horizontal hoops welded to the stringers and vertical bars.

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.

6113. MANHOLE RUNGS

Manhole step rungs shall be cast iron or ductile iron; fabricated to the Shop Drawings. All rungs shall be hot dipped, galvanized. The step surface of all rungs shall be of the non-slip type and be of drop section design.

6114. TREADS

Treads shall conform to the details shown in the Shop Drawings and shall be of the floor grating or checkered plate type. Floor grating treads shall have non-slip nosing. Exterior grating treads shall be galvanized. Treads shall be attached to stringers by welding or bolting.

6115. CAST IRON FRAMES AND COVERS

Cast iron frames and covers shall conform to the General Specification in Section 6200 "Metal Fabrication", and be furnished and set by the Contractor. Frames with flanges shall have equally spaced side braces. All covers and grates shall have two (2) lift holes located 180° 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 or similar device. 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 shall have letters cast in. The Contractor shall receive approval of Shop drawings prior to casting.

6116. BAR SCREENS, WHEEL GATES, FLAPGATES AND STOPILOGS

Bar screens and wheel gates shall be fabricated as detailed of structural grade steel. Spacing of screen bars shall be as shown in the Drawings.

Guides shall be structural grade steel.

Wheels shall be hollow or solid cast steel with self lubricating bronze roller or ball bearings. They shall be such as to rotate around a fixed shaft, and give easy roll when the screens are moved vertically. The wheels shall be set so as not to move or wobble on the shaft. The shaft (axle) shall be set flush with the frame of the screens or racks and shall be such as to provide easy disassemblage of the mechanism.

The frame assembly of all screens shall be fitted with spring steel clips welded to the frame. The clips shall assist in positioning the screen.

6117. RUBBER "J" SEALS

The Contractor shall furnish and install water tight joint material equal to "J" seals where indicated on the Drawings.

Rubber "J" seals shall be fabricated from high grade tread type compound. The basic polymer shall be synthetic rubber. The material shall be compounded and cured to have the following characteristics:

Tensile strength, minimum	-	175 and 210 kg per sq.cm
Elongation at break, minimum	-	450%
Shore durometer (Type A)	-	60 - 70
Specific gravity	-	1.16 + 0.04
Absorption of water, by weight percent maximum (2 days at 70°C)	-	5%
Compression set (constant deflections) percent of original deflection, maximum	-	30%

Tensile strength after oxygen bomb aging (48 hours, 70°C, 21 kgs per sq.cm)	-	80%
percent of tensile strength before aging minimum		
Elongation after oxygen pressure test (48 hours, 70°C, 21 kgs per sq.cm)	-	80%
percent of elongation before aging, minimum		

6118. COVERS AND CHECKERED PLATE

Checkered plate shall be safe and durable. Raised lugs shall be especially designed to increase skid resistance to prevent accidents. Lug patterns shall be submitted for approval. Build up of weld metal for a lug pattern will not be permitted. Removable plates shall have recessed handles. Hinges shall be provided where shown in the Drawings.

6119. THRESHOLDS

All thresholds shall be aluminum extrusion, similar to details shown on the Drawings. Aluminum shall have a standard mill finish. Thresholds shall be firmly anchored by means of cinch bolts and screws. A minimum of three anchors shall be provided for each of the two sides.

6120. FENCES

Ornamental steel fences shall be in accordance with the details shown in the Drawings. Locks, keys and master keys shall be in accordance with the General Specification in Section 9505 "Hardware". All fencing shall be shop primed and finish painted in accordance with the General Specification in Section 9400 "Painting".

6121. SHEAR GATES

Shear gates shall be fabricated from mild steel and conform to the sizes and details shown on the Drawings. Gates shall be positioned by pinning. Guides, to be cast in concrete, shall be furnished and installed accurately to preclude binding or distortion of the gate.

6122. RAILS

Steel rails of the sizes, lengths, weights and details shown on the Drawings shall be furnished and installed for bridge cranes, monorails, trash rack rake, wheel gates. In general it is anticipated that the rails for conveying systems will be furnished with the system. When the Contractor proposes to furnish rails separately they shall be compatible with the requirements of the equipment to be mounted on the rails.

The Contractor may substitute good quality rails as normally available in local markets.

Rails shall be attached with accessories as noted on the Drawings in an approved manner.

6123. DOVETAIL ANCHORS

Anchor slots and anchors for anchorage of exterior walls to concrete shall be fabricated of galvanized sheet to the details indicated on the Drawings. Slots shall run continuously the height of the wall and anchors shall be installed between every third concrete and hollow brick block course, unless noted otherwise. Grooves shall be provided with filler material during concreting to prevent concrete from entering the anchor slot.

6124. STOPGATE GANTRY

Gantry shall be manually operated and equipped with steel wheels with grease lubricated ball bearings on casters to allow a full 360 degree turn. Gantry shall be constructed of steel members to the details indicated.

The gantry shall have a built-in hoist and trolley of the capacity noted.

The hoist shall be on a trolley mounted on the cross beam between the end supporting frames.

It shall be so designed that when the pull on the lifting chain is stopped the chain will be locked and further vertical movement will occur when the lifting chain is pulled.

After erection the Contractor shall furnish labor as required to operate the gantry under proposed operating conditions. Any defects shall be corrected at the Contractor's expense.

6125. STEEL HANGERS FOR WOOD FRAMING

Steel rafter hangers, gussett plates, and similar devices for wood framing shall be fabricated from gage steel and galvanized after fabrication and drilling. Sizes shall be as indicated on the Drawings.

SECTION 6200. METAL FABRICATION

6210. GENERAL

This section covers the workmanship standards applicable to the various phase of metal work fabrication, the methods and precautions for erection of metal structures and machines, the general requirements for tests and trials on such structures and machines to insure conformance with the Specifications, and miscellaneous requirements incident to the Work.

6202. WORKMANSHIP

(1) General

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 Works 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.

(2) Dimensional Tolerances for Structural Work

Dimensions shall be measured by means of an approved calibrated steel tape of the same temperature as the structure at the time of measurement. Unevenness of platemwork shall not exceed the limitation of standard mill practice as specified in the American Institute of Steel Construction, "Manual of Steel Construction".

An allowable variation of 1 mm is permissible in the overall length of members with both ends milled. Members without milled ends, which are to be assembled to other steel parts of the structure, shall not deviate from the dimensions shown on the Drawings by more than 1.8 mm for members 10 meters or less in length, and by not more than 3 mm for members over 10 meters in length.

(3) Camber

Unless otherwise specified, joists having spans of 12 meters or greater shall have minimum cambers as given in the table at the end of this Section. Reverse camber in any joists in excess of 1/1000 th of the span shall be cause for rejection.

TABLE OF MINIMUM CAMBER

<u>Span of Joints Meters</u>	<u>Minimum Camber at Center Centimeters</u>
12 to 14.9	1.0
15 to 17.9	2.0
18 to 20.9	3.0
21 to 23.9	4.0
24 to 26.9	5.0
27 to 29.9	6.0
30 to 36	7.0

6203. WELDING

Welding of parts shall be in accordance with the Standard Code for Arc and Gas Welding in Building Construction of the AWS and shall only be done where shown on the Drawings, specified, or permitted by the Engineer. All welding shall be done only by welders certified as to their ability to perform welding in accordance with locally accepted testing requirements. The AWS Code will be used as guide.

Welding of pressure vessels shall be in accordance with the ASME, "Boiler and Pressure Vessel Code" and/or JIS B8243 "Construction of Pressure Vessels".

Welding of steel water pipe shall be in accordance with AWWA C206, "Field Welding of Steel Water Pipe Joints".

Damage to galvanized areas shall be thoroughly cleaned by wire brushing and all traces of welding flux and loose or cracked zinc coating removed prior to painting. The cleaned area shall be painted with two coats of zinc oxide-zinc dust paint conforming to the requirements of Federal Specifications MIL-P-15145. The paint shall be properly compounded with a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight. As an alternate to the above, the Contractor may submit for approval the use of a galvanizing rod or galvanizing solder to repair damaged areas.

6204. FLAME CUTTING

Low-carbon structural steel may be cut by machine-guided or hand-guided torches instead of by shears or saw. Flame cutting of material, other than low-carbon structural steel, shall be subject to approval and where proposed shall be definitely indicated on Shop

Drawings submitted to the Engineer. Where a torch is mechanically guided, no chipping or grinding will be required except as necessary to remove slag and sharp edges. Where a torch is hand guided, all cuts shall be chipped, ground, or machined to sound metal except where material is to be welded, in which case burrs and rough edges only shall be removed. Where the torch is mechanically guided, flame gauging will be permitted in preparation for welding.

6205. BOLTED CONNECTIONS

(1) Bolt Holes

Holes for unfinished bolts, unless noted otherwise, shall be not more than 1.6 millimeters larger than the nominal diameter of the bolts. Unless otherwise specified or shown on the Drawings, holes for turned bolts shall be not more than 0.50 millimeters larger than the nominal diameter of the bolt. Where the thickness of the material is greater than the nominal diameter of the bolt, holes for unfinished bolts shall be subpunched and reamed or sub-drilled and reamed or drilled from the solid metal. Holes for turned bolts shall be truly cylindrical throughout and drilling or reaming shall be done after the parts to be connected are assembled. Mismatching of holes shall be cause for rejection.

(2) Bolt and Nuts

Threads of bolts and nuts shall conform to ANSI standards. Bolt and nuts shall conform to the applicable provisions of Federal Specifications FF-B-575b for "Bolts, Hexagon and Square" and FF-N-836a for "Nut, Plain (Square, Hexagon and Cap), Nut Slotted and Castellated, Hexagon". The finished shank shall be long enough to provide full bearing, and washers shall be used under the nuts to provide full grip when the nuts are tightened.

(3) Washers

Plain washers shall conform to the requirements of ANSI B27.2, "Plain Washers", heavy series and lock washers shall conform to the requirements of ANSI B27.1, "Lock Washers" heavy series. Washers shall be provided for applications specified elsewhere and where indicated on the Drawings. Galvanized washers shall be provided under the bolt head and also the nut in assembling all galvanized parts.

(4) Special Bolted Connections

Where turned bolts with closer fits than specified above are required, the bolts shall have a nominal body diameter at least 1.6 mm larger than the nominal diameter of the threaded portion and the body length shall be 1.6 mm to 3.2 mm greater than the combined thickness of the connected members unless otherwise indicated on the Drawings. Holes shall be as specified or indicated on the Drawings. Plain washers shall be provided.

6206. MACHINE WORK

(1) General

Unless otherwise shown on the Shop Drawings, all tolerances, allowances and gages of metal fits of cylindrical parts shall conform to ANSI B4.1 and Errata "Preferred Limits and Fits for Cylindrical Parts", for the class of fit as shown on the Drawings or otherwise required. In general, tolerances for machine finished surfaces, designated by non-decimal dimensions, shall be within 0.4 mm. Sufficient machining stock shall be allowed on placing pads to insure surfaces of solid material. Finished contact or bearing surfaces shall be true and exact to secure full contact. Journal surfaces shall be polished and all surfaces shall be finished with sufficient smoothness and accuracy to insure proper operation when assembled. Parts entering any machine shall be carefully and accurately machined and all like parts shall be interchangeable. All drilled holes for bolts shall be accurately located.

(2) Finished Surfaces

Where surface finishes are indicated on the Drawings, or specified herein, the symbols used or finishes specified, are in accordance with ANSI B46.1, "Surface Roughness, Waviness and Lay". Values of roughness height specified are arithmetical average deviation expressed in micro inches. Roughness specified is the maximum value and any lesser degree will be satisfactory. Compliance with specified surface will be determined by sense of feel and by visual inspection of the work compared to roughness comparison specimens, in accordance with the provisions of ANSI B46.1. Values of roughness width and waviness height are not specified, but shall be consistent with the general type or finish specified by roughness height. Flaws such as scratches, ridges, holes, peaks, cracks or checks which will make the part unsuitable will be cause for rejection.

Where the finish is not indicated or specified, the type of finish shall be that type which is most suitable for the surface to which it applies and shall be consistent with the class of fit required. Surfaces to be machine finished shall be indicated on the Shop Drawings by symbols which conform to ANSI B46.1.

(3) Unfinished Surfaces

So far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined, to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown on the Drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts may be filled in a

manner approved by the Engineer.

(4) Pin Holes

Pin holes shall be bored true to gages, smooth and straight, and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position.

(5) Gears

Unless otherwise specified or shown on the Drawings all gears shall have machine cut teeth of a form conforming to the applicable AGMA standards.

(6) Shafting

Unless otherwise specified, all shafting shall be turned or ground steel shafting. Fillets shall be provided where changes in section occur. Cold-finished shafting may be used, where keyseating is the only machine work required.

(7) Bearings

Unless otherwise specified or shown on the Drawings, bearings may be lined with babbitt or bronze. Babbitt shall conform to ASTM B23, "White Bearing Alloys". Where the bearing pressure is in excess of 14 kg/cm^2 , bearings shall be lined with bronze. Unless otherwise required or authorized, pressures on lined bearings shall not exceed 70 kg/cm^2 of projected area. Antifriction bearings of types and of sizes not less than those recommended by the bearing manufacturer for the duty may be permitted at the discretion of the Engineer. All bearings shall be properly aligned and provided with a suitable means for lubrication. Antifriction bearings shall be so installed as to provide for lubricant and to exclude dirt and grit.

