LIST OF CONTENTS

1.0 Scope

2.0 Specification

3.0 Design

3.1 General Design
   3.1.1 Clearances
   3.1.2 Clearance between piping
   3.1.3 Sizes allowed
   3.1.4 Material
   3.1.5 Corrosion allowance on wall thickness

3.2 Piping Arrangement
   3.2.1 Underground Piping
   3.2.2 General Guide lines for routing of pipe lines.

3.3 Guidelines for different piping items
   3.3.1 Pipe Fittings and Bends
   3.3.2 Valves
   3.3.3 Pipe blinds (Ring and Disc)
   3.3.4 Relief Valves
   3.3.5 Automatic Control Valves
   3.3.6 Double Block Valves
   3.3.7 Steam Traps
   3.3.8 Strainers and Filters
   3.3.9 Thermal Expansion of Piping

3.4 Guidelines for Equipments
   3.4.1 Pumps
   3.4.2 Compressors
   3.4.3 Turbines and Steam Driven Equipments
   3.4.4 Heat Exchanger

3.5 Auxiliary Connections
   3.5.1 Vents
   3.5.2 Drains
   3.5.3 Flushing Connection
   3.5.4 Sample Connections
   3.5.5 Orifice Plates
   3.5.6 Connection to Drinking Water

3.6 Supports, Anchors and Guides

3.7 Service Connections and Utilities
3.8 Safety Showers and Eye Baths
3.9 Steam Tracing
3.10 Special requirements for Toxic, Hydrocarbon and Flamable Fluide.
1.0 **SCOPE**

1.1 This specification covers general design requirements with respect to layout and details for piping design.

1.2 **Addendum Specification**

This specification may be supplemented by special requirements for a particular job, in which event the later shall take precedence in case of a conflict.

2.0 **SPECIFICATIONS**

Criteria for design, fabrication and erection of non IBR piping systems shall be in accordance with ASME B 31.3 Process Piping Code latest edition and those for IBR piping shall be in accordance with Indian Boiler Regulations.

**REFERENCE STANDARDS**

- ASME B 31.3 - Process Piping Code
- IBR - Indian Boiler Regulations
- PDIL Engineering Standards
  - ES 6002 -- General Piping Specification
  - ES 6012 -- Safety Valve Installation and Piping
  - ES 6029 -- Steam trap Installation
  - PDS : P (V 004)-- Dimension of Control Valve manifold
    - P 032 -- Pipe trench
    - P 123 -- Vent, drain, steam trap and Instrument tapping assemblies
    - PS 01 -- Pipe support - Standard type and applications
    - PS 02 -- Pipe spacing
    - ST 202 -- Details of sump for installation of Gate Valve

3.0 **DESIGN**

3.1 **General Design**

3.1.1 **Clearances**

(a) **Walkways and Platforms**

The minimum clear headroom over main walkways, passageways and working areas at grade or floor elevations shall be 2.20 m. The minimum clearance over secondary walkways and elevated platforms,
passageways and working areas shall be 2.0 m. The minimum width for
main walkways shall be 1.2 m. The minimum width for secondary walks
and minor access points shall be 0.75 m. The minimum width for
catwalks shall be 0.6 m. (Ref./Fig.1)

(b)  Roads and Rail Roads

The minimum clear head room over rail roads shall be 6.0 m measured
from the top of track. The minimum clearance over primary roadways
shall be 7.5 m. Secondary roads may have lower clearance, but not less
than 5.0 m. Minimum clear head room over areas designated as main
access ways or tracking areas (other than roads) shall be 3.7 m.

(c)  Equipment

Clearance should be available for maintenance and removal of
equipment without disturbing other equipment. Dismantling of sections of
pipe is permissible, if required for removal of equipment, when not
operating. Piping to equipment shall be designed to permit ready
removal of equipment without further pipe supports being required.
Particular attention should be paid to layout of cable racks, instrument
piping, etc. to ensure this.

In areas where entry of handling equipment (e.g. Forklift truck or 5t
Crane) is required for maintenance or handling of pumps and other
machinery not otherwise accessible, the minimum clear head room for
piping under which the handling equipments are required to move shall
be 4.5 m.

Manholes and other access openings shall have a minimum clearance of
0.75 metre in front of face of vessel or equipment flange (not cover plate
where larger clearance may be required), and a minimum of 0.30 m from
edges of flanges to nearest pipe or construction.

(d)  Minimum Clearance for Piping Above Grade

Usually bottom most part of any line is provided with a drain line. To
facilitate proper draining (may be to a catch pot, in some cases) and
proper supporting arrangement of the pipe the bottom of pipe should
normally be kept at a minimum elevation of 400 mm from finished floor
level. Where this is not possible elevation may be lowered to even 150
mm giving due care to proper draining and supporting of pipes. This
does not apply to drain pipes. Insulation and valves, should be taken in
consideration while determining this clearance. In case of control valves,
the minimum clearance shall be as per PDS: V 004.
3.1.2 Clearance Between Piping

In consideration of maintenance, the flange, or heat insulation, etc., the clearance between pipe surfaces should be sufficient but minimum for them. The clearances are shown in PDS: PS 02. The clearance indicated in PDS: PS 02 are minimum and shall have to be increased where large lateral thermal movements are involved, particularly where high temperature pipes are taking a 90° turn. Vertical pipe lines through floors shall be combined to reduce the opening size in floors.

3.1.3 Sizes Allowed

In general, no piping less than ½ " shall be used except for instrument piping. 1 ¼", 3 ½ " and 5" pipe sizes normally should not be used. Where such sizes are used, valves should be of 1", 3" and 4", respectively.

3.1.4 Material

Piping material shall be selected in accordance with respective piping class. Reference may be made to General Piping Specification - Piping Element data sheet for selection of appropriate piping classification number for the specified service conditions. Where system of higher service rating tie into systems of lower rating, an isolation valve shall be provided and the higher service rating specification shall be continued including the isolation valve.

3.1.5 Corrosion Allowance on Wall Thickness

The minimum corrosion allowance for piping shall be as follows:

Cast iron and carbon steel piping -- 1mm

Corrosion resistant materials, including aluminium, alloy steel, high nickel alloys and copper -- Nil

3.2 Piping Arrangement

3.2.1 Under Ground Piping

3.2.1.1 Buried Pipes

In general, pipes should not be buried unless a specific advantage like protection freezing, fire or accidental damage or easy drainage by gravity flow etc. are gained. Traditionally the following lines may be buried:

(a) Cooling water distribution headers.
(b) Fire Water mains
(c) Sewage Lines
(d) Drain lines (where gravity flow requirement necessitates the lines to be buried).
3.2.1.2 Piping in Trenches

(a) All piping requiring inspection and servicing or being provided with protective heating and located below grade shall be in trenches.

(b) Pipe trenches shall be sufficiently large to allow for repair of lines and shall be provided with removable covers. Typical trenches details have been indicated in PDS: P 032. Sump for valves and trenches shall be as per PDS: ST 202 & ST 203.

Underground piping shall be done as per ES 6018. However, some of general precautions to be taken are as follows:

i) Provide casing pipe made of reinforced concrete or Carbon Steel to protect underground pipes passing under roads or access ways.

ii) Wherever electrical cables are coming on the way of pipes, pipes will be taken below the cables.

iii) Wherever valves are to be provided, valve chamber of suitable size should be constructed of brick or concrete.

iv) Pipes shall clear the fouling with trench foundations and layout of trench will be such as not to interfere with construction access.

v) Trenches shall be provided with proper slope and suitable draining scheme.

3.2.2 General Guide Lines for Routing of Pipe Lines

(a) Pipe lines shall be installed neatly so as to be as short and direct as possible, with a minimum of directional changes. The flexibility shall be considered while deciding the routing of hot pipe lines.

(b) Dead legs and pockets shall be avoided. This is important in case of pipe line containing slurries or suspensions, fluids of high crystallization point, corrosive fluids etc.

(c) Overflow lines, drain lines, barometric lines from condensers etc. should be as steep as possible. Barometric lines should preferably be installed vertical, if this is not possible, one of the two alternatives indicated in Fig.2 can be adopted.

(d) All piping within battery limits shall be elevated to provide minimum clear head room as indicated in section 3.1 unless process consideration indicates otherwise, e.g. in pump suction lines.

(e) Main service pipes, such as HP and LP steam condensate, fuel oil, town’s water, cooling water, town’s gas, compressed air etc. will often most conveniently follow the road network and the piping layout thus is largely settled by general site conditions. However, use of 45° bends and cross overs is permitted for economy reasons, where it does not impair the appearance of the plant.
(f) All piping shall be grouped in banks whenever practicable.

(g) All overhead piping shall be run at specific elevation established in advance for piping in any one direction say, North-South and at some other specific elevations for all piping to other direction East-West (Fig.3). However, where unnecessary pockets & changes in elevation can be avoided, exceptions to the established elevation are permitted. (This might occur in special cases such as overhead vapour lines, lines where pressure drop is critical, where vapour binding might occur or where sloping of lines is necessary).

(h) There shall preferably be no overhead piping over stirrers, submerged pumps, covers, etc. Where such pipings can not be avoided, due consideration will be given regarding space for removal of equipment on maintenance.

(i) On sites covering large areas with considerable distance between plants and where only infrequent access points (as on tank farms) serve the purpose, it is economical to run the interconnection piping on slippers instead of heavy raised pipe rack.

(j) In a rather compact layout of complex plants where access to various areas are important interconnecting pipes will be laid on raised pipe racks. Layout of racks most often conveniently follow road network to cater the needs of main service pipes, such as, steam, condensate, fuel oil, cooling water, air, N₂ etc. by various plant areas.

In designing layout of pipes on rack some general rules may be followed:

i) Pipes should not obstruct access to crane or truck for maintenance requirements.

ii) Spacing of pipes should be minimum practical values, spacing may be reduced by staggering flanges and valves.

iii) While using two tiers of pipes to reduce width, it is advised to run utility lines on top rack so that any spillage from higher pipes to the lower is harmless (Ref. Fig.3). Steam pipes should be located on upper tier. In case a single tier is used process lines which interconnect equipments on the same side of yard will be located towards that edge of yard. (Ref. Fig.4)

iv) Regardless of service, heavy lines should be placed over or near the trestle column to reduce bending moments on structure. (Ref. Fig.4 & 5)

v) Pipings along East-West will have an elevation different from those running North-South.

vi) Hot lines requiring expansion loops shall be grouped together and expansion loops, wherever required, will be tried to be put together with larger diameter/higher temperature pipes forming outer loops. (Ref. Fig.6)
vii) Provision of space for electrical and instrument cables will be kept while deciding rack layout.

viii) To give adequate arm for expansion loops of hot lines it is advantageous to put hotlines on one side of the rack rather than locating it in central location.

ix) Branch steam lines will preferably be tapped from top of headers.

x) Screwed and flanged joints shall not be located over roads or walkways or buried under roads.

(k) Pipes carrying non-conducting flammable volatiles must be bonded for electrical continuity and earthed to prevent the accumulation of static electricity charges which can, if arcing to earth near the pipe discharge, cause fire or explosion. Screwed piping using PTFE threadseal tape on the screwed joints must also be bonded. The PTFE tape can effectively insulate line sections from each other.

(l) No hot pipes shall run near power cables. Any local heating of the cables will reduce its allowable power capacity rating and may damage the cable. Do not run solvent or acid lines over plastic cables.

(m) Slopes

i) Slope shall be provided for saturated steam lines, other ordinary lines (if required for process reasons) and for slurry lines.

<table>
<thead>
<tr>
<th>Line Sizes (inches)</th>
<th>Steam Lines and Ordinary Lines</th>
<th>Slurry Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&quot;</td>
<td>1 : 200</td>
<td>1 : 100</td>
</tr>
<tr>
<td>4&quot;</td>
<td>1 : 400</td>
<td>1 : 200</td>
</tr>
<tr>
<td>8&quot;</td>
<td>1 : 600</td>
<td>1 : 300</td>
</tr>
<tr>
<td>16&quot;</td>
<td>1 : 800</td>
<td>1 : 400</td>
</tr>
</tbody>
</table>

ii) Overflow, drain and barometric lines shall be provided with higher slopes as indicated below:

Overflow and Drain