

**9.1.5**

**METALS**



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## 9.1.5 METALS

### 9.1.5.1 STRUCTURAL STEELWORK

#### 9.1.5.1.1 Scope of Work

The Contractor shall provide all labour, materials, equipment and incidentals necessary to furnish and install structural steelwork and required to erect the structural framing as shown on the drawings.

#### 9.1.5.1.2 Detailing

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

The Contractor shall furnish a mill certified report, in triplicate, of the tests for each lot 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 British Standard requirements. 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.

#### 9.1.5.1.3 Materials

##### 9.1.5.1.3.1 Steel

All Structural Steel shall, comply with the mechanical and chemical composition and other requirements of the latest editions of relevant following Standards and grades including the following specified.

Structure shapes, plates and bars unless otherwise noted	Hot-rolled Section and Plates. BS 4360: "Weldable Structural Steel" Grade 43A. <b>or</b> ASTM A36 "Structural Steel	JIS G3101, "Rolled Steel for General Structures Class 2
Corrosion resistant structural shapes, plates and bars Square steel columns	ASTM A242, "High Strength Low-Alloy Structural Steel"	JIS G3114, "Hot-Rolled Atmospheric Corrosion Resisting Steel for Welded Structure" Hot-rolled Hollow

	Sections. BS 4360: "Weldable Structural Steel : Grade 43C. <b>or</b> AISI C1015	
Round Tube. BS 1775: "Steel tubes for Mechanical, Structural and General Engineering Purposes" Grade 16 or BS 4360 Grade 43C.	BS 639, AWS Spec. for Arc Welding Rods	JIS Z3201 "Gas Welding Rods for Mild Steel"  JIS Z3210, "Covered Electrodes for Mild Steel Sheet"
Lipped C section purlins. Australian Standard (AS 1397) Hot dipped zinc coated G 450 - Z 275 (450 N/mm <sup>2</sup> Minimum yield stress and 275 g/mm <sup>2</sup> minimum coating mass)		JIS Z3211, "Covered Electrodes for Mild Steel"  JIS Z3212, "Covered Electrodes for High Tensile Strength Steel"
Cold Rolled Section. BS 1449 Part 1 : "Carbon Steel plate, sheet and strip". Minimum yield strength Shall be 250 N/mm <sup>2</sup> ,		JIS Z3213, "Covered Electrodes for Low-Allow High Tensile Strength Steel"  JIS Z3214, "Covered Electrodes for Atmospheric Corrosion Resisting Steel"  JIZ Z3221, "Stainless Steel Covered Electrodes"
Steel pipe (medium weight)	BS 1387, "Steel Tubes and Tubular Suitable for Screwing to BS 21 Pipe Threads"	<b>or</b> , JIS G342, "Carbon Steel Pipes for Ordinary Piping"
Ductile iron High strength steel bolts	ASTM A536 (grade 60-40-18) ASTM A325, "High Strength Bolts for Structural Steel Joints"	JIS G5502, "Spheroidal Graphite Castings"
Structural steel Bars and shapes "Structural Steel"	ASTM A36	JIS G3101 "Rolled Steel for General Structures" Class 2

Mild Steel for Railing, posts, Flanges and sleeves (standard strength unless noted otherwise)	ASTM A53 "Welded and Seamless Steep Pipe"	JIS G3454, "Carbon Steel Pipes for Pressure Service"
Cast iron	ASTM A48 (class 30) "Gray Iron Castings"	JIS G5501, "Gray Iron Castings"
Bolts and Nuts	ASTM A307 Low Carbon Steel Externally and Internally Threaded Standard Fasteners"	<b>or</b> , High-Strength friction grip bolts to BS 4395 or grade 8.8 bolts to BS 3692
Cast Steel	ASTM A27 "Mild-to-Medium-Strength Carbon-Steel Casting for General Application"	JIS G5101, "Carbon Steel Castings"
Stainless steel pipe	ASTM A269, type 304 "Seamless and Welded Austenitic Stainless Steel Tubing for General Service"	JIS G3448, "Light Gauge Stainless Steel Pipes For Ordinary Piping"
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"	JIS G4312, type 304 "Heat-Resisting Steel Sheets and Plates"
Stainless steel bars and shapes	ASTM A276, type 304 "Stainless and Heat-Resisting Steel Bars and Shapes"	JIS G4311, type 304 "Heat-Resisting Steel Bars" and JIS G4317 "Hot Roll and Stainless Steel Equal Leg Angles"
Aluminium for structural Shapes	ASTM B221, alloy 6061, temper T6, "Aluminum-Alloy Extruded Bars, Rods, Shapes, and Tubes"	JIS H4100, "Aluminum and Aluminum Alloy Extruded Shapes"
Architectural aluminium	ASTM B221, alloy 6063, Temper T5	
Rolled steel	ASTM A283 "Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality"	JIS G3101, "Rolled Steel for General Structures" Class 2

#### **9.1.5.1.3.2 Bolts, Nuts and Washers**

- (a) All bolts and nuts shall comply with the following British Standards
- BS 4190 : ISO metric black hexagon bolts, screws and nuts". Strength Grades 4.6  
BS 3693 : ISO metric black hexagon bolts - Strength Grade 8.8. BS 3692 : Nuts and washers.
- (b) All plain washers shall comply with BS 4320 : "Metal washers for General Engineering purposes" and shall be normal diameter series of normal range thickness unless detailed otherwise on the drawings.
- (c) All spring washers shall comply with BS 4464 : "Spring washers for General Engineering and Automobile purposes (Metric Series)".
- (d) All bolts washers and nuts shall be 'non rust' either black or bright in appearance and shall not be painted.

See Clause 6.5 ( c ) and ( d ) for electrode materials.

#### **9.1.5.1.4 Workmanship**

Unless otherwise specified, structural steel shall be fabricated in accordance with the requirements of the British 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 Section 9.1. 5.3 "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 or British Standards. 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 truing 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.

#### **9.1.5.1.5 Field Connections**

Field connections shall be made by welding High-Strength friction grip bolts to BS 4395 or Grade 8.8 bolts to BS 3692 or, as shown on the drawings or approved shop drawings.

#### **9.1.5.1.6 Welding**

Welding shall be in accordance with Section 9.1. 5.3 "Metal Fabrication".



The Contractor may substitute field bolting where field welding is shown, provided bolting details showing shop drawing have been approved.

#### **9.1.5.1.7 Bolting**

Bolts shall conform to BS 4190 or BS 3693 or JIS B1186, "Sets of High Strength Hexagon Bolts, Hexagon Nuts and Plain Washers for Friction Grip Joints".

Anchor bolts shall be of mild steel with hexagonal nuts. Threads shall be clean cut and conform to ANSI, B1.1, "Unified Screw Threads" coarse thread UNC, Class 3A or British Standards.

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 utilise screed plates. The Contractor may substitute wooden templates in lieu of screed plates upon written approval by the Engineer.

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

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

All bolt, nut and washers, threads shall be hot dip galvanised and shall conform to British Standards, ANSI B1.1, Class 2A or JIS B0250.

#### **9.1.5.1.8 Painting**

##### **(1) Shop Painting**

All structural steel shall be given shop primer after fabrication and cleaning but before shipping in accordance with sub-section "Painting".

All steel work shall be thoroughly cleaned of all loose mill scale, rust, and foreign matter before shop painting. Each individual piece shall be painted prior to assembly. Edges where field welding is required shall not be painted.

Paint shall be applied only to dry surfaces.

##### **(2) Field Painting**

After erection the Contractor shall thoroughly prepare and clean the entire surface of all structural steel of all dirt, grease, rust or other foreign matter. The entire surface of all members shall be field painted as specified in sub-section "Painting".

## **9.1.5.2 MISCELLANEOUS METALS**

### **9.1.5.2.1 Scope of Work**

The Contractor shall furnish all labour, materials, equipment and incidentals necessary to supply and install all miscellaneous metals, concrete anchors and ornamental iron required and as shown on the drawings.

### **9.1.5.2.2 Shop Drawings**

The Contractor shall prepare shop drawings for all work mentioned in this Specification. All such shop drawings shall be approved by the Engineer before the work commences.

Every drawing shall be A1 Size show the number and sizes of all rivets and bolts, complete details of welds, type of electrodes, welding procedure including where the welds are to be made, and any other relevant information.

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 utilised in the work. 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, unless otherwise approved in writing by the Engineer.

### **9.1.5.2.3 Co-ordination**

The Contractor shall completely co-ordinate the work 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 this section, that are to be built into the work of other contractor, and shall supervise and be responsible for the proper location and installation of such.

### **9.1.5.2.4 Fabrication**

All miscellaneous metal work shall be formed true to detail, with clean, straight, sharply defined profiles, and smooth surfaces of uniform colour 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 jointed where least conspicuous.

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

#### **9.1.5.2.5 Finishes**

All steel work shall be thoroughly cleaned, by effective means, of all loose mill scale, rust, grease and foreign matter and shall be given one shop coat of paint after fabrication but before shipping. Shop painting shall be in accordance with the requirements specified in the sub-section for "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.

Galvanised surfaces shall not be painted, unless noted otherwise.

Casting 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 Section 9.1.5.3 "Metal Fabrication".

Galvanising shall conform to Section 9.1.5.5 "Galvanising".

All aluminium exposed surfaces shall have satin finish, free from die markings, scratches, welding discoloration, "leave-off-marks", or other surface blemishes. Unless otherwise specified, aluminium shall be given an Anodic oxide treatment in accordance with the Aluminum Association Specification AA-C22-A31 or JIS H8601, "Anodic Oxidation Coating on Aluminum and Aluminum Alloys" and JIS H8602, "Coating Combined with Anodic Oxidation and Organic Finishing on Aluminum and Aluminum Alloy". Aluminium, which after installation, will be exposed to severe corrosive conditions or wearing, shall have a finish equal to the Aluminum Association Specification AA-C22-A41. A coating of methacrylate lacquer shall be applied to all aluminium before shipment from the factory.

All exposed stainless steel surfaces shall be polished finish, free from die markings, welding discolorations or other surface blemishes.

#### **9.1.5.2.6 Installation**

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

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

All aluminium surfaces to come in contact with concrete or masonry shall receive a heavy protective coating of bituminous applied in a neat manner. All aluminium surfaces to come in contact with dissimilar metals shall receive a heavy brush coat of zinc chromate primer followed by two coats

of aluminium paint and a fabric separator. The dissimilar metal surface shall receive two coats of masonry paint.

#### **9.1.5.2.7 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.

Threads for all nuts and bolts shall comply with ANSI B1.1, "Unified Screw Threads", coarse thread, UNC class 3A or JIS B0205, "Metric Coarse Screw Threads".

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

Galvanised bolts shall be of the hot dip galvanised type.

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

Bolt and nut threads shall be galvanised and shall conform to BS 729, ANSI B1-1, Class 2A or JIS B0205.

#### **9.1.5.2.8 Nails and Spikes**

Nails and spikes shall be of the proper type, of new wire of adequate size and number to securely fasten and hold members in place. Samples of concrete masonry nails shall be submitted to the Engineer for approval and shall be of the corrugated or split type. Cut nails will not be accepted for masonry nails.

#### **9.1.5.2.9 Miscellaneous Shapes**

Miscellaneous shapes shall include but not be limited to sump cover plates, floor plates, angles, beams, fabricated plates, channels, bars and metal anchors for embedment in concrete or masonry.

Miscellaneous shapes shall be mild steel, unless stated otherwise. All material shall be in accordance with the details shown or specified.

#### **9.1.5.2.10 Hand Railings**

Hand railings indicated to be steel pipe shall be constructed pipe conforming to BS1387 "Steel Tubes and Tubulars Suitable for Screwing to BS21 Pipe Threads" Medium class or JIS G3452, "Carbon Steel Pipes for Ordinary Piping".

Railings shall be constructed of 38 mm pipe unless otherwise indicated and shall be galvanised unless otherwise called for on the drawings. Joints shall be welded in conformance with the details shown except railings required to be galvanised shall have galvanised 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. Vertical posts shall be provided every one (1) meter unless otherwise indicated on the drawings.

Where steel toe boards are noted on the drawings they shall be 10 cm. high of 4 mm thick steel plate attached to the railing posts by means of clips to prevent movement. Toe boards shall be continuous.

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

Railing posts may be set in boxed out sleeves, or pipe sleeves. Posts shall be grouted in using cement mortar and a steel cover plate. Galvanised chains shall be installed across openings in railings where indicated. One end of each chain shall be provided with a hook and eye for attachment purposes.

Chain links shall be 6 mm wide with twelve links per 30 cm.

Removable pipe railing shall be provided where shown and as detailed.

#### 9.1.5.2.11 Gratings

All gratings shall be welded rectangular opening type, galvanised flat bar gratings with seat angles, anchors and supports of galvanised steel. All gratings up to and including 1 meter shall be furnished in pieces approximately 1.0 m in width and all gratings for spans greater than 1.0 m shall be furnished in pieces approximately 0.8 m in width. All openings required in gratings shall be cut after fabrication but before galvanising. Gratings shall be banded where openings are provided and shall be strengthened as necessary. Installed units shall be true to plane and free of warpage and irregularities. Units shall be divided for ease of installation and removal, using the following *minimum size to span ratios unless otherwise shown on the drawings.*

Maximum Span	Bolts (mm at @ m)	Seat Angles (mm)	Shelf Angles (mm)
0.9	12 at @ 1.2	25 x 25 x 5	50 x 50 x 6
1.2	12 at @ 1.1	40 x 40 x 6	50 x 50 x 6
1.5	12 at @ 0.9	50 x 50 x 6	50 x 50 x 6
1.8	12 at @ 0.7	75 x 50 x 8	50 x 50 x 6
1.95	12 at @ 0.6	65 x 50 x 8	50 x 50 x 6
2.1	16 at @ 0.6	50 x 50 x 6	50 x 50 x 6
2.4	16 at @ 0.6	60 x 60 x 10	60 x 60 x 6

#### 9.1.5.2.12 Safety Steps

Safety steps shall be cast iron or ductile iron unless otherwise specified on the drawings; fabricated to the details shown on the drawings. All safety steps shall be hot dip galvanised unless it is of stainless steel. The surface of all safety steps shall be of the non-slip type. The step section shall be a minimum of 15 cm from the vertical surface.

Each safety step shall be manufactured to safely hold a weight equal to 450 kilograms, when embedded in masonry or concrete. The top step shall be placed no more than 15 cm from the top surface and the lowest step shall be placed a maximum of 30 cm from the bottom surface.

Step bar shall be installed every 30 cm interval vertically on centre in concrete and masonry; and shall not be subjected to any loads for a minimum of seven (7) days after placement.

#### **9.1.5.2.13 Cast Iron Frames and Covers**

Cast iron frames and covers shall conform to AISC specifications for the Design, Fabrication and Erection of structural steel for Buildings. Section 9.1.5.3 "Metal Fabrication"; conform to the details shown or the manufacturer's recommendation, 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 degrees apart, unless noted otherwise. Frames, covers and grate seats shall be machined to a true plane surface and shall seat firmly without rocking.

Covers required to be locked shall be provided with locking devices which will secure the covers to the frame and which will only be operated by a special wrench 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 required to be hinged shall be provided with the necessary hinges.

Covers shall have letters cast in. Unless shown otherwise, all lettering shall be in English. The Contractor shall receive approval of shop drawings by the Engineer prior to casting.

All small parts, bolts and erection fasteners shall be included.

#### **9.1.5.2.14 Bar Screens**

Bar screens shall be fabricated as detailed of non-corrosive aluminium alloy or stainless steel. Spacing of screen bars shall be as shown.

Guides shall be of the same material as the bar screen.

#### **9.1.5.2.15 Gates**

Steel gates shall be in accordance with the details shown on the drawings. Locking devices for gates shall be as detailed. Locks, keys and master keys shall be in accordance with sub-section "Hardware". All materials shall be shop primed and finish painted in accordance with sub-section "Painting".

#### **9.1.5.2.16 Steel Hangers for Wood Framing**

Steel rafter hangers, gusset plates, and similar devices for wood framing shall be fabricated from gauge steel and galvanised after fabrication and drilling.

#### **9.1.5.2.17 Barbed Wire Fencing**

Stock proof barbed wire fencing shall conform to BS 1722:part 3 except that dimensions shall be as shown on the drawings.

Barbed wire shall be of mild steel conforming to BS 4102.

### **9.1.5.3 METAL FABRICATION**

#### **9.1.5.3.1 Scope of Work**

This section specifies the workmanship standards applicable to the various phases of metal work fabrication, the methods and precautions for erection of metal structures and machines to insure conformance with the specifications and miscellaneous requirements incidental to the work.

#### **9.1.5.3.2 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 a cause for rejection. Finished members shall be free from kinks or bends. Shearing shall be accurately done, and all portions of the work neatly finished. Corners shall be square and true, unless otherwise shown on the drawings. Where re-entrant cuts cannot be made by shearing, a rectangular punch may be used. Re-entrant cuts shall be filleted, unless otherwise approved by the Engineer. Bends, except for minor details, shall be made by approved dies or bending rolls. Where heating is required, precautions shall be taken to avoid overheating the metal and it shall be allowed to cool in such a manner as not to destroy the original properties of the metal. Steel with welds will not be accepted, except where welding is definitely specified, called for on the drawings, or otherwise approved. All bolts, nuts, and screws shall be tight. The ends of pipes, except for handrails, 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 platework shall not exceed the limitation of standard mill practice as specified in the British Constructional Steelwork Association Ltd. "National Structural Steelwork Specification for Building 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 structures, 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 1/1000th of the span shall be a cause for rejection.

#### **9.1.5.3.3 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, 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" or JIS B8243, "Construction of Pressure Vessels", or approved equivalent standard.

Welding of steel water pipe shall be in accordance with AWWA C206, "Field Welding of Steel Water Pipe Joints" or JIS Z3601, "Recommended Practice for Manual Arc Welding (Steel Sheet)", JIS Z3603, "Recommended Practice for Submerged Arc Welding (Mild Steel Sheet)" and JIS Z3605, "Recommended Practice for Semi-Automatic Arc Welding", or approved equivalent standard.

Damage to galvanised 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 American Federal Specification MIL-P-15145. The paint shall be properly compounded with a suitable vehicle in the ration 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 galvanising rod or galvanising solder to repair damaged areas.

#### **9.1.5.3.4 Flame Cutting**

Low-carbon structural steel may be cut by machine guide or hand guided torches instead of by shears or saw. Flame cutting of material, other 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.

#### **9.1.5.3.5 Bolted Connections**

##### **(1) Bolt Holes**

Holes for unfinished bolts, unless noted otherwise, shall be not more than 1.6 mm 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 mm larger than the nominal diameter of the bolt. Where the thickness of the material is greater than the nominal diameters of the bolt, holes for unfinished bolts shall be sub-punched 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 a cause for rejection.

##### **(2) Bolts and Nuts**

Threads of bolts and nuts shall conform to BS, ANSI, JIS or ISO standards. Bolts and nuts shall conform to the applicable provisions of American 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" or JIS B1180, "Hexagon Head Bolts", JIS B1181, "Hexagon Nuts" and JIS B1186, "Sets of High Strength Hexagon Bolt, Hexagon Nut and Plain Washers for Friction Grip



Joints". 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" or JIS B1256, "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. Galvanised washers shall be provided under the bolt head and also the nut in assembling all galvanised 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. Threads shall be Class 3 fit in accordance with the Federal Specification. Holes shall be as specified or indicated on the drawings. Plain washers shall be provided.

### 9.1.5.3.6 Machine Work

(1) General

Unless otherwise shown on the drawings, all tolerances, allowances and gauges of metal fits of cylindrical parts shall conform to ANSI B4.1 "Preferred Limits and Fits for Cylindrical parts", for the class of fit as shown 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 surface 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 deviations 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 provision of ANSI B46.1. Values of roughness width and waviness height are not specified, but shall be consistent with the general type of 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 surface, 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 gauges, 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, JIS or other standard approved equivalent.

(6) Shafting

Unless otherwise specified or authorised, 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 babbit or bronze. Babbit shall conform to ASTM B23, "White Bearing Alloys" or JIS H5401, "White Metal". Where the bearing pressure is in excess of 14 kg/sq. cm, bearings shall be lined with bronze. Unless otherwise required or authorised, pressures on lined bearings shall not exceed 70 kg/sq. cm of projected area. Anti-friction 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. Anti-friction bearings shall be so installed as to provide for lubricant and to exclude dirt and grit.

(8) Protection of Machined 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 surface of ferrous metals which will be exposed after installation shall be painted as specified in sub-section "Painting". Corrosion resisting steel, non ferrous metal and galvanised 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.

**9.1.5.3.7 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 with 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 hole 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.

**9.1.5.3.8 Metallic Coatings**

(1) Zinc Coatings

Zinc coatings shall be applied in a manner and of a thickness and quality conforming to Section 9.1.5.5 "Galvanising".

**9.1.5.3.9 Castings and Forgings**

(1) General

Each casting shall have the mark number 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

Repairs 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 castings 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 a cause for rejection.

**9.1.5.3.10 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 ensure that all metal thickness of the finished castings will be in accordance with the dimensions and tolerances shown on the drawings.

#### **9.1.5.3.11 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 manufacturer. 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.

#### **9.1.5.3.12 Shop Assembly**

Machinery and structural units furnished shall be assembled in the shop. Items to be shop assembled shall be as specified or as shown 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 ensure 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 Engineer's representative, unless exempted 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.

#### **9.1.5.3.13 Field Assembly**

##### **(1) General**

All parts to be installed shall be thoroughly cleaned; 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. Stillon wrenches, cold chisels, or other tools, likely to cause injury to the surfaces or 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 Section 9.1.2 "Concrete".

#### **9.1.5.3.14 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 work 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 and, unless otherwise authorised, in the presence of the Engineer. 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 labelled and prepared for shipment.

(2) Analysis of Material

The Contractor shall furnish certificates listing the serial numbers and the chemical and physical properties of metals tested. The Engineer shall notify the Contractor 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, magnetic, dye penetrant, X-ray, gamma-ray or any other test that will thoroughly investigate the part in question. The cost of such investigation shall be borne by the Contractor with no additional cost to the Employer. Any defects in composition or grain structure will be a cause for rejection and the rejected part shall be replaced and re-tested at the Contractor's expense.

(4) Tests of Machinery and Structural Units

Each complete machinery and structural unit as required by the drawings or the Specification shall be erected and tested as specified in sub-section 9.1.1.4.4 "Testing", unless exempted by 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 the Maintenance Period. 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 this Specifications.

**9.1.5.3.15 Tables of Minimum Camber**

Span of Joints (meters)	Minimum Camber at Centre (centimetres)
12 ≤ < 15	1.0
15 ≤ < 18	2.0
18 ≤ < 21	3.0
21 ≤ < 24	4.0
24 ≤ < 27	5.0
27 ≤ < 30	6.0
30 ≤ < 36	7.0

**9.1.5.4 ALUMINIUM WORK**

**9.1.5.4.1 Scope of Work**

Provide all labour, materials, equipment and incidentals required to furnish and install aluminium windows, louvers, and screenings including frames and accessories.

**9.1.5.4.2 Shop Drawings and Approvals**

Contractor shall submit for approval shop drawings showing details of construction, descriptive literature and samples of each type proposed, along with the name and details of the manufacturer or fabricator.

**9.1.5.4.3 Materials and Components**

(1) Windows Louvers and Frames

The material shall be conforming to ASTM B 221, alloy 6063 , Temper T5 and shall be anodised to a thickness of 20 microns in bronze colour. The components shall be fabricated of extruded aluminium sections and plates. The thickness of the sections shall be 1.2 mm minimum.

(2) Screenings

Insect screens shall be of aluminium gun metal 18 x 16 mesh, 2.8 mm gauge aluminium wire.

(3) Accessories

Fastening devices such as screws, bolts, nuts, rivets etc., shall be of aluminium or stainless steel .

Washers shall be of neoprene rubber, aluminium or stainless steel.

Sealing materials shall be of poly-sulphide rubber.

**9.1.5.4.4 Installation**

All external faces of aluminium shall be applied with peelable protection film or the like before despatching from the factory. The insect screen shall be mounted on a removable frame to the inner side of the window frame. The windows shall have locking devices, hinges etc., to the approval of the Engineer.

Where aluminium faces come into contact with steel, masonry or other materials, they shall be treated with a coat of Zinc Chromate or alkali - resistant bituminous paint before installation.

**9.1.5.5 GALVANISING**

**9.1.5.5.1 Scope of Work**

The Contractor shall furnish all labour, materials, equipment and incidentals necessary to galvanise all materials specified or shown on the drawings. Materials shall be galvanised by the hot dip or electro depositing process, unless noted otherwise.

**9.1.5.5.2 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 galvanising. All members, nuts, bolts, washers and appurtenances shall be galvanised before a structural unit is assembled. All un-coated 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 :

- 1) Adequately design all items for galvanising
- 2) Properly select all steel for its suitability to be fabricated and to withstand normal galvanising operation.
- 3) 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 Galvanised Structural Steel Products and Procedure for Detecting Embrittlement.

#### **9.1.5.5.3 Test Coupons**

Test coupons, for determining the quantity and quality of the galvanising, shall be of such size and shall be wired to the materials to be galvanised 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 (Electromagnetic) Test Methods". If tests are ordered by the Engineer, they shall be paid by the Contractor with no additional cost to the Employer.

#### **9.1.5.5.4 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 ensure the total removal of all acid, prior to galvanising.

#### **9.1.5.5.5 Galvanising**

##### **(1) Plates and Shapes**

All plates and shapes shall be galvanised after fabrication. After being cleaned, all materials shall be zinc coated (galvanised) in accordance with ASTM A-123, "Zinc (Hot-Galvanised) Coating on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strip" or BS 729 - " Hot dip galvanised coatings on Iron and Steel articles". 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 1/1000 of the axial length between the points which are to be supported laterally. Finished tension members shall not have lateral variations exceeding 3 mm for each 1.5 meters of length. Sharp kinks of bends will be a cause for rejection of the material. All holes in material shall be free of excess swelter after galvanising.

No machine or shop work, die work, punching, or grinding, will be allowed after galvanising.

##### **(2) Hardware**

Bolts, nuts, washers, lock-nuts, and similar hardware shall be galvanised in accordance with ASTM A-153, "Zinc Coating (Hot Dip) on Iron and Steel Hardware" or JIS H8641, "Zinc Coating (Hot-Dipped) on Iron or Steel". Excess swelter shall be removed by centrifugal spinning. The Contractor shall submit samples of bolts and nuts for approval. Nuts and tapped holes scheduled for galvanising shall be oversized tapped or re-tapped prior to galvanising. Tapping or re-tapping of threads after galvanising will not be permitted.



(3) Assembled Products

Galvanising 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 galvanised 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 grams per sq. m unless noted otherwise. The testing of zinc coat shall be in accordance with ASTM A386 or JIS H0401, "Method of Test for Zinc Coating (Hot-Dipped) on Iron or Steel".

(4) Pipe

Galvanising of pipe shall be in accordance with Section 2.7 of BS1387, "Steel Tubes and Tabulars Suitable for Screwing to BS21 Pipe Threads" or JIS G3442, "Galvanised Steel Pipes for Water Service".

**9.1.5.5.6 Straightening**

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

All plates and shapes which have been warped by the galvanising process shall be straightened by being re-rolled 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 galvanising, such defects shall be cause for rejection.



## **9.1.6 PAINTING AND PROTECTIVE COATINGS**



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## **9.1.6 PAINTING AND PROTECTIVE COATINGS**

### **9.1.6.1 GENERAL**

The work included in this section consists of the furnishing of all labour, materials, apparatus, scaffolding, and all appurtenant work in connection with the painting, in accordance with these specifications.

#### **9.1.6.1.1 Surfaces to be Painted or Protected**

In general, the following surfaces are to be painted.

- a) All exposed piping and other metal surfaces, interior and exterior.
- b) All submerged metal surfaces.
- c) All structural and miscellaneous steel, including tanks.
- d) The interior of tank and pits as specified in the painting schedule and as required after equipment installation.
- e) The interior of structures as specified in the painting schedule and shown on the plans as required after equipment installation.
- f) Equipment furnished with and without factory finished surfaces, except as specified below.
- g) All interior and exterior exposed surfaces of buildings, and exterior exposed surfaces of the water towers and reservoirs

#### **9.1.6.1.2 Surfaces not to be Painted**

The following surfaces in general shall not be painted.

- a) Concrete surfaces subject to pedestrian traffic.
- b) Plastic Surfaces.
- c) Non-ferrous metal unless otherwise noted or indicated. (Galvanised metal shall not be considered a non-ferrous metal).
- d) Mechanical Equipment with approved factory finish as specified herein.
- e) Electrical equipment with approved factory finish as specified herein.
- f) Piping which is specified as galvanised.

In no case shall any concrete, wood, metal or any other surface requiring protection be left unpainted even though not specifically defined herein.

#### **9.1.6.1.3 Submittals**

Materials specifications, surface preparation and application instructions, and colour sample cards shall be submitted to the Engineer for approval.

#### **9.1.6.1.4 Paint to be Provided to Employer**

The Contractor shall leave on the job site at the conclusion of the Contract a minimum of four (4) litres of each type and colour of finish paint used on the work. Each container shall be properly labelled for identification.

#### **9.1.6.2 MATERIALS**

All paint materials shall be first quality products manufactured for the exposures involved, as approved by the Engineer. Paints which are to be in contact with water or chemical solutions shall be completely inert and free of lead and other toxic substances.

##### **9.1.6.2.1 System A Materials**

Primer -	Zinc-rich epoxy primer.
Intermediate -	Universal type primer
Finish -	Vinyl acrylic finish

##### **9.1.6.2.2 System B Materials**

Primer -	Epoxy primer
Intermediate -	Polyester epoxy enamel
Finish -	Same as intermediate.

##### **9.1.6.2.3 System C Materials**

Primer -	Zinc-rich epoxy primer
Intermediate -	Epoxy polyamide coaching conforming to Steel Structures Painting Council Paint 16-68T.
Finish -	Same as intermediate.

##### **9.1.6.2.4 System D Materials**

Primer -	Vinyl-based cementitious block filler.
Intermediate -	Vinyl acrylic emulsion,. F.S.TT-P-19.
Finish -	Same as intermediate.

##### **9.1.6.2.5 System E Materials**

Tnemec Seroes 66 Hi-Build Epoxyline System or approval equal.

Primer -	Epoxy polyamide masonry filler or coating
Intermediate -	Epoxy polyamide coating.
Finish -	Same as intermediate.

#### **9.1.6.2.6 System F Materials**

Primer -	Latex base, F.S. TT-P-645.
Intermediate -	Latex flat, F.S. TT-P-29
Finish -	Same as intermediate.

#### **9.1.6.2.7 System G Materials**

Primer -	Pigmented oil primer, F.S. TT-S.179.
Intermediate -	Enamel under coat, F.S.TT-E-543.
Finish -	Semigloss enamel, S.S. TT-E-508.

#### **9.1.6.2.8 System H Materials**

Primer -	Exterior wood primer, F.S. TT-P-25.
Intermediate -	Exterior gloss, F.S. TT-E-489..
Finish -	Same as intermediate.

#### **9.1.6.2.9 System I Materials**

Primer -	for ferrous metal, red lead primer, F.S.TT-P-86. for galvanised, zinc-duct zinc-oxide primer; F.S.-TT-P641.
Intermediate -	Exterior gloss enamel, F.S.TT-E-489.
Finish -	Same as intermediate.

### **9.1.6.3 WORKMANSHIP**

#### **9.1.6.3.1 Protection of the Work**

The Contractor shall take the necessary steps to protect the work of others during the time his work is in progress. The Contractor shall be responsible for any and all damage to the work. Paint shall be applied only during periods of favourable weather.

#### **9.1.6.3.2 Preparation of Paint**

All materials specified or selected for use under these specifications shall be delivered unopened at the job site in their original containers and shall not be opened until inspected by the Engineer. Paint containers shall be opened only when required for use. Paint shall be thoroughly stirred or agitated to uniformly smooth consistency suitable for proper application. In all cases, paint shall be prepared and handled in a manner to prevent deterioration and inclusion of foreign matter. No paint shall be reduced or applied in anyway except as herein specifically called for or, if not specifically called for, then it shall be applied in accordance with the manufacturer's recommendations.

#### **9.1.6.3.3 Preparation of Surfaces**

The Contractor shall examine carefully all faces to be finished and before beginning any of his work shall see that the work of the other trades has been left or installed in a workmanlike



condition to receive paint. Metals shall be clean, dry, and free from mill scale, rust, grease, and oil. Where required, existing concrete surfaces shall be sandblasted as directed by the Engineer.

#### **9.1.6.3.4 Workmanship**

Each coat of paint shall be applied at the proper consistency and brushed evenly, free of brush marks, sags, runs, with no evidence of poor workmanship. Care shall be exercised to avoid lapping paint on glass or hardware. Paint shall be sharply cut to lines. Finished paint surfaces shall be free from defects or blemishes.

#### **9.1.6.3.5 Protective Coverings**

Protective coverings or drop cloths shall be used to protect floor, fixtures, and equipment. Care shall be exercised to prevent paint from being spattered onto surfaces which are not to be painted. Surfaces from which such paint cannot be removed satisfactorily shall be painted or repainted, as required to produce a satisfactory finish.

#### **9.1.6.3.6 Tints**

Whenever two (2) coats of paints are specified, the first coat shall contain sufficient powdered aluminium or carbon black to act as an indicator or proper coverage, or the two(2) coatings must be of contrasting colour.

#### **9.1.6.3.7 Brushing**

All paint shall be applied by brush unless otherwise specifically approved by the Engineer.

#### **9.1.6.3.8 Instructions**

All coatings shall be performed by personnel experienced in the application of said coating systems and in accordance with the manufacturer's printed instructions. The final appearance shall exhibit a uniformly textured and coloured coating free of excessive gloss or dull spots, blemishes, sags, runs, pinholes, and other defects.

#### **9.1.6.3.9 Ventilation**

The Contractor shall not permit painting to begin in enclosed places, until a forced draft ventilation system of sufficient air volume has been placed in operation.

#### **9.1.6.3.10 Right of Rejection**

No exterior painting or interior finishing shall be done under conditions which may jeopardise the appearance or quality of the painting or finishing in any way. The Engineer shall have the right to reject all material or work that is unsatisfactory, and require the replacement of either or both at the expense of the Contractor.

### 9.1.6.3.11 Application of Painting System :

#### (1) System A

Metal subject to corrosive moisture or atmosphere and condensation.

- 1) Surface Preparation : All metal surfaces shall be field sandblasted in accordance with Steel Structures Painting Council Specification SSPC-SP-10 (Near-White Blast Cleaning). Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed.
- 2) Coating : Prime coat shall have a minimum thickness of 0.05 mm. An intermediate coat shall have a minimum thickness of 0.05 mm. and finish coat shall have a minimum thickness of 0.1 mm. The total system shall have a minimum dry film thickness of 0.2 mm.
- 3) Time Between Coatings : A minimum of 12 hours time is required before additional coats may be applied to the prime coat, two hours for the intermediate coat, and two hours for the finish coat.

#### (2) System B

Metals not subject to chemical attack, normal indoor exposure, except as specified otherwise.

- 1) Surface Preparation : All surfaces shall be freed of dirt, dust, grease, or other foreign matter before coating. Surfaces shall be cleansed in accordance with the Steel Structures Paint Council Specification SSPC - SP-7 (Brush-off Blast Cleaning). Weld surfaces and rough edges shall be ground and weld splatter removed.
- 2) Application shall be in strict conformance with the manufacturer's recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application of each coat.
- 3) Coating System : The system shall have a minimum total dry film thickness of 0.1 mm resulting from a prime coat and at least two finish coats.

#### (3) System C

Metals submerged or intermittently submerged in water or corrosive liquid.

- 1) Surface Preparation : All metal surfaces shall be field sand-blasted in accordance with Steel Structures Painting Council Specification SSPC-SP-10 (Near-White Blast Cleaning). Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed, and welds neutralised with thinner.
- 2) Application : shall be in strict conformance with the manufacturer's recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall received a brush-applied coat of the specified coating prior to application of each coat.

- 3) Coating System : The prime coat shall have a minimum thickness of 0.08 mm and two or more finish coats shall have a minimum total thickness of 0.4 mm. The total system shall have a minimum dry film thickness of 0.48 mm.

(4) System D

Exterior or interior brick, concrete, and concrete block work exposed to view not subject to immersion in liquids and not subject to pedestrian traffic except as otherwise specified. Interior surfaces not specifically indicated shall not be painted. All concrete block surfaces to be painted shall be filled with a latex type block filler supplied by the paint manufacturer whose products are used prior to first or prime paint coat.

- 1) Surface Preparation : All surfaces shall be freed of dirt, dust, grease, and other foreign matter before coating. Cracks and voids shall be repaired or filled with a suitable material compatible with the specified paint.
- 2) Coating : The first coat shall be applied to cover and provide a smooth base. The finish coat shall be applied to a dry film thickness of 0.04 mm minimum.
- 3) Time Between Coats : The filler coat may be recoated in 12 hours, the finish coat is dry for a recoat in two hours.

(5) System E

Concrete subject to intermittent or continuous submergence, unless specified otherwise in other sections of these specifications.

- 1) Surface Preparation : All surfaces shall be brush-off blasted to remove all dirt, dust, form oil, curing compounds, and other deleterious compounds. In general, the concrete shall be reasonably smooth, and free of pockets and cavities.
- 2) Coating System : The prime coat and intermediate and finish coats shall each have a minimum dry film thickness of 0.1 mm. The total system shall have a *minimum* dry film thickness of 0.3 mm.
- 3) Time Between Coats : All coats shall be applied within 24 hours of the previous coat, or in accordance with the manufacturer's instructions.

(6) System F

Interior concrete, masonry and plaster surfaces scheduled or directed to have a flat finish. Concrete block masonry surfaces shall be given a coat of block filler according to system D prior to painting.

- 1) Preparation, Coating, and Time : As specified for System D.

(7) System G

Interior concrete, masonry, and plaster scheduled to have an enamel finish. Concrete block masonry surfaces shall be given a coat of block filler according to System D prior to painting.

- 1) Surface Preparation : All surfaces shall be freed of dirt, dust, grease, and other foreign matter before coating. Cracks and voids shall be repaired or filled with a suitable caulking material compatible with the specified paint. Efflorescence shall be neutralised with zinc sulphate solution and allowed to dry.
- 2) Coating : The prime coat shall be applied to cover and provide a smooth base. The undercoat and finish coat shall be applied to a total dry film thickness of 0.075 mm minimum.
- 3) Time Between Coats : Each coat shall be completely dry before the next coat is applied.

(8) System H

Interior and exterior wood.

- 1) Surface Preparation: Unless already properly hand sanded, sandpaper smooth by hand and dust clean. Neatly fill nail holes, cracks and depressions therein with approved filler, coloured to match required finish; when dry, sandpaper and smooth.
- 2) Coatings : Prime coat shall be applied to cover and provide a smooth base. Each finish coat shall be applied to a minimum dry film thickness of 0.05 mm.
- 3) Time Between Coats : As specified for System G.

(9) System I

For interior and exterior metal not painted under System A, B, and C.

- 1) Surface Preparation : For ferrous metal, as specified for system B. Wash galvanised surfaces with solvent thinner.
- 2) Coatings : Apply each coat to a minimum dry film thickness of 0.05 mm.
- 3) Time Between Coats : As specified for System G.

## 9.1.6.4 PAINT SCHEDULE

### 9.1.6.4.1 General

The following schedule shall indicate the coating system to be used. All surfaces shall be painted except those specified deleted herein. The Engineer shall select the colours.

### 9.1.6.4.2 Process Piping Colour Code

All exposed pipe, including tubing, galvanised pipe and polyvinyl chloride pipe, shall be identified by colour code to show its function. Painted surfaces shall be colour coded in accordance with the coding schedule and adhesively applied colour bands of an approved tape type shall be used on plastic and any other pipe not readily susceptible to painted finish. Piping which is not painted

shall be provided with 30 cm wide colour bands at every 3 m and at each change of direction. Labels and arrows showing direction of flow shall be installed on all piping at every 3 m and at each change of direction. Colours and labels shall conform to the following schedule or as selected by the Engineer where not shown or otherwise required by applicable codes and regulations.

#### PROCESS PIPING COLOUR CODE SCHEDULE

Item	Colour	Label
Process Air	Orange	AA
Chlorine	Yellow	CL
Drains	Black	Drain
Portable/Filtered Water	Light Blue	PW
Raw Water	Grey	RW

#### 9.1.6.4.3 General Coating System

The following list shall indicate the coating system. For this coating system "Piping" shall be defined as all pipe, valves, fittings, supports, operating stems and guides. Mechanical equipment shall include all drives, motor control panels, and all other electrical equipment as shall be selected by the Engineer. This specification shall however be applied only to the equipment which are included in the scope of Work.

Architectural coating systems are specified in the BOQ.

#### COATING SYSTEM SCHEDULE

	Item	System	Colour
A.	<u>Motor and Pump Rooms</u>		
	All interior and exterior surfaces	D	*
	All mechanical equipment piping and exposed metal	B	*
B.	<u>Miscellaneous</u>		
	All miscellaneous interior exposed metal surfaces	B	*
	All miscellaneous exterior exposed metal surfaces	A	*
	All submerged metal surfaces mechanical equipment and piping	C	Black

\* Colour per pipe colour code schedule or as selected by the Engineer.

## 9.1.6.5 PROTECTIVE COATINGS

### 9.1.6.5.1 Epoxy Resin Coating to Floors

The Pump house floors, valve chamber floors and valve house floors shall be treated with water dispersed epoxy resin coating. The colour should be compatible to colour of gray cement or approved by the engineer.

It should be two parts epoxy resin. Two coats shall be applied at the minimum rate of 0.33 litres/m<sup>2</sup>.

	Part A	Part B
Density :	not less than 1.4 kg/litre	not less than 1.0 kg/litre

Density when mixed should be not less than 1.2 kg/litre

Application temperature shall be between 20 to 35 deg C

Life at 30 deg C should be not less than 30 minutes.

The coating shall be permeable to water vapour, non-flammable light fast.

After the full cure ( 7 days ) it should be weather resistant.

The pump house walls, valve chamber walls and valve house walls shall be applied with similar coating but the colour to be approved by the Engineer.