(8) Protection of Machine Surfaces

Machine-finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces of large parts and other surfaces shall be protected with wooden pads or other suitable means. Unassembled pins and bolts shall be oiled and wrapped with moisture resistant paper or protected by other approved means.

Finished surfaces of ferrous metals to be in bolted contact shall be washed with a rust inhibitor and given one thin coat of white or blue lead and tung oil.

Finished surfaces of ferrous metals which will be exposed after installation shall be painted as specified in the General Specification in Section 9400 "Painting". Corrosion resisting steel, non ferrous metal and galvanized surfaces shall not be painted.

(9) Lubrication

Before erection or assembly, all bearing surfaces shall be thoroughly cleaned and lubricated with approved lubricant. After assembly, all lubricating systems shall be filled with the lubricant specified, or approved and, as required, additional lubricant shall be applied at regular intervals to maintain the equipment in satisfactory condition until accepted.

6207. STEEL PLATE AND PROTECTION ANGLES

Steel plate and protection angles required for the protection of concrete work shall be erected true to line and grade within the tolerances specified below. The edges of exposed faces may have a vertical or horizontal distortion from a straight line not greater than 3 mm per meter of length, provided, that distortion for any single piece shall not exceed 1.0 mm and provided, that when the warp is greater than 1.6 mm an extra anchor holes shall be drilled near the proper corner and the piece drawn into position thereby. All bolt heads on the exposed face shall be countersunk and fitted or ground so that the heads are flush with the finished surface. Joints between abutting sections shall be square and flush and the butting ends shall be sawed or otherwise made smooth and regular.

6208. METALLIC COATINGS

(1) Zinc Coatings

Zinc coatings shall be applied in a manner and of a thickness and quality conforming to the Standard Specification titled "Galvanizing" of Division 5.

(2) Cadmium Coatings

Cadmium coatings shall be of a quality and thickness conforming to the requirements of ASTM A165, "Electrodeposited Coatings of Cadmium on Steel" type NS.

(3) Chromium Coatings

Chromium coatings shall be applied in conformity with ASTM B177, "Chromium Coatings on Steel for Engineering Use"

6209. CASTINGS AND FORGINGS

(1) General

Each casting shall have the mark number cast upon it. Each

casting shall have the heat number stamped or cast upon it. Each forging shall have the mark number stamped upon it. Dimensions of casting shown on the approved Shop Drawings will be the finish dimensions.

(2) Castings

Repair to castings shall not be made without the knowledge and prior approval of the Engineer. Deviations from the dimensions and the thickness of castings, as shown on the Drawings, will not be permitted to exceed such amounts as will impair, by more than 10 percent, the strength of the casting as computed from the dimensions shown. Warped or otherwise distorted castings or castings that are oversize to such an extent as will interfere with proper fit with other parts of the machinery will be rejected. The structure of the metal in the castings shall be homogeneous and free from excessive non-metallic inclusions. Excessive segregation of impurities or alloys at critical points on a casting will be cause for its rejection.

6210. PATTERNS

In the construction of patterns, care shall be taken to avoid sharp corners or abrupt changes in cross section, and ample fillets shall be used. The Contractor shall add such draft and increases in pattern thicknesses as will conform to this standard foundry practice and as may be necessary to insure that all metal thickness of the finished castings will be in accordance with the dimensions and tolerances shown on the Drawings.

6211. LIST OF MATERIALS

When so requested by the Engineer, the Contractor shall furnish three (3) copies of all purchase orders, mill orders, shop orders for materials, and work orders, including all orders placed by each subcontractor. Where mill tests are required, the purchase orders shall contain the test site address and the name of the testing agency. The Contractor shall also furnish a shipping bill or memorandum of each shipment of finished pieces or members to the project site, giving the designation mark and weight of each piece, the number of pieces, the total weight, shipping line and number. Copies of certified shipping bills, in duplicate, shall be delivered promptly.

6212. SHOP ASSEMBLY

Machinery and structural units furnished shall be assembled in the shop. Items to be shop assembled shall be specified in the Particular Specifications or on the Drawings. An inspection shall be made to determine the correctness of the fabrication and matching

of the component parts. The tolerances shall not exceed those shown on the Drawings and each unit assembled shall be closely checked to insure that all necessary clearances have been provided and that binding does not occur in any moving part. Assembly and disassembly work shall be performed in the presence of a representative inspector, unless waived in writing by the Engineer, and any errors or defects disclosed shall be immediately remedied by the Contractor. Before disassembly for shipment, each piece of a machine or structure shall be match-marked to facilitate erection in the field. The location of match-marks shall be indicated by circling with a ring of white paint after the shop coat of paint has been applied, or as otherwise directed.

6213. FIELD ASSEMBLY

(1) General

All parts to be installed shall be cleaned thoroughly; all packing compounds, rust, dirt, grit and other foreign matter removed; all holes and grooves for lubrication cleaned; and all enclosed chambers or passages examined to make sure that they are free from injurious materials. Where units or items are shipped as assemblies they will be inspected by a representative of the Engineer, prior to installation. Disassembly, cleaning and lubrication will not be required except where there is indication that such work is necessary to place the assembly in a clean and properly lubricated condition. The top of all steel floor plating and gratings, shall be installed flush with abutting curb surfaces. Stillson wrenches, cold chisels, or other tools, likely to cause injury to the surfaces of rods, nuts, or other parts, shall not be used for the work of assembling and tightening parts. Bolts and screws shall be tightened firmly and uniformly, but care shall be taken not to overstress the threads by using excessive force or wrenches of excessive length. When a half nut is used for the purpose of locking a full nut, the half nut shall be placed first and followed by the full nut. Threads of all bolts, nuts, and screws shall be lubricated by lead and oil before assembly. Driving and drifting bolts or keys will not be permitted.

(2) Alignment and Setting

Each machinery or structural unit shall be accurately aligned by the use of steel shims, or other approved methods, so that no binding in any moving parts or distortion of any members occurs before it is finally fastened in place. The alignment of all parts with respect to each other shall be true within the respective tolerances required. The machines shall be set true to the elevations shown on the Drawings.

(3) Blocking and Wedges

All blocking and wedges used for the support during

installation, of parts to be grouted in, shall be removed before final grouting, unless otherwise directed by the Engineer. Blocking and wedges, left in the foundation with the approval of the Engineer, shall be of steel or iron.

(4) Foundations and Grouting

Concreting of sub-bases and frames and the final grouting under parts of machines shall be in accordance with the procedures as specified in the General Specification titled "Concrete Works" in Division 3.

6214. TESTS AND TRIALS

(1) General

The Contractor shall at his expense, perform analyses and tests to demonstrate that all materials are in conformity with the Specifications, except where such tests are waived in writing by the Engineer. Should the Contractor desire to use stock materials, not manufactured specifically for the Works covered by these Specifications, he shall submit evidence, satisfactory to the Engineer, that such material conforms to the requirements of the Specifications and detail tests of these materials will not be required, if so approved by the Engineer. Tests, except where modified, shall be made as indicated in the respective Specifications or on the Drawings. The Contractor shall furnish certified reports in triplicate of all required analyses and tests. The Contractor shall furnish, upon request, specimens and samples for independent analysis and test, all properly labeled and prepared for shipment.

(2) Analysis of Material

The Contractor shall furnish certificates listing the heat numbers and the chemical and physical properties of metals. The Engineer shall submit in writing the items requiring data.

(3) Non-Destructive Testing

When doubt exists as to the soundness of any part, such part may be subjected to any form of non-destructive testing as determined by the Engineer. This may include ultrasonic, magnaflux, dye penetrant, x-ray, gamma ray or any other test that will thoroughly investigate the part in question. Any defects in composition or grain structure will be cause for rejection and the rejected part shall be replaced and retested at the Contractor's expense.

(4) Tests of Machinery and Structural Units

Each complete machinery and structural unit as required by the Drawings or Particular Specifications shall be erected and tested in the shop in the presence of a representative of the Engineer. Waiving of tests, however, shall not relieve the Contractor of responsibility for any fault in operation, workmanship, or material that may later develop before the completion of the Contract or Guarantee Periods. After being assembled in place at the site, each complete machine or structural unit shall be tested to demonstrate that it meets Specification requirements in all respects and is suitable for performing the work intended. The details for tests on the various machinery and structural units shall conform to the requirements of the pertinent Sections of these Specifications.

SECTION 6300. GALVANIZING

6301. GENERAL

This Section covers all labor, materials, equipment and incidentals necessary to galvanize all materials specified or shown on the Drawings. Materials shall be galvanized by the hot-dip or electrodepositing process, unless noted otherwise.

6302. WORKMANSHIP

The zinc coating shall adhere tenaciously to the surface of the base metal. The finished product shall be free from blisters and excess zinc, and the coating shall be even, smooth, and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening and other fabricating shall be done as far as is practicable before the galvanizing. All members, nuts, bolts, washers and appurtenances shall be galvanized before a structural unit is assembled. All uncoated spots or damaged coatings may be cause for rejection. Repair of damaged coatings will be at the discretion of the Engineer.

Products that are warped or distorted to the extent of impairment for the use intended, shall be rejected.

It will be the responsibility of the Contractor to:

- a. Adequately design all items for galvanizing.
- b. Properly select all steel for its suitability to be fabricated and to withstand normal galvanizing operation
- c. Prevent damage to the material by over pickling or by use of excessively high temperatures.

All material shall be provided without embrittlement. Workmanship shall conform to ASTM A143, "Practice for Safeguarding Against Embrittlement of Hot Galvanized Structural Steel Products and Procedure for Detecting Embrittlement".

6303. TEST COUPONS

Test coupons, for determining the quantity and quality of the galvanizing, shall be of such size and shall be wired to the materials to be galvanized before immersion so as to represent the amount of coating deposited on the finished product.

Non-destructive tests for uniformity of coating may be ordered

to be made with a magnetic instrument in accordance with ASTM E376, "Measuring Coating Thickness by Magnetic Field or Eddy Current (Electro-magnetic) Test Methods".

6304. CLEANING

After the shop work has been completed and accepted, all material shall be cleaned of rust, loose scale, dirt, oil, grease, and other foreign substances and pickled. Particular care shall be taken to clean slag and spatter from welded areas. Pickling shall be completed in such a manner to insure the total removal of all acid, prior to galvanizing.

6305. GALVANIZING

(1) Plates and Shapes

All plates and shapes shall be galvanized after fabrication. After being cleaned, all materials shall be zinc coated (galvanized) in accordance with ASTM A-123, "Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strip". Where members are of such lengths that they cannot be dipped in one operation, great care shall be exercised to prevent warping. Finished compression members shall not have lateral variations greater than 1/1,000 of the axial length between the points which are to be supported laterally. Finished tension members shall not have lateral variations exceeding 3 millimeters (1/8 inch) for each 1.5 meters (5 feet) of length. Sharp kinks or bends will be cause for rejection of the material. All holes in material shall be free of excess spelter after galvanizing.

No machine or shopwork, die work, punching, or grinding, will be allowed after galvanizing.

(2) Hardware

Bolts, nuts, washers, locknuts, and similar hardware shall be galvanized in accordance with ASTM A-153, "Zinc Coating (Hot Dip) on Iron and Steel Hardware". Excess spelter shall be removed by centrifugal spinning. The Contractor shall submit samples of bolts and nuts for approval. Nuts and tapped holes scheduled for galvanizing shall be oversized tapped or retapped prior to galvanizing. Tapping or retapping of threads after galvanizing will not be permitted.

(3) Assembled Products

Galvanizing of shop fabricated items shall be the hot-dip zinc process, after fabrication. All assembled products shall be

assembled and prepared in accordance with ASTM A385, "Practice for Providing High Quality Zinc Coatings (Hot Dip) on Assembled Products".

Following all manufacturing operations, all items to be galvanized shall be thoroughly cleaned, pickled, fluxed and completely immersed in a bath of molten zinc. The resulting coating shall be in accordance with ASTM A386, "Zinc-Coating (Hot Dip) on Assembled Steel Products". The coating shall have an average weight of 550 gms per sq.m (2 oz per sq.ft), unless noted otherwise. The testing of zinc coat shall be in accordance with ASTM A386.

(4) Pipe

Galvanizing of pipe shall be in accordance with Section 2.7 of BS 1387, "Steel Tubes and Tubulars Suitable for Screwing to BS 21 Pipe Threads".

6306. STRAIGHTENING

To minimize straightening, all work shall conform to ASTM A384, "Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies".

All plates and shapes which have been warped by the galvanizing process shall be straightened by being rerolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. If, in the opinion of the Engineer, the material has been harmfully bent or warped in the process of fabrication or galvanizing, such defects shall be cause for rejection.

DIVISION 7. MECHANICAL WORK

SECTION 7000. VALVES

7001. General

The scope of work consists of all gate valves, check valves, butterfly valves, pressure reducing valves, pressure relief valves, air release and anti-vacuum valves, plug valves, and globe valves, 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.

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 the specified tests, to the Engineer for approval. No valve shall be installed prior to approval by the Engineer.

The Contractor shall submit detailed design and Shop Drawings and schedules of all valves.

Shop Drawings shall include but not be limited to the following:

- a. Lists and schedules of material
- b. Details of proposed joints and harnesses
- c. Names of suppliers
- d. Dates of delivery of materials to the site

Shop Drawings shall show size, details, materials and thickness of all items and all installation details.

7002. MATERIALS

All valves shall be of size shown on the Drawings and, as far as possible, all valves of the same type shall be from one manufacturer.

All valves shall have the name of the maker and the working pressure for which they are designed cast in raised letters upon some appropriate part of the body.

Valves 50 mm in size and smaller shall be all bronze, unless

otherwise specified, except for handwheels which shall be of cast or malleable iron, and provided with screw ends.

Stuffing boxes shall be of the "O" ring type, unless specified otherwise.

Valves shall be equipped with handlevers, handwheels, chains, or hand, pneumatic or electric operations as shown on the Drawings. They shall open by turning to the left or counterclockwise. Operators shall have arrows cast thereon to indicate the direction of rotation for opening the valve.

Valves, designed for flow in one direction only, shall have direction arrows cast on the body.

The minimum working pressure of valve shall be as specified herein unless otherwise shown in the schedules.

7003. GATE VALVES 75 MM TO 900 MM

The gate (sluice) valves shall conform to JIS B2062 "Sluice Valves for Waterworks" for the maximum working pressure of 7.5 kg per sq. cm and JWWA B115 "10 kg per sq. cm Sluice Valves for Water Works" for the maximum pressure of 10 kg per sq. cm as a rule, or specified below.

Gate valves shall be iron-body, bronze mounted, non-rising stem valves with either double-disc or solid wedge gates as shown in the schedules. Valves 300 mm in diameter and smaller shall be designed for working pressure of 14 kg/cm² and larger valves shall be designed for a working pressure of 10.0 kg/cm². 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 and bonnet shall be of grey, cast iron having a minimum tensile strength of 2,200 kg/cm². Minimum wall thickness of body and bonnet shall be as shown on the following table.

Valves shall have flanged ends unless otherwise noted shown on the Drawings. Flange dimensions and drilling shall conform to the Specification 5006 "Flange Joints".

Valves Diameter		Minimum Thickness	
mm	(in)	mm	(in)
75	(3)	9.4	(0.37)
100	(4)	10.2	(0.40)
150	(6)	10.9	(0.43)
200	(8)	12.7	(0.50)
250	(10)	16.0	(0.63)
300	(12)	17.3	(0.68)
350	(14)	19.4	(0.76)
400	(16)	21.6	(0.85)
500	(20)	24.6	(0.97)
600	(24)	27.4	(1.08)
700	(28)	32.5	(1.28)
800	(32)	36.6	(1.44)
900	(36)	39.1	(1.54)

The stuffing box and wrench nut (if required) shall be cast iron meeting the requirements specified above. The stuffing box shall be 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 asbestos conforming to U.S. Federal Specification HH-P-34c, Type A, or flax packing conforming to Federal Specification HH-P-106d. Hemp or jute packing shall not be used. Synthetic rubber "O" ring seals may be used, subject to the approval of the Engineer, provided the design incorporates at least two "O" rings and the dimensions of the "O" rings conform to U.S. Military Specification MIL-P-5514.

The gland assembly shall be of solid, solid-bushed, or two-piece design. Gland flanges may be formed as a flanged end on the gland, or as a separate part. Glands for valves 300 mm in diameter and smaller shall be made of cast bronze conforming to ASTM B62 or ASTM B132; rolled bronze conforming to ASTM B21, half hard; or forged bronze conforming to ASTM B124. Glands for valves larger than 300 mm in diameter may be made of cast iron as specified for the valve body with bushings of bronze as specified for bronze glands. Glands may be cadmium plated (ASTM A165) or zinc-coated (ASTM A123) steel if approved by the Engineer. Gland flanges (if used) shall be cast iron conforming to the requirements for the body or bronze conforming to the requirements for the gland.

Gland bolts shall be cast bronze conforming to ASTM B132, Alloy 864; rolled bronze conforming to ASTM B21; or rustproofed steel as specified for the stuffing box. Gland bolt nuts shall be cast bronze conforming to ASTM B132 or rolled bronze conforming to ASTM B21, half hard.

Bolts, studs and nuts for the bonnet and stuffing box shall conform to ASTM A307, Grade B and shall be cadmium plated in conformance with ASTM A165, Grade N.S. or zinc-coated in conformance

with ASTM A153 or A164, Type G.S.

Gates shall be cast iron as specified for the body or 85-5-5-5 cast bronze. Cast iron gates shall have bronze rings rolled, peened or pressed into dovetail grooves machined into the disc to provide a face to match or exceed the face of the body seat ring. Bronze for rings shall be sufficiently malleable to conform to the disc grooves when applied as specified and shall have a minimum compressive strength, without permanent deformation, of 280 kg/cm². Gate rings shall be machine finished after being fully secured to the disc.

Body seat rings shall be 85-5-5-5 cast bronze accurately threaded and screwed into machine seats in the body. The face of the ring shall be machine finished. The width of the body seat rings shall be sufficient to result in a maximum bearing pressure of the gate on the seat ring of 140 kg/cm² and the thickness of the ring shall be not less than 20 percent of the calculated width.

Double-disc gate valves shall be equipped with a free and positive operating internal wedging device, simple and rugged in design, which, in closing the valve, will, when the discs cover the ports, press them firmly against the body seats and, in the opening direction, release the wedging load before both discs start to move. Wedges and wedging surfaces shall be 85-5-5-5 bronze castings or cast bronze conforming to ASTM B132. Pins and bolts in the wedging mechanism of all valves shall be rolled bronze conforming to ASTM B21, half hard. In valves 400 mm and larger, all wedging surfaces shall be bronze to bronze. In valves less than 400 in diameter, wedging surfaces may be bronze to iron but not iron to iron. As an alternate, copper-nickel alloy, monel conforming to ASTM B 149, or 300 series stainless steel, to iron may be used and copper-nickel alloy or monel (ASTM B149) may be used for wedging surfaces.

Solid-wedge gate valves shall have tongue-and-groove guides on the sides of the gate and in the body to keep the gate centered between the seats throughout its length of travel. In valves 400 mm in diameter and larger, bearing surfaces between the gate and the guides shall have a length equal to at least 50 percent of the port diameter of the valves and the guide contacts shall be 85-5-5-5 bronze castings, cast bronze conforming to ASTM B132, or rolled bronze conforming to ASTM B21, any alloy, half hard.

Valve stems shall be cast, forged, or rolled bronze. Bronze for cast stems shall conform to ASTM B132, or ASTM B21, any alloy, half hard, except that ASTM B132, Alloy 864 shall not be used for valves larger than 600 mm. Bronze for forged and rolled stems shall conform to ASTM B132, Alloy 864, ASTM B21, ASTM B150 or ASTM B148. All stem collars shall be made integral with stems. Stem nuts shall be 85-5-5-5 bronze castings or conform to ASTM B132 Alloy A or B.

The threads of stems and stem nuts (disc bushings) shall be of square Acme, modified Acme, or 1/2 V type with a sufficient number of cuts to avoid straining the metal. Stems shall be turned and threaded straight and true, and shall work true and smooth and in perfect line throughout the lift of opening and thrust of closing the valve. The diameter of the stem at the base of the thread, or at any point below that portion shaped to receive the wrench nut of operator shall not be less than shown on the following table.

Diameter of Valve mm (in)	Min. Diameter of Stem mm (in)	Min. Number of Turns to Open
75 (3)	21.8 (0.86)	9
100 (4)	21.8 (0.86)	12
150 (6)	25.4 (1.00)	18
200 (8)	25.4 (1.00)	24
250 (10)	28.4 (1.12)	30
300 (12)	30.3 (1.19)	36
350 (14)	33.3 (1.31)	42
400 (16)	36.6 (1.44)	48
500 (20)	44.5 (1.75)	48
600 (24)	50.0 (1.97)	48
700 (28)	53.2 (2.09)	60
800 (32)	58.3 (2.30)	60
900 (36)	63.5 (2.50)	72

Stems in valves up to and including 400 mm in diameter shall have a lead of not more than 8.5 mm. Stems in valves 500 mm and larger shall have a lead of not more than 12.7 mm. (See Table above for minimum number of turns to open).

Gaskets for stuffing box and bonnet shall be asbestos or a rubber composition.

By-passes, when required by the schedule, shall be 75 mm in diameter for valves 500 mm and smaller, 100 mm in diameter for valves 600 mm and 700 mm in diameter, and 150 mm for larger valves. By-pass valves shall be of the same size as the by-pass and shall conform to this Specification. By-passes shall be provided on all valves 400 mm in diameter and larger. They shall be side-mounted.

All interior and exterior ferrous surfaces except bearing surfaces shall be cleaned of rust, scale and grease and receive two coats of coal-tar epoxy paint applied at the place of manufacturer.

Markings shall be cast on the bonnet or the body of each valve and shall show the manufacturer's name or mark, the year the valve casting was made, the size of the valves and the designation of working water pressure - "14.0 W." The markings shall have the minimum size of 25 mm and 3 mm raised from the surrounding surface.

After manufacture, each gate valve shall be submitted to operation and hydrostatic tests at the manufacturer's plant as follows.

Each valve shall be operated in the position for which it was designed to insure free and perfect functioning of all parts in the intended manner. Any defects of workmanship shall be corrected and the test repeated until satisfactory performance is demonstrated.

For double-disc gate valves, a hydrostatic test pressure equal to twice the rated working pressure of the valve shall be applied between the discs; this test shall show no leakage through the metal or flange joints. Subsequently, a test shall be made at the rated working pressure, applied between the discs; this second test shall show no leakage through the metal or at flange joints, and the leakage past either seat shall not exceed a rate of 11.6 ml/hr/cm of nominal valve size.

For solid-wedge gate valves, a hydrostatic pressure equal to twice the rated working pressure of the valve shall be applied with both ends bulkheaded and the gate open; this test shall show no leakage through the metal or flange joints. Subsequently, a test shall be made at the rated working pressure, applied (through bulkheads) alternately to each side of the closed gate with the opposite side open for inspection; this second test shall show no leakage through the metal or at flange joints, and the leakage past either seat shall not exceed a rate of 11.6 ml/hr/cm of nominal valve size.

7004. GATE VALVES 62.5 MM AND SMALLER

Valves for steel and iron pipe lines shall be iron body, bronze mounted U-bolt gate valves having a solid wedge, inside screw and rising stem. Valves shall have screwed ends and be rated 14 kg cold W.O.G. Body and bonnet shall be cast iron as specified for large gate valves herein and U-bolt and nuts shall be steel. Handwheel shall be malleable iron. Packing nut, stem bushing and wedge shall be made from 85-5-5-5 bronze castings. The stem shall be silicon brass conforming to ASTM B198, Alloy 875. The gland shall be made from brass rod conforming to ASTM B16. The seat ring shall be seamless brass tubing conforming to ASTM B135. The Bonnet gasket and packing shall be asbestos.

Valves for I.P.S. copper lines shall be bronze, union bonnet, gate valves having a solid wedge, inside screw and rising stem. Valves shall have screwed ends and be rated 14 kg, cold W.O.G. Except as otherwise specified herein all parts shall be made from 85-5-5-5 bronze castings. The handwheel shall be malleable iron. The stem shall be silicon brass conforming to ASTM B198, Alloy 875. The gland shall be made from brass rod conforming to ASTM B16. Packing shall be asbestos.

Valves for copper tubing shall conform to the requirements for gate valves for I.P.S. copper specified above except that the bonnet may be of the screw in type and the valve shall have solder ends.

Gate valves, 62.5 mm, in diameter and smaller shall be tested as specified above for gate valves 75 mm and larger except that the test pressure shall be 25 kg. Valves shall be suitably embossed to show manufacturer's name or mark, size of valve and working water pressure "14.0 W".

7005. SWING CHECK VALVES 75 MM TO 900 MM

Check valves shall be iron-body, bronze mounted, with full opening and ends as indicated on the Drawings. Valves 300 mm in diameter and smaller shall be designed for a working pressure of 14 kg/cm² and larger valves shall be designed for a working pressure of 10.0 kg/cm².

Swing check valves shall be suitable to operate in a horizontal or vertical position with flow upward. Valves shall be constructed so that disc and body seat rings may be easily removed and replaced without removing the valve from the line. Valves shall be furnished with hinge arms, levers and springs or weights as required by the schedule.

The valve body and cover shall be of grey cast iron meeting the requirements specified for cast iron gate valve bodies. Cover bolts, nuts and gaskets shall meet the requirements for cast-iron gate valves specified above. Body thickness shall be substantially the same as specified for gate valves. Discs shall be bronze faced cast iron or solid bronze. Bronze discs of disc rings, body seat rings, disc arms and connections between arms and discs shall be made from 85-5-5-5 bronze castings except arms and connections for bronze faced cast-iron discs may be cast steel.

The hinge pin shall be either Type 302 stainless steel or brass rod conforming to ASTM B16. Side plugs if required, shall be brass rod conforming to ASTM B16 or silicon brass conforming to ASTM B198, Alloy 875. Glands, if required, shall be bronze bushed cast iron with steel studs and nuts.

Body seat rings shall be accurately threaded and screwed into a machined seat in the body. The face of the ring shall be machine finished.

All interior and exterior ferrous surfaces except bearing surfaces, shall be cleaned of rust, scale and grease and receive two coats of coal-tar epoxy paint applied at the place of manufacture.

Check valves shall be marked as specified for cast-iron gate valves.

Each valve shall be subjected to hydrostatic test at the manufacturer's plant. A hydrostatic pressure of 25 kg/cm² shall be applied with both ends bulkheaded; this test shall show no leakage through the metal or joints. Subsequently a test shall be made at 3 kg/cm² applied through a bulkhead on the inlet side with the outlet side open for inspection; this second test shall show no leakage through the metal or at joints, and the leakage through the disc shall not exceed a rate of 11.6 ml/hr/cm of nominal valve size.

7006. CHECK VALVES 62.5 MM AND SMALLER

Valves for steel and iron pipelines shall be iron-body, bronze mounted lift check valves with renewable seat and disc and screwed ends. Valves shall be rated at least 14 kg cold W.O.G. Body shall be cast iron as specified for large check valves and cap and union bonnet ring shall be made from 85-5-5-5 bronze castings. The disc and seat ring shall be machined from bronze castings conforming to ASTM B61 or a copper-nickel alloy. The seat ring shall be accurately threaded and screwed into the body. The face of the seat ring and the disc shall be machine finished.

Valves for I.P.S. copper lines shall be bronze body, swing check valves with renewable disc and screwed ends. Valves shall be rated at least 14 kg cold W.O.G. Body and cap shall be made from 85-5-5-5 bronze castings. The stop plug, side plugs, hanger pin and hanger nut shall be made from brass rod conforming to ASTM B16. The disc shall be made from bronze rod conforming to ASTM B140, Alloy 314, or castings conforming to ASTM B61 and the hanger shall be ASTM B61. The seat face and disc shall be machine finished. The plane of the seat face shall be 50° from the axis of the body.

Valves for copper tubing shall be as specified for I.P.S. copper piping above except that the valve shall have solder ends.

Check valves, 62.5 mm in diameter and smaller, shall be tested as specified above for check valves 75 mm and larger. Valves shall be suitably embossed to show manufacturer's name mark, size of valve and working water pressure, "14.0 W."

7007. TILTING DISC CHECK VALVES

Tilting disc check valves shall be iron-body, bronze or stainless steel mounted, with ends as indicated on the drawings. Valves shall be designed for a working pressure of 14 kg/cm² and shall be suitable for operation in a horizontal pipe line. Body shall be two-piece, cast-iron construction. The body gaskets and bolts shall meet the applicable material requirements specified herein for cast-iron gate valves as far as they apply. Discs shall be bronze faced cast iron or ductile iron, or solid bronze. Bronze discs or disc rings and body seat rings shall be made from 85-5-5-5

castings or leaded tin bronze conforming to ASTM B143, Alloy 922. Pivot pins and bushings shall be made from bronze conforming to ASTM A148, Alloy 955RT and 954 respectively. Stainless steel trim, Type 302 or 304 may be used in place of the bronze specified. Mating surfaces of body seat and disc seats shall be machine finished. Bodies shall be provided with suitable hand holes for cleaning. Pivot pin housings shall be fitted with ball check grease fittings.

All interior and exterior ferrous surfaces except bearing surfaces shall be cleaned of rust, scale and grease and receive two coats of coal-tar epoxy paint applied at the place of manufacture.

Check valves shall be marked as specified for cast-iron gate valves.

Each valve shall be hydrostatically tested at the manufacturer's plant as specified for swing check valves 75 mm and larger.

7608. BUTTERFLY VALVES FOR WATER

The butterfly valves shall conform to JWWA B114 "Butterfly Valves for Water Works" and/or specified below.

Valves shall be iron-body, rubber-seated butterfly valves with ends as indicated on the schedule. Valves shall be designed for the maximum nonshock shutoff pressure shown on the schedule and a maximum operating torque as shown on Table A. Valves shall have flanged ends and flanges shall conform to Division 5 "Piping Works".

Valve bodies shall be either cast-iron conforming to the requirements specified for cast-iron gate valves or to ASTM A48, Class 40, or of ductile iron conforming to ASTM A536, Grade 65-45-12. Valves shall have laying length and minimum body shell thickness as shown on Table B.

Valve discs shall be cast with no external ribs transverse to the flow. The design shall be such as to sustain full differential pressures across a closed valve disc without exceeding a working stress of 1/5 of the tensile strength of the material used. The thickness of the valve disc shall be not more than 2-1/4 times the shaft diameter listed in Table C.

If the rubber seat is mounted in the body, the valve disc shall be made from authentic grey iron castings conforming to ASTM A436, Type 1 or 2, and the periphery shall be machined to a smooth spherical surface. The rubber seat shall be cemented and clamped, bonded, or vulcanized to a recess in the valve body. The method of bonding or vulcanizing shall be proved by ASTM D429, Method A or B. The minimum strength for Method A shall be 17.5 kg/cm² and the minimum peel strength for Method B shall be 5.3 kg/cm².

If the rubber seat is mounted on the valve disc, the disc shall be made of grey or ductile iron as specified for the body. The rubber seat shall be held in place on the disc edge by a one-piece

TABLE A

Maximum Operating Torques

Maximum Operating Torque

Valve Diameter mm	in	Class 25A		Class 25B		Class 75A		Class 75B		Class 150A		Class 150B	
		kg.m	ft.lb	kg.m	ft.lb	kg.m	ft.lb	kg.m	ft.lb	kg.m	ft.lb	kg.m	ft.lb
75	3	1.7	8	1.7	8	1.7	12	1.7	12	2.0	19	2.0	19
100	4	1.9	14	1.9	14	3.0	22	3.0	22	5.0	36	5.0	36
150	6	4.6	33	4.6	33	7.2	52	7.2	52	12.8	93	12.8	93
200	8	8.4	61	8.0	63	13.1	95	13.1	95	24.2	175	24.2	175
250	10	13.5	98	15.9	115	22.1	160	22.8	165	44.2	320	44.2	320
300	12	20.2	146	27.7	200	33.2	240	38.7	280	70.5	510	70.5	510
350	14	28.3	205	42.8	310	47.0	340	62.2	450	99.5	720	99.5	720
400	16	38.0	275	65.0	470	65.0	470	92.6	670	142	1,030	142	1,030
450	18	49.8	360	91.0	660	83.1	600	130	940	187	1,330	205	1,460
500	20	61.5	445	127	920	106	770	180	1,300	250	1,800	260	2,050
600	24	94.0	680	214	1,550	166	1,200	304	2,200	400	2,900	484	3,500
700	28	135	980	353	2,550	235	1,700	484	3,500	630	4,550	754	5,450
800	32	201	1,450	554	4,000	349	2,450	728	5,250	845	6,000	1,110	8,000
900	36	298	2,150	746	5,400	470	3,400	1,045	7,550	1,175	8,500	1,605	11,600
1,000	40	415	3,000	1,020	7,400	630	4,550	1,440	10,400	1,550	11,200	2,190	15,800
1,100	44	540	3,900	1,350	9,800	838	6,050	1,930	13,900	1,940	14,000	2,910	21,000
1,200	48	608	5,050	1,760	12,700	1,110	8,000	2,490	18,000	2,560	18,500	3,800	27,500
1,350	54	1,003	7,250	2,350	17,000	1,660	12,000	3,530	25,500	4,090	29,500	5,530	40,000
1,500	60	1,370	9,900	3,430	24,800	2,420	16,100	4,840	35,000	5,320	38,500	7,470	54,000
1,600	64	1,690	12,200	4,150	30,000	2,720	19,600	5,980	42,500	6,360	46,000	9,130	66,000
1,800	72	2,350	17,000	5,880	42,500	3,730	27,000	8,300	60,600	8,370	60,500	12,440	90,000

In each case, numerical portion of the class designation is the maximum nonshock shutoff pressure. The letter portion of the class designation refers to the maximum operating torque given in the table under the appropriate class designation. Example: A 600 mm (24-in) Class 10.5A (1503) valve is designed for a maximum nonshock shutoff pressure of 10.5 kg/cm² (150 psi) and a maximum operating torque for valve of 484 kg.m (3500 ft.lbs).

TABLE B

Laying Lengths and Minimum Body Shell Thicknesses

Valve Diameter		Laying Length*		Class 25A, B		Class 75A, B		Class 150A, B	
mm	in	mm	in	mm	in	mm	in	mm	in
75	3	125	5	9.4	0.37	9.4	0.37	9.4	0.37
100	4	125	5	10.2	0.40	10.2	0.40	10.2	0.40
150	6	125	5	10.9	0.43	10.9	0.43	10.9	0.43
200	8	150	6	11.7	0.46	11.7	0.46	11.7	0.46
250	10	200	8	12.7	0.50	12.7	0.50	13.7	0.54
300	12	200	8	13.7	0.54	13.7	0.54	14.7	0.58
350	14	200	8	13.7	0.54	14.7	0.58	16.0	0.63
400	16	200	8	14.7	0.58	16.0	0.63	17.3	0.68
450	18	200	8	16.0	0.63	17.3	0.68	20.1	0.79
500	20	200	8	16.8	0.66	18.1	0.71	21.1	0.83
600	24	200	8	18.9	0.74	20.4	0.80	23.6	0.93
700	28	300	12	20.1	0.79	22.8	0.90	26.7	1.05
800	32	300	12	22.8	0.90	25.4	1.00	29.3	1.15
900	36	300	12	24.7	0.97	28.7	1.13	32.0	1.22
1,000	40	300	12	26.2	1.03	29.2	1.15	33.4	1.31
1,100	44	375	15	28.2	1.11	31.0	1.22	35.4	1.39
1,200	48	375	15	30.0	1.16	34.8	1.37	37.6	1.48
1,350	54	375	15	33.0	1.30	38.4	1.51	41.4	1.63
1,500	60	375	15	35.4	1.39	41.2	1.62	48.0	1.89
1,600	64	450	18	39.4	1.55	44.2	1.74	50.0	1.97
1,800	72	450	18	44.5	1.75	50.4	2.00	60.5	2.375

* Valves otherwise meeting the requirements of this Specification may exceed this length providing the Contractor assumes all responsibility for piping layouts involving butterfly valves.

TABLE C
Minimum Shaft Diameters*
Minimum Shaft Diameter

Valves Diameter mm	Class 25A		Class 25B		Class 75A		Class 150A		Class 150A	
	mm	in	mm	in	mm	in	mm	in	mm	in
75	12.7	1/2	12.7	1/2	12.7	1/2	12.7	1/2	12.7	1/2
100	15.9	5/8	15.9	5/8	15.9	5/8	15.9	5/8	15.9	5/8
150	19.0	3/4	19.0	3/4	19.0	3/4	19.0	3/4	19.0	3/4
200	22.2	7/8	22.2	7/8	22.2	7/8	22.2	7/8	22.2	7/8
250	25.4	1	25.4	1	25.4	1	25.4	1	25.4	1
300	28.6	1 1/8	28.6	1 1/8	28.6	1 1/8	28.6	1 1/8	28.6	1 1/8
350	31.8	1 1/4	31.8	1 1/4	31.8	1 1/4	31.8	1 1/4	31.8	1 1/4
400	34.9	1 3/8	34.9	1 3/8	34.9	1 3/8	34.9	1 3/8	34.9	1 3/8
450	38.1	1 1/2	38.1	1 1/2	38.1	1 1/2	38.1	1 1/2	38.1	1 1/2
500	41.3	1 5/8	41.3	1 5/8	41.3	1 5/8	41.3	1 5/8	41.3	1 5/8
600	47.6	1 7/8	47.6	1 7/8	47.6	1 7/8	47.6	1 7/8	47.6	1 7/8
700	54.0	2	54.0	2	54.0	2	54.0	2	54.0	2
800	60.4	2 1/4	60.4	2 1/4	60.4	2 1/4	60.4	2 1/4	60.4	2 1/4
900	66.7	2 5/8	66.7	2 5/8	66.7	2 5/8	66.7	2 5/8	66.7	2 5/8
1,000	72.9	3	72.9	3	72.9	3	72.9	3	72.9	3
1,100	79.2	3 1/4	79.2	3 1/4	79.2	3 1/4	79.2	3 1/4	79.2	3 1/4
1,200	85.4	3 1/2	85.4	3 1/2	85.4	3 1/2	85.4	3 1/2	85.4	3 1/2
1,300	91.7	3 3/4	91.7	3 3/4	91.7	3 3/4	91.7	3 3/4	91.7	3 3/4
1,400	98.0	4	98.0	4	98.0	4	98.0	4	98.0	4
1,500	104.3	4 1/4	104.3	4 1/4	104.3	4 1/4	104.3	4 1/4	104.3	4 1/4
1,600	110.6	4 1/2	110.6	4 1/2	110.6	4 1/2	110.6	4 1/2	110.6	4 1/2
1,700	116.9	4 3/4	116.9	4 3/4	116.9	4 3/4	116.9	4 3/4	116.9	4 3/4
1,800	123.2	5	123.2	5	123.2	5	123.2	5	123.2	5

* Based on the use of stainless steel, Type 302, 303, 304, or 316.

Type 304 stainless steel retaining ring with stainless steel and nylon locking screws. The mating seat surface shall be machined from Type 304 stainless steel and recess mounted in the body.

For valves with the rubber seat mounted in the valve body, the minimum thickness of the rubber at the seating surface shall be as specified in Table D. For valves that seat at an angle, the portion of the seat that extends over the face of the body flanges shall be 1/4-in thick. The minimum dimensions of rubber seats mounted on the disc edge shall be as specified in Table E.

The design of the seat shall be such as to provide tight shutoff under the tests required by this Specification. A thickness of rubber not less than 50 percent of the overall thickness shall be maintained between the rubber seating surface and any fabric reinforcement. Rubber seats that employ a metal or other rigid noncompressible insert shall have a rubber thickness equal to the overall minimum required thickness between the rubber seating surface and the rigid insert.

TABLE D

Minimum Rubber Seat Thickness for Valves with Rubber Seat in Body.

Valve Size		Min. Seat Thickness			
		90-deg Seating		Angle Seating	
mm	in	mm	in	mm	in
25-100	3-4	6.3	1/4	7.9	1/16
150	6	7.9	5/16	7.9	5/16
200-250	8-10	9.5	3/8	7.9	5/16
300-350	12-14	11.1	7/16	9.5	3/8
400-500	16-20	12.7	1/2	9.5	3/8
600	24	19.0	3/4	12.7	1/2
700-1200	30-48	25.4	1	12.7	1/2
1350-1800	54-72	25.4	1	15.9	5/8

TABLE E

Minimum Rubber Seat Dimensions for Valves With Rubber Seat Applied to Disc

Valves Size		Thickness		Radial Width	
mm	in	mm	in	mm	in
75-350	3-4	6.3	1/4	12.7	1/2
400-1000	16-42	9.5	3/8	19.0	3/4
1100-1800	48-72	12.7	1/2	25.4	1

Rubber seats shall be new natural or synthetic rubber and may be reinforced. Valve seat shall be perpendicular to the pipe axis or at an angle not less than 83 degrees from the pipe axis.

Valve shafts shall be made of Type 302, 303, 304, or 316 stainless steel or Monel. 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 1/2 shaft diameters.

Valve shafts shall have a minimum diameter extending through the valve bearings and into the valve disc as specified in Table C.

Valve shafts shall be securely attached to the valve disc by means of stainless steel keys, dowel pins, taper pins, or any combination of the three. The connection between the shaft and disc shall be designed to transmit shaft torque equivalent to at least 75 percent of torsional strength of the minimum required shaft diameters. Dowel and taper pins shall be mechanically secured.

Valve shafts shall be full size for the portion of the shaft that extends through the valve bearings, valve disc, and shaft seal. If the valve shaft is turned down to fit connections to the valve-operating mechanism, the turned-down portion shall have fillets with radii equal to the offset. The turned-down portion of the shaft shall be capable of transmitting torque equivalent to at least 75 percent of the torsional strength of the minimum required shaft diameter, and shall be capable of transmitting the maximum operator torque without exceeding a torsional shear stress of 8,050 kg/cm².

Shaft seals shall be provided wherever shafts project through the valve body. Seals shall be designed to allow replacement of seals without removing the valve shaft. Seals shall be designed for use of split V-type packing, O-ring seals or pulldown packing.

O-rings shaft seals shall be contained in a removable corrosion-resistant recess.

Shaft seals of the type utilizing a stuffing box and pulldown 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. Gland or gland assemblies shall be of cast bronze. Packing for stuffing boxes shall be of asbestos or flax. Materials shall be as specified for cast-iron gate valves.

Valves shall be fitted with sleeve-type bearings contained in face of the valve body to the inside end of the sleeve bearing. The sleeve bearing shall not exceed 3.2 mm. Bearings shall be designed

for a pressure not exceeding the published design load for the bearing material, of 1/5 of the compressive strength of the bearing or shaft material. Bearing materials shall have a proven record of service of not less than 5 years.

If a shaft is designed for connection to an operator, a bearing shall be provided beyond the shaft seal. The housing for this bearing shall be rigidly attached to the valve body. If the operator is furnished as part of the valve assembly, the bearing may be fitted into the valve operator housing, which shall be rigidly attached to the valve body.

Each valve shall be equipped with either one or two thrust bearings set to hold the valve disc securely in the center of the valve seat, except for valves 500 mm and smaller without hydraulic or external axial shaft loads.

Sleeve and other bearings fitted into the valve body proper shall be of "self-lubricated" materials that do not have a harmful effect on water or rubber, and which do not have a coefficient of friction in excess of 0.25 when run at the maximum bearing pressure.

All interior and exterior ferrous surfaces except bearing surfaces shall be cleaned of rust, scale and grease and receive two coats of coal-tar epoxy paint, applied at the place of manufacture.

Markings shall be cast on the cover or the body of each valve and shall show the manufacturer's name or mark, the year, the valve casting was made, the size of the valve and the designation of working water pressure - 14.0 W." The markings shall have the minimum size of 25 mm and 3 mm raised from the surrounding surface.

After manufacture each valve shall be shop-operated three times from the fully closed to the fully opened position, and the reverse, under a no-flow condition, to demonstrate that the complete assembly is workable.

Each valve shall be hydrostatically tested for leaks at the place of manufacture. This test shall be conducted with the body ends in a horizontal plane. With the disc in the closed position, air pressure shall be supplied to the lower face of the disc for the full test duration, as follows:

Class 1.8A (25A) and 1.8B (25B) - 1.8 kg/cm²
Class 5.3A (75A) and 5.3B (75B) - 5.3 kg/cm²
Class 10.5A (150A) and 10.5B (150B) - 10.5 kg/cm²

The upper surface of the valve disc shall be visible and shall be covered with a pool of water at zero pressure. The length of test shall be at least 5 min. and there shall be no indication of leakage past the valve disc (visible in the form of bubbles in the water pool on top of the disc) during the test period. As an alternative to this test procedure, Class 10.5A (150A) and 10.5B (150B) valves may be given a 10.0 kg/cm² hydrostatic test for 5 min. and the valve shall be drop tight.

In addition, each valve shall have a hydrostatic test with an internal hydrostatic pressure equivalent to two times the specified shut-off pressure applied to the inside of the valve body for a period of 10 minutes. The disc shall be in a slightly open position. 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.

"Proof-of-design tests" will be required on one prototype valve of each size and class of a manufacturer's design and the Contractor shall submit certified copies of the reports covering these tests to the Engineer for approval before shipping any butterfly valves furnished under this Specification.

Each prototype valve shall be hydrostatically tested with twice the specified shutoff pressure applied to one side of the disc and zero pressure on the other side. This test is to be made in each direction across the disc. Under this hydrostatic test, the Contractor may make special provisions to prevent leakage past the seats. No part of the valve or disc shall be permanently deformed by this test.

The purpose of the "proof-of-design tests" is to provide evidence of the adequacy of each basic type offered by a manufacturer to perform under design pressures within the applicable rating for a sufficient number of operations simulating a full service lift. This adequacy is to be proved by tests, as described below made on valves selected to represent each basic type of seat design of a size within each applicable group in Table F, and in a pressure class or classes equal to or greater than the valves specified in the Schedules. The required number of cycles are shown in Table F.

TABLE F

Test Cycles Required

Size Group		Number of Cycles
mm	in	
75-500	3-20	10,000
600-1100	24-44	5,000
1200-1800	48-72	1,000

Every cycle shall consist of applying the differential pressure to the disc in the closed position, then opening the valve (which will relieve the pressure) to the wide open position, and then closing the disc. The valve shall be droptight under the rated pressure differential upon completion of the cycle test.

7009. BUTTERFLY VALVES FOR AIR

Butterfly valves in air piping shall meet all the applicable requirements specified above for butterfly valves for water except as otherwise specified herein.

Rubber seats shall be synthetic rubber suitable for use with air temperatures up to 115°C. Bearings may be nylon.

Valves for low pressure air lines may be of the wafer type designed to fit between two pipe flanges.

Butterfly valves for air piping shall be designed to provide an air-tight seal and all components shall be suitable for use under operating temperatures up to 115°C.

7010. PRESSURE REDUCING VALVES 62.5 MM AND LARGER

Pressure reducing valves shall be of the iron-body, fully bronze mounted, hydraulically operated, self-contained differential piston type. The valve shall be operated by an external pilot valve and have a single seat with the seat base equal to the valve size. Valves shall be designed for a working pressure of 14 kg/cm².

The valve shall be designed with air and water cushion to prevent water hammer and shock.

The valve body and cover shall be made of grey cast iron as specified for cast-iron gate valves, body shall be the globe body style.

The piston, liner and seat crown shall all be made from 85-5-5-5 bronze castings. The piston shall be provided with a renewable leather cup and rubber seat and liner shall be provided with a leather cup. The seat crown shall be accurately threaded and screwed into the valve body and shall have a cored V-port opening to allow water passage.

The follower rings, rod, gland, bushing and screws shall be made from commercial brass.

The cover gaskets and bolts shall be as specified for the body and bonnet of cast-iron gate valves.

The valve shall be capable of closing "droptight" and opening to permit full flow. The valve shall have an integral indicator to show the position of the valve.

The pilot valve shall be of the single seated, balanced design type, globe body pattern. It shall be diaphragm operated and spring loaded, conveniently adjustable over a range of at least 2.1 kg/cm². Valve body shall be 85-5-5-5 brass. Piping and control valve shall be brass.

All interior and exterior ferrous surfaces except bearing surfaces shall be cleaned of rust, scale and grease and receive two coats of coal-tar epoxy paint, applied at the place of manufacture.

Markings shall be cast on the cover or the body of each valve and shall show the manufacturer's name or mark, the year the valve casting was made, the size of the valve and the designation of working water pressure - "14.0 W." The markings shall have the minimum size of 25 mm and 3 mm raised from the surrounding surface.

After manufacture, each pressure reducing valve shall be submitted to hydrostatic tests at the manufacturer's plant as follows.

Each valve shall be bulkheaded at both ends and a hydrostatic pressure of 15.75 kg/cm² shall be applied. This test shall show no leakage through the body metal, cover or any joints. Each valve shall also be tested at a hydrostatic pressure of 10.0 kg/cm² and show no leakage through the seat (leakage shall not exceed that specified for gate valves).

7011. PRESSURE REDUCING VALVES 50.8 MM AND SMALLER

Pressure reducing valves for water shall be of the bronze body, self-contained, direct-acting, spring-loaded, diaphragm-actuated type. Valves shall have screwed or union ends and be designed for initial pressure of not less than 14 kg/cm².

Valve body and internal cast parts shall be made from 85-5-5-5 bronze. Valves shall have malleable iron handwheel on bronze adjusting screw. Seats shall be renewable stainless steel, Type 302, 304 or 316, and disc and diaphragm shall be compatible with liquid being controlled and its temperature.

Spring cages, diaphragm housings and adjusting screw shall be sealed against leaks. All parts subject to wear shall be accessible for repair or replacement without removing valve from the line.

Each valve shall be hydrostatically tested as specified for pressure reducing valves 6.5 mm and larger.

7012. AIR RELEASE AND ANTI-VACUUM VALVES

Air release and anti-vacuum valves shall be iron body valves of

the type shown on the Schedule. Valves shall be designed for a working pressure of 14 kg/cm².

Valve bodies, covers and baffles shall be cast-iron as specified for gate valves. Cover bolts and gaskets shall meet the requirements for cast-iron gate valves. Floats shall be stainless steel, Type 302, 304 or 306, conforming to ASTM A167; monel, alloy 400 conforming to ASTM B 164; or copper conforming to ASTM B 152. Seats shall be Buna-N.

Large orifice (vacuum breaking) valves shall have a ball sealed orifice, fully open when the valve chamber is empty and closed "drop-tight" when the chamber is full of water.

Small orifice (air release) valves shall be float actuated and be open when valve chamber is empty and closed "drop-tight" when the chamber is full of water. Internal levers, pins, screws, etc., shall be stainless steel or bronze.

Double orifice valves shall incorporate the characteristics of both the small orifice and the large orifice valves. The valves shall exhaust small pockets of air when line is under pressure, fully open the large orifice when the valve chamber is empty and fully close "drop-tight" when chamber is full of water.

Small valves may be of all bronze (85-5-5-5) construction.

All interior and exterior ferrous surfaces except bearing surfaces shall be cleaned of rust, scale and grease and receive two coats of coaltar epoxy paint, applied at the place of manufacture.

Each valve shall be hydrostatically tested at a water pressure of 21 kg/cm² by the manufacturer. This test shall show no leakage through the body, cover or fittings. The valves shall be operated to demonstrate proper operation.

7013. HIGH SPEED AIR VALVES

High speed air valves to be installed on the main water pipeline of the Works shall be conformed with JkWA B 118 "High Speed Air Valves for Water Works" and/or equivalent.

The valves shall use Class I with flanged type for the respective diameter of the valves unless noted otherwise.

Function of the valves shall have sufficient exhaust capacity, capable of relieving and admitting instantaneously a large volume of air from or into pipeline, sensitively actuated for exhaust and intake of air. Valve's motion shall conform to Section 8 in the JWWA B 118.

The valves shall consist of valve box, float valve, loose valve body, cover and air relieving and admitting holes. The structures, materials and dimensions of the respective valves are shown on the reference figure and annex table in the JWWA B 118.

Selection of the diameter of the valves shall be made based on the profiles of the pipeline to be installed, installation interval of the valves and diameter of pipeline except the valves specified in the Drawings.

7014. JOINTS FOR VALVE ENDS

Joints for valve ends shall match the respective pipeline that they are located in. The description of pipe joints is specified in the General Specifications in Section 5000 "Piping". All joints for buried valves over 300 mm in diameter, which are not bolted or welded, shall be harnessed.

Valves to be installed in plastic pipelines shall use threaded or flanged connections.

All valves shall have flanged ends, with flange dimensions conforming to Division 5, except as otherwise shown on the Drawings or as specified.

SECTION 7100. SLUICE GATE

7101. GENERAL

Sluice gates shall be furnished as indicated on the Drawings. The gates shall be the product of a manufacturer having five or more years' experience in the manufacture of similar sized sluice gates of the design head as required by this applications.

The work shall be complete with wall thimbles, operating stems, hand operated floorstands, whichever is indicated or specified, and all other incidental appurtenances and accessories.

(1) Design

All sluice gate parts, including structural elements of the lift mechanism, shall be designed for the head shown, with a minimum safety factor of five in respect to the tensile strength of the material. Except in the case of 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. The sluice gates and appurtenances shall be designed for installations as shown on the Drawings.

(2) 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 surface so that they can be assembled without fittings, chipping or remachining. All parts shall conform accurately to the design dimensions and shall be free of all defects in workmanship or material that will impair their service. All attaching bolt holes shall be accurately drilled to the layout indicated on the Shop Drawings. The sluice gates shall be completely shop assembled to insure the proper fit and adjustment of all parts.

7102. MATERIALS

All materials used in the construction of the gates and appurtenances shall be the best suited for the application and shall conform to the following specifications.

(1) Iron Castings

For wall thimbles, frames, gate body and guides, and stem guides ASTM A126, "Gray Iron Castings for Valves, Flanges, and Pipe Fittings", Class B.

(2) Bronze Castings

For wedges, thrust nuts, lift nuts and stem couplings - ASTM B147, "High Strength Yellow Brass (Manganese Bronze) and Leaded High-Strength Yellow Brass (Leaded Manganese Bronze) Sand Castings", alloy 8A.

(3) Bronze

For seat facings in frames and discs - ASTM B21, "Naval Brass Rod, Bar, and Shapes", alloy B.

(4) Stainless Steel

For stems and fasteners - ASTM A276, "Stainless and Heat - Resisting Steel Bars and Shapes", type 304. For stems - ASTM A276, type 304 and ASTM A320, "Alloy-Steel Bolting Materials for Low-Temperature Service", B8 and B 8F for fasteners.

7103. REQUIREMENTS

The sluice gates shall be cast iron, fully bronze mounted with side wedges (and top wedges where indicated) for seating head conditions. All gate components shall be designed to safely withstand the heads to be encountered. Seating and unseating head conditions shall be found in the Particular Specification. Head conditions shall be measured from the bottom of the gate.

7104. FLUSH BOTTOM CLOSURES

Flush bottom closures shall have compressible resilient seals attached to the bottom of the gates, or sliding members with a bronze or stainless steel bar and bronze or stainless steel fasteners. The seal shall be especially molded shape seal designed to fit a lip machined on the bottom rib of the gate. The seal shall be shaped to produce a wide sealing area on a machined cast iron stop bar bolted and keyed to the gate frame and forming a flush invert. The differential sealing pressure of the resilient seal on the stop bar shall be variable by adjustment of the side wedges on the gate. The flush bottom closure shall be designed to provide a self-cleaning, smooth, unobstructed flow path at the opening invert.

7105. FRAMES

The frames shall be of cast iron, one-piece construction of flat frame type with rectangular opening as indicated on the Drawings. All contact surfaces of the frame shall be machined. The frame shall have machined dovetailed grooves on the front face into which bronze seat facings shall be driven and machined to a .0016 mm finish.

7106. SLIDE

The slide shall be of cast iron, one-piece construction, rectangular with integrally cast vertical and horizontal ribs. A

tongue on each side, extending the full length of the gate, shall be machined on all sides with a 1.6 mm clearance maintained between the gate tongue and the gate guide groove. Wedge pads for side wedges shall be cast integrally on the gate and machined to receive the adjustable bronze wedges. A heavily reinforced nut pocket shall be cast integrally on the vertical centerline and above the horizontal center and be of such shape to receive the square-backed bronze thrust nut. The thrust nut pocket shall be drained.

7107. GUIDES

The guides shall be cast iron, one piece, bolted to the frame, designed to withstand the total thrust due to the seating and unseating water pressure and the wedging action. The guides shall be machined on all contact water surfaces and a groove shall be machined the entire length of the guide to allow 1.6 mm clearance between the gate tongue and the gate guide groove. The guides shall be of such length as to retain and support at least half the gate in the full open position. The guides shall be attached to the frame with stainless steel studs and nuts, and shall be dowelled to prevent any relative motion between the guides and the frame. They shall be capable of taking the whole thrust produced by water pressure and wedging action. Bronze wedge seats shall be attached to machined pads on the guides, where, in the closed position, they will make full contact with the wedging surfaces on the slide.

7108. WEDGES

The wedges shall be solid cast bronze, machined on all contact surfaces, and keyed to the cast iron pads to maintain adjustment by preventing undesirable or lateral motion. They shall be attached to the gate with silicon bronze studs and shall have silicon bronze adjusting screws with lock nuts. Wedges shall be fully adjustable and so designed that they will remain in the fixed position after adjustment.

On gates 60 cm and wider, that will be subjected to unseating heads of 1.50 m or more, top and bottom wedging devices shall be provided.

7109. SEAT FACINGS

All seat facings shall be malleable extruded bronze. The extruded seat facings shall be of a special shape to fill and permanently lock in the machined dovetail grooves when pneumatically impacted in place. Attaching pins and screws will not be allowed. The installed seat facings shall be machined to a .0016 mm finish or better.

These faces shall be of ample section and so finished that the maximum clearance between the seating surfaces, with the slide in the closed position, shall be 0.01 cm.

7110. THRUST NUT

Each gate shall be provided with a thrust nut for connecting the stem to the slide. The thrust nut shall be made of cast bronze, Grade III or VIII. It shall be of ample design to take the normal loads developed during the opening and closing of the gate, which shall be constructed to prevent turning of the thrust nut in the pocket in the slide.

On the rising-stem gates, the thrust nut shall be threaded and keyed or pinned to the stem.

7111. ASSEMBLY BOLTS, STUDS, NUTS AND ANCHOR BOLTS

All assembly bolts, studs, nuts and anchor bolts shall be furnished such number, size and spacing as required to enable satisfactory installation. They shall be made of stainless steel. An adequate number of holes shall be provided in the flange on the back of the gate to prevent leakage under the design beads and to resist the shearing action caused by closing and opening forces.

7112. WALL THIMBLE

Wall thimbles shall be furnished for the sluice gates, which shall be of the sections and depths as indicated on the Drawings. They shall be cast iron, one-piece construction and of adequate section to withstand all operational and reasonable installation stresses. The wall thimbles shall be internally braced during concrete placement. A center ring or waterstop shall be cast around the periphery of the thimble. The front flange shall be machined and have tapped holes for the sluice gate attaching studs and metal stamped vertical centerlines with the word "TOP" for correct alignment. The opposite end of the wall thimble shall be machined to provide the exact depth shown. The large rectangular wall thimbles shall be provided with holes in the invert to allow satisfactory concrete placement beneath the thimble. A permanent gasket of uniform thickness shall be provided between the sluice gate and the wall thimble. Studs to fasten the gate to the thimble shall be stainless steel.

7113. STEMS 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. The threaded portion of the stem shall have machined cut threads of the ACME type. The number of threads per inch shall be such as to work most effectively with the lift mechanism used. The top of the stem shall be provided with a stop collar. Also plastic stem covers must be provided.

7114. STEM GUIDES

Stem guides shall be cast iron, bronze bushed, mounted on cast iron brackets. They shall be adjustable in two directions and shall be spaced at sufficient intervals to adequately support the stems.

The guides 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.

7115. MANUAL OPERATING MECHANISM

The manual lift mechanism shall be either the handwheel type without gear ratio or the crank-operated type with either a single or double gear type and shall have a lift nut of cast bronze, Grade III or Grade VIII, threaded to fit the operating stem. Ball or roller bearings shall be provided above and below the flange on the lift nut to take the maximum thrust developed in opening and closing the gate.

Gears shall be of cast nodular 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 geared lifts shall be suitable for portable motor operation.

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

The design of the lift mechanism shall be such that the slide can be operated with an effort of no more than eighteen kilograms on the crank or handwheel but shall be able to withstand without damage an effort of up to 90 kilograms. The maximum crank radius shall be 380 cms.

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 a position indicator to show the position of the gate at all times. The indicator shall be attached to the lift mechanism.

7116. PAINTING

All ferrous parts of the sluice gates and stem guides shall be painted in accordance with the General Specification in Section "Painting". (All machined iron surfaces including drilled and tapped holes shall be coated with a protective grease.)

7117. SHOP TESTING

Each completely assembled gate, in the vertical position, shall be shop inspected for proper seating. Seat facings shall be machined and wedges adjusted to exclude a 0.1 mm thickness gauge between the frame and gate seating surfaces. The gate discs shall be fully opened and closed in its guide system to insure that it operates freely.

SECTION 7200. APPURTENANCES OF VALVE AND GATE

7201. OPERATORS FOR VALVES IN 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.

Extension stems for valves shall be of ANSI schedule 80 galvanized steel pipe with pinned couplings. Pipe manufactured to British Standard, medium grade will also be accepted.

The operating mechanism of butterfly 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.

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 housings, supports and connections to the valve shall be designed with a minimum safety factor based on the ultimate strength, of three, based on the yield strength, of the material used.

The guides 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.

7202. MANUAL VALVE OPERATORS

(1) General

Manual operators shall require an input force of not greater than 18 kilograms pull. Hand wheel shall be of cast iron, clearly marked with an arrow and the word "open" cast in relief on the rim.

The manual lift mechanism shall be either the handwheel type without gear ratio or the crank-operated type with either a single or double gear type and shall have a lift nut of cast bronze, Grade III or Grade VIII, threaded to fit the operating stem. Ball or roller

bearings shall be provided above and below the flange on the lift nut to take the maximum thrust developed in opening and closing the gate.

Gears shall be of cast nodular 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 geared lifts shall be suitable for portable motor operation.

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

The design of the lift mechanism shall be such that the slide can be operated with an effort of no more than eighteen kilograms on the crank or handwheel but shall be able to withstand without damage an effort of up to 90 kilograms.

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 a position indicator to show the position of the gate at all times. The indicator shall be attached to the lift mechanism.

(2) Material

Materials used in construction of manual operator lifting devices shall meet the minimum requirements of the following ASTM or AISI specification:

<u>Material</u>	<u>Designation</u>
Cast Iron-For gear housing, pedestal, controller housing, hand rails and other miscellaneous parts	ASTM A 48, Class 30
Cast Bronze-For stem nut and worm gears	ASTM B 148 Alloy 9C or 9D; or ASTM B 147 Alloy 8C
Steel worms	AISI 8620
Steel for spur gears and helical gears	AISI 441
Steel for shafting	AISI 1020 or 1018

(3) Gear Case

The gear case shall be of cast iron. Flanges for motor attachment, pedestal attachment, and an electrical control cabinet shall be integrally cast, fully machined, and template drilled. Bearing and grease seal seats shall be machined using jigs and fixtures to insure proper positioning of these parts in the assembled unit. Other surfaces requiring precision fit shall be machined and jig drilled, or both.

(4) Pedestal

Pedestal shall be of fabricated steel or of cast iron with sufficient section to withstand the full load encountered in the gate operation, maintaining the safety factor specified.

(5) Gears

The reduction gearings 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 against the maximum specified unbalanced head. Helical and spur gears shall be of alloy steel accurately machined. The worm shall be of alloy steel and hardened, running with a worm gear of nickel or manganese bronze. Torque requirements shall be computed on the basis of an efficiency of not greater than 50 percent.

(6) Bearings

Roller bearings shall be provided on the stem nut to take the thrust developed during opening and closing of the gate under full unbalanced head. All other gears and shafting shall be mounted on antifriction bearings throughout.

(7) Stem Nut

Stem nut shall be of high-tensile bronze whose physical characteristics and resistance to wear shall be equivalent or superior to bronze for specified operating conditions. The stem nut shall engage the threads of the stem and shall be rotated by power to raise or lower the gate. The stem nut shall be of two-piece construction to permit installation and removal without complete disassembly of the lifting device.

All operators shall be of the hand wheel type, unless noted otherwise. Hand wheels shall have arrows indicating the direction to close.

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 shafts and special seals to prevent corrosion. 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 covers and shall be adjustable. A cap shall center and guide the entrance and location of the operating wrench.

7203. ELECTRIC VALVE OPERATORS

Shaded-pole, motor type, electric operators for use on open-shut lines up to and including 100 mm line size shall be alternating current operated, reversing type. Shaded pole motors, if used shall be totally enclosed, with gears operating in an oil bath. Internal factory adjusted limit switches shall be incorporated to open motor power circuit at each extreme of travel. Additional internal or external limit switches shall be furnished mounted, for operation of remote indication, monitoring or interlocking circuits. Each switch shall have double pole, double throw contact arrangement, rated at 5 amp, 220 volt, alternating current, non-inductive load. Motor shall be designed for operation on 220 volt, single phase, 50 hertz power supply. Voltage reduction, if required, shall be integral with each unit. Operators shall have 125 percent maximum torque input required for all type valves.

Operators on valves on lines 150 mm and over shall be of the reversing iron-positioning type. Valves in non-hazardous areas shall be NEMA IV, weatherproof.

Each operator shall have over travel limit switches and auxiliary limit switch contacts for use with external circuits as required. Reversing contractors shall be furnished and mounted in valve operator housing.

(1) Rate of Operation

All parts of the lift mechanism shall be designed to move the gate slide at a rate of approximately 300 mm per minute minimum under the full specified unbalanced operating head.

(2) Electric Motor

Motors 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. The motors shall be totally enclosed, nonventilated 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°C over 40°C ambient.

(3) Torque Protection

The operating unit shall include an adjustable torque or thrust-limiting switch capable of cutting off 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, and detailed instructions shall be furnished to the Engineer for final setting after installation.

(4) Limit Switches

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, indicator lights, and so forth, shall be factory installed.

(5) Controllers

Each unit may have two integral controllers, one for remote operation and one for local operation at the floor stand. Each controller shall be a three-button, two light pushbutton station, mounted in a suitable fabricated steel enclosure.

(6) Lubrication

All gearing and bearings shall be grease or oil lubricated to permit year-round operation in temperatures ranging from -29°C through 60°C. Oil or grease seals shall be provided above and below the bearing on the stem nut and on other exterior openings in the gear case where grease or oil can escape.

(7) Handwheel

The operating unit shall be equipped with a handwheel for manual operation. The handwheel shall be connected so that operation of the motor will not cause the handwheel to rotate and the operation of the handwheel shall not cause the motor rotor to rotate. The handwheel 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 handwheel is in use, the design of the unit shall prevent the power from being transmitted to the handwheel. The handwheel shall require an effort of no more than 27 kilograms on the rim to operate the gate under maximum specified unbalanced head. An arrow and the word "open" or "close" shall be placed on the handwheel to

indicate direction of resultant gate movement. Lettering shall be in the Thai and English language.

(8) Hammer Blow

The operating unit shall include a built-in lost-motion device that will permit the motor to attain full speed before the hammer blow necessary to initiate gate motion in either opening or closing of the gate is imparted.

(9) Electrical Controls Enclosure

All controls shall be mounted in an enclosure integrally cast as a part of the gear case. The enclosure shall be provided with a hinged cast-iron cover, the face of which shall be machined and drilled to match this portion of the gear case. The cover shall be secured by adequate fasteners and a gasket shall be provided to weatherproof the joint. "Open", "Stop" and "Close" pushbuttons shall be located on the cover and shall be provided with indicator lights. Red and green lights shall also be provided to indicate gate positions red for open and green for closed. Both these lights shall remain on when gate is in intermediate position between closed and open.

The electrical enclosure shall be provided with strip heaters. All controls including those specified in this section, together with limit switches, torque switches, and so forth, shall be factory wired.

Valves shall travel from one extreme position to the other position within the time limits specified in the Particular Specifications.

7204. ACCESSORIES

(1) Floor Boxes

Floor boxes shall be of cast iron, of ample strength and size, and shall be equipped with a readily removable brass floor plate. Cast iron shall be ASTM A126, "Gray Iron Castings For Valves, Flanges and Pipe Fittings", class B. Floor boxes shall be of the "plain type" where intermediate stem guides are used and of the "bushing type" where necessary to preserve stem alignment. Bushing to be cast bronze conforming to ASTM B 132 Alloy A, Grade II.

(2) Valve Boxes

Valves boxes for buried valves shall be of the PVC or cast iron slide pattern type to permit adjustment of the box length and shall be equipped with a round base and a readily removable box top, on which is cast the letter "W". The top shall be provided with a chain attached to the wall of the box stem.

The sliding type valve box is adjusted by sliding the upper section over the lower section. Flanges on both sections serve to locate the upper section and hold it in place. This design minimizes transmission to the valve of stresses imposed by loads moving over the valve box at ground level.

Extension sections shall be furnished to increase the length of any valve box beyond its maximum adjustable length. These shall be used when boxes are not grading, and are used to make up a valve box of unusually great length by incorporating one or more intermediate or extension sections.

Valve box covers are so designed that they remove easily to provide access to the valve operating nut. They shall be strong and rugged, designed to stay in position and resist damage under heavy traffic conditions.

(3) Air Cocks (Pet Cocks)

Cocks for air control and release shall be standard, all brass, flat or tee head, with male and female threads and air tested for 125 pounds per square inch working air pressure. One wrench for operation of the air cock shall be furnished with each cock. The size of the cocks shall be as shown on the Shop Drawings.

(4) Solenoid Valves

Solenoid valves shall be bronze, designed to operate on 220 volt, single phase, 50 hertz current. Valves shall be normally closed (open when energized, closed when de-energized); 2-way valves with general purpose enclosure (NEMA 1), unless otherwise specified. The size of the cocks shall be as shown on the Shop Drawings. Units shall be mountable in any position without affecting operation.

(5) Limit Switches

Valves and other positioned devices, where indicated on process flow diagram and/or listed, shall be equipped with separate "dry" contact limit switches for operation of remote panel mounted indicating lamps or for processor use. Separately mounted switches shall be machine tool weatherproof type with silver alloy contacts rated at 5 amps, 220 volts, 50 hertz. Where additional contacts are required for circuit interlocks, limit switches shall have double pole, double throw contacts. Switches shall be NEMA IV construction. Switches on separate valves shall be mounted and adjusted by the manufacturer.

Valves with electric operators containing built-in limit switches shall have a spare set of normally open - normally closed, form "C", contact actuated at either extreme position of valve travel. Contacts shall be rated at not less than 5 amps, 220 volts, 50 hertz.

(6) Corporation Stops

The corporation stop shall be made of Grade I cast bronze (ASIM B 62-70) having the following properties:

Chemical Composition

Copper, 84.0 -86.0%; Nickel max. 1.0%
Lead, 4.0 - 6.0%; Iron max. 0.3%
Tin, 4.0 - 6.0%; Phosphorus max. 0.05%
Zinc, 4.0 - 6.0%

Mechanical Properties

Tensile strength, min. 21.1 kg/sq.cm
Yield Strength, min. 9.8 kg/sq.cm
Elongation in 5 cm, 20%

The threads shall be in accordance with B.S. 21. When fitted with the tapped coupling and tested at 6.0 kg/cq.cm the joint shall be completely watertight.

Each piece of corporation stop shall be subjected to the test pressure of 8.0 kg/sq.cm at the factory for the minimum period of 5 seconds.

The nominal size of the corporation stop shall be the same as the outlet of the tapped coupling to be corporated as shown on the Drawings.

7205. INSTALLATION OF VALVES, GATES AND APPURTENANCES

All valves, gates and appurtenances shall be installed in accordance with Drawings and direction by the Engineer. 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.

7206. TESTING OF VALVES, GATES AND APPURTENANCES

(1) General

The Contractor shall notify the Engineer at least thirty working days prior to shop tests. The Engineer reserves the right to witness all tests.

(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 reverse, under a noflow condition, to demonstrate that the complete assembly is workable.

(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 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 min, and there shall be no indication of leakage past the valve during the test period.

(4) Hydrostatic Tests

Valves specified shall be hydrostatically tested. Hydrostatic test shall conform to the following:

With the valve disc in a slightly open position, internal hydrostatic pressure equivalent to two times the specified working pressure shall be applied to the inside of the valve body of each valve for a period of 10 min. 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) Field Testing

When the valves, gates and appurtenances have been completely installed and as soon as operating conditions permit, they shall be given a field test as required in accordance with the General Specifications and by the Engineer to demonstrate that they have been suitably installed, that they meet all requirements, are in good operating condition and are, in every way, adequate for the service intended.

Buried valves shall be bench tested for leakage. The Contractor shall test buried valves at 125% of working pressure prior to installation in the presence of the Engineer's representative. All visible water leakage including leakage through the packing shall be corrected to the satisfaction of the Engineer. No leakage will be permitted.

7207. PAINTING

Valves and appurtenances shall be painted and/or coated by suitable material to prevent rust on ferrous components until the time of installation. All pipe connection openings shall be capped to prevent the entry of foreign matter prior to installation.

All valves, gates and appurtenances, which will be exposed to view in the finished work, shall be shop primed on the exterior, in accordance with the General Specification in Section "Painting", unless noted otherwise.

All non-exposed valves, gates and appurtenances shall have the ferrous parts, except finish or bearing surfaces, painted with two (2) coats of coal-tar epoxy paint to a total thickness of 16 mils.

7208. TOOLS AND SPARE PARTS

There shall be furnished all special tools that may be required for the installation and servicing of the equipment. These tools shall be properly packed in a suitable steel box with the contents listed on the outside in neat lettering in contrasting color, in the English language. Each tool box shall be provided with a lock and keys conforming to the General Specification of Division 9 titled "Hardware". Hinges for the tool box shall be of the continuous hinge type.

The Contractor shall furnish tools and spare parts in accordance with the schedules provided in the Particular Specifications and/or the Contractor's recommendations.

7209. OPERATING MANUALS

Six (6) sets of all instructions and operating manuals for each type of valve, gate and appurtenance shall be provided in the English language.

SECTION 7300. DRAINAGE PUMPS

7301. GENERAL

The work shall be required to furnish and install, ready for operation drainage pumps, in the locations noted on the Drawings, as specified herein.

(1) Data to be Furnished

Literature and Shop Drawings, describing the equipment in sufficient detail, including materials of construction and parts list, to indicate full conformance with the detail Specifications and to show installation details shall be provided by the Contractor.

(2) 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.

7302. PUMPS

(1) Pump

The pumps, each with the capacity noted on the Drawings, shall be furnished.

a. 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 insure positive alignment. A strainer of corrosion resistant material shall be securely attached to the suction side of the casing. Strainer shall have 14 mm diameter holes. Casing shall be provided with bronze wearing rings.

b. 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.

c. Shaft

The shaft shall be of forged steel, turned and ground and of sufficient diameter to transmit the power of the motor and

operate at maximum speed without vibration. A stuffing box shall be provided where the shaft passes through the pump supporting plate.

d. Bearings

The upper bearing shall be a combined radial and thrust type antifriction bearing, grease lubricated. The lower bearing shall be made up of a non-seizing, non-scoring high lead-bronze bearing bushing.

e. Coupling

The pump shall be directly connected to the electric motor through a flexible coupling of sufficient size to transmit the maximum power of the electric motor.

f. Pump Support Plate

Each pump shall be supported from on oval steel plate mounted on the pit cover plate. The pump discharge shall pass through and be rigidly supported by the supporting plate. A float switch shall be mounted on each supporting plate.

(2) Motor

Electric motor shall conform to requirements and shall be vertical, open drip-proof, ball bearing type. Each motor shall be actuated through a float switch mounted on the pump supporting plate and operated by a copper float with rod and float stops. Float switch shall have NEMA IV enclosure.

(3) Sump Cover Plates

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.

(4) Installation

The pumps shall be installed in full accordance with the manufacturer's recommendations and as shown on the Drawings.

(5) Testing

Upon completion of installation, the Engineer will require an operating test on the pumps. The Contractor shall furnish the labor and materials required for such tests and shall at his own expense correct any defects.

(6) Painting

All non-machined surfaces shall be shop primed and field painted as specified under the General Specification in Section 9400 "Painting".

(7) Name-Plates

Brass 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.

DIVISION 8. ELECTRIC FACILITIES

SECTION 8000. GENERAL

8001. RULES AND REGULATIONS

All equipment and work under this Contract shall comply with the requirements of the Provincial Electricity Authority, and all local ordinances. The Contractor shall file the required notice with any municipal department having jurisdiction over such permits and obtain and pay for all permits required.

8002. MATERIALS

The materials used in all systems shall be new, unused, and as hereinafter specified. All materials where not specified shall be of the very best of their respective kinds. Samples of materials or manufacturer's specifications shall be submitted for approval.

Electrical equipment shall at all times during construction be adequately protected against mechanical injury or damage by water. If any apparatus has been damaged, such damage shall be repaired by the Contractor at his own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such expense of the Contractor or shall be replaced by the Contractor at his own expense.

8003. SAMPLES

Samples of equipment, as directed by the Engineer, shall be submitted for approval. These samples shall be delivered to the Engineer, all charges prepaid, and be properly labeled with the name of item, manufacturer's name, and name of project.

8004. DRAWINGS

- a. All shop drawings shall be checked by the Contractor for accuracy and Contract requirements before submittal. Shop Drawings shall bear the signature of the Contractor and date checked and shall be accompanied by the statement that the Shop Drawings have been examined for conformity to Specifications and Drawings. This statement shall also list all discrepancies with the Specifications and Drawings.
- b. The Engineer's check shall be only for conformance with the design concept of the Project and compliance with the Specifications and Contract Drawings. The Engineer's approval

shall in no way relieve the Contractor from the responsibility of, or the necessity of, furnishing materials and workmanship required by the Contract Drawings and Specifications which may not be indicated on the Shop Drawings.

- c. The Contractor shall be responsible for all dimensions to be confirmed and correlated to the job site and the coordination of his work with the work of all other trades.
- d. No material shall be ordered or shop work started until the Engineer's approval of Shop Drawing has been given.

8005. INSPECTION

The Works under this Contract shall be installed in accordance with the requirements of Provincial Electricity Authority and all local ordinances. The Contractor shall file the required notice with any municipal department having jurisdiction over such permits, and obtain and pay for all permits required.

8006. MARKING

The Contractor shall provide nameplates of lamacoid sheet, with engraved white letter on black background, secured to the equipment in a permanent manner. All markings shall be as approved by the Engineer and shall be applied to all pieces of equipment such as switches, circuit breakers, panelboard, motor starters, etc.

8007. CONTRACTOR'S REPRESENTATIVE

The Contractor shall retain at the Site, during the period of electrical construction, a competent electrical foreman, satisfactory to the Engineer, who shall be in full charge of the work under this division.

SECTION 8100. GENERAL REQUIREMENTS OF SWITCHGEARS AND SWITCHBOARDS

8101. TYPE AND ENCLOSURE

The switchgears and switchboards shall be of indoor use selfsupported metal-clad for switchgears and of metal enclosed for switchboards. The said equipments shall be dead front cubicle type of complete vermin proof. Class of the equipments enclosure shall be equivalent and or more than the class F2 specified by JEM1153 standard.

8102. STRUCTURE

- a. The switchgears and switchboards shall be made of rigid structural steel frame, and enclosure of adequate thick rolled steel plate.
- b. The said equipments shall be free from twist during handling and after installation and shall be free from magnetic vibration.
- c. The equipment including circuit breakers, busbars and instrument transformers shall be capable of withstanding without damage the electromagnetic and thermal stresses of short circuit currents.
- d. The equipments shall be furnished with lockable front door with chrome plated handles and either removable or fixed panels of adequate thickness on top, rear, bottom and sides in accordance with manufacturers instructions.
- e. The control switches, signal lights, etc. shall be mounted on a front door.
- f. Adequate provisions shall be made for future extension at both ends at 3.3 KV lined-up switchgear assembly.
- g. 3.3 KV feeder switchgears shall unless otherwise specified contain two circuit breakers in each switchgear and each circuit breaker compartment shall have hinged lockable front door.
- h. Ventilating louvers shall be provided on the doors, removable panels and other locations, where required, to allow natural circulation of air to prevent undue temperature rise. Louvers shall be fitted with screens to prevent entry of insects and vermin.

The equipments to be installed in the highly humid and damp place shall be so constructed as to prevent damp damage.

- i. The equipments shall be provided with anticondensation heater together with ON/OFF switch.

- j. The circuit breakers, together with circuit breaker compartment, shall be provided with automatic safety shutters.
- k. Transporting lifter for circuit breakers and circuit contactors shall be supplied by the Contractor.

8103. Power Buses and Earth Bus

- a. Power buses shall be of three phase and of copper having suitable current rating, and shall be supported by porcelain or resin insulators designed to withstand forces due to the momentary short circuit current of the system.
- b. Earth bus shall be continuous along the entire length of the lined-up switchgear assembly. Earth bus shall be of copper and sized and supported to withstand the short circuit current of the system.

8104. SMALL WIRING

- a. The switchgears and switchboards shall be wired complete at the factory. All small wiring shall be made with 600 V PVC insulated wire and sized 2 sq.mm or larger.
- b. All small wiring shall be neatly run and securely fixed in the plastic duct with cover and the said wiring shall be able to be checked by wiring diagrams without removing bindings.
- c. Separate lugs shall be used for each conductor. The size of the lug shall be suited to the size of conductor terminated. Washers, spring washers or other approved locking devices shall be used.
- d. Numbered ferrules shall be fitted to each end of all wires. Ferrules shall be of white tape of self-sticking with black numbers.

8105. TERMINAL BOARDS

- a. Terminal boards which are used for connecting incoming and outgoing wires to and from the switchgears and switchboards shall have pairs of terminals for incoming and outgoing wires, and not more than two wires shall be connected to any one terminal.
- b. Terminal boards shall be rated for 600 V and insulating barriers shall be provided between each adjacent pair of terminals. Transparent covers shall be provided on terminal boards.

- c. All connections shall be made at the front side of the terminal boards.

8106. PAINTING

All steel surfaces of switchgears and switchboards shall be painted with two coats of sealing primer and surfacer, and not less than two coats of finish paint. Painting color shall be approved by the Engineer.

8107. VOLTAGE OF CONTROL CIRCUITS

Voltage of control circuits shall be as follows:

<u>Item</u>	<u>For 22 KV and 3.3 KV Metal-clad Switchgear</u>	<u>For 3.3 KV Motor Starter and Motor Control Center</u>
Control circuit	100 V DC	220 V AC
Signal light circuit	100 V DC	220 V AC
Interlock circuit and Alarm circuit	100 V DC	100 V DC
Other circuit	220 V AC or 380 V AC	-----

8108. METERS

- a. All electrical instruments and meters for panels mounted on their external surface shall be of the flush pattern with transparent cover of air tight construction, and 110 mm square circular scale type and be provided with external zero adjustment.
- b. All meters shall be marked with a red line at the rated value of the scale.
- c. The accuracy of the electrical instruments and meters shall be the followings:

DC Ammeter and Voltmeter:	Within $\pm 1.5\%$ of full scale
AC Ammeter and Voltmeter:	Within $\pm 1.5\%$ of full scale
Wattmeters	: Within $\pm 1.5\%$ of full scale
Power-factor meters	: Within $\pm 4^\circ$ in phase angle
Frequency meters	: Within $\pm 1\%$ of central frequency

8109. INSTRUMENT, CONTROL AND AUXILIARY SWITCHES

- a. Instrument switches for ammeters and voltmeters shall be provided with chrysanthemum shape grip.
- b. Control switches for circuit breakers shall be provided with pistol type grip.
- c. Control switches shall be provided with transparent plastic grip cover so as to prevent maloperation of the circuit breakers.
- d. Push buttons shall be of the momentary type.
- e. The contacts of all switches and push buttons shall be strong and to have positive wiping action when operated.
- f. All instrument switches and control switches shall be provided with labels or engravings for clear indication of operating position of the switch.
- g. All auxiliary relays, switches, contactors and mechanisms for indication, protection, metering, control, interlocking, supervisory and other services shall be mounted in approved accessible positions of panels and be protected in approved manner.

8110. ALARMING SYSTEM

- a. Visible and audible alarming system shall be provided as specified herein or as directed by the Engineer. The visible alarming shall be given by lamp type annunciator, while the audible alarming shall be given by a buzzer and a bell mounted onto the switchgear or switchboard.
- b. The lamps of the annunciator shall be able to have ON/OFF check by a push button switch.
- c. The alarming system shall be provided with push button switches to cancel the visible and audible alarm.

8111. SIGNAL LAMPS

- a. The switchgears and switchboards shall be provided with signal lamps and indicating lamps.
- b. The lenses and lamps shall be changeable from front of the panel.

8112. PROTECTION RELAYS

- a. All protection relays shall be of the flush pattern with transparent cover, drawout type, and moisture and dust proof construction.
- b. The protection relays shall be of induction disc type of inverse time delay characteristics and instantaneous element as required.
- c. The said relays shall be provided with operation indicator of hand reset type and shall be able to be reset without opening the relay cover.

8113. TEST TERMINAL

The secondary circuits of potential and current transformers shall be provided with test terminals of plug and socket type for easy inspection.

8114. CIRCUIT BREAKER

(1) 22 KV circuit breaker

- a. The circuit breaker shall be of vacuum circuit breaker and shall be rated for 24 KV, 50 Hz, 600A continuous current and an interrupting capacity of 500 MVA or more.
- b. The circuit breaker shall be of three pole, single throw, electrically trip free type, with control box, operation counter, auxiliary switches.
- c. The circuit breaker shall be operated by means of solenoid mechanism, and also equipped with a manual handle for emergency manual closing or test.
- d. The circuit breaker shall be equipped with secondary plug for control circuit which shall manually engage in the operating and test position to complete control circuits.
- e. The circuit breakers of equal rating shall be completely interchangeable.

(2) 3.3 KV Circuit Breaker

- a. The vacuum circuit breaker shall be rated for 7.2/3.6 KV, 50 Hz, and an interrupting capacity of 250 MVA or more at 3.6 KV. Rated current of the said breakers shall be 600 A.

- b. The circuit breaker shall be of three pole, single throw, mechanically and electrically trip free, with position indicator, operation counter, auxiliary switches, primary and secondary disconnecting devices and a mechanical and electrical interlock mechanism.
- c. The circuit breaker shall be operated by means of solenoid mechanism, and also equipped with a manual handle for emergency manual closing or test.
- d. The circuit breaker shall be equipped with secondary plug for control circuit which shall manually engage in the operating and test position to complete control circuits.
- e. The circuit breakers of equal rating shall be completely interchangeable.

(3) Molded Case Circuit Breaker

- a. Molded case circuit breaker shall be manually operated or motorized operation, and trip free from the handle, and provided with inverse time thermal elements for overload protection, and instantaneous magnetic elements for short circuit protection, both on all poles. The circuit breaker shall be any one of four or three or two poles.
- b. Molded case circuit breaker shall have auxiliary switches, voltage tripping mechanism.
- c. Rated interrupting capacity of the circuit breakers shall be selected for the short circuit current of the systems on which they are applied.
- d. Circuit breaker shall include external handle which clearly indicates "on", "off", or "tripped", and shall be lockable in the "off" position.
- e. Trip rating of air circuit breaker shall be coordinated with motor rating served when those are used combination starter.

8115. COMBINATION STARTER

- a. The starter shall be a combination of magnetic type contactor and three units of current limiting type power fuses.
- b. The contactor shall be rated for 3.3 KV, 50 Hz, 200 A continuous current and interrupting capacity of 25 MVA at 3.3 KV.
- c. The contactor shall be of three pole, single throw, and be equipped with an operation counter, auxiliary switches, a set of silicon rectifier for operation of the starter, a latch

mechanism, primary and secondary disconnecting devices, and a mechanical and electrical interlock mechanism.

- d. The rated voltage of the fuses shall be 3.6 KV, and the interrupting capacity of 250 MVA at 3.6 KV.
- e. The combination starter of equal rating shall be completely interchangeable.
- f. A magnetic contactor will be considered as an alternative of this type.

8116. STARTING REACTOR

The reactor shall be of three phase with dry type and shall have three taps of 80%, 65% and 55% of the primary voltage which shall be 3 KV.

8117. STATIC CAPACITOR

- a. The capacitor shall be of three phase with oil immersed type and shall be 3.3 KV, 50 Hz of the rated voltage.
- b. The capacitor shall have discharge coils in its case and shall have enough capacity to improve power factor of high tension motor to 90%.

8118. POTENTIAL AND CURRENT TRANSFORMER

- a. Primary rating of potential and current transformers shall be suited for the ratings of the circuit to be connected.
- b. Potential and current transformers shall be insulated for the full voltage rating of the switchgear.
- c. Potential transformer shall be of indoor, single phase or three phase type and with protective fuses.
- d. 3 KV and 380 V potential transformer shall be assembled into with drawable construction.
- e. Grounding potential transformer shall have current limiting resistance.
- f. Current transformer shall be of indoor, single phase, molded and dry type.
- g. Current transformer shall have enough overcurrent strength.

SECTION 8200. GENERAL REQUIREMENTS OF MOTOR CONTROL CENTER

8201. GENERAL

- a. Power source shall be rated for three phase, four wire 380-220 V, 50 Hz.
- b. Rated current of bus shall be as follows:

Horizontal bus	600 A
Vertical bus	300 A
- c. Motor control center shall be so designed as to safely withstand without damage against prospective fault current.
- d. Motor control center shall consist of an assembly of metal enclosed sections vertically assembled, joined together to form a totally enclosed free standing unit designed to permit easy addition or removal of sections in the field.

8202. STRUCTURE

- a. Main power bus shall be at top sections of control center, and vertical power bus shall be easily accessible each section of control center.
- b. Starter units, air circuit breaker units, and other equipment in separate compartments shall be isolated by steel barriers.
- c. Grounding bus shall extend through the length of the motor control center.
- d. Control center shall have ample space for entrance of connecting power and control circuits from either its top or bottom. Main incoming lines shall be fed from either the top or bottom of the control center.
- e. Control center shall have ample width of horizontal wiring tray at either the top or bottom of each section.
- f. Control center shall have complete accessibility from the front to starters, control devices, and all other components for wiring and maintenance in order to permit back to wall installation.
- g. Control center shall have engraved nameplates reading "Motor Control Center 1", "Motor Control Center 2", etc. for each motor control center, and also individual nameplates for each compartment with wording as required by the Owner.
- h. All spare auxiliary and relay contacts shall be wired to external connection terminal blocks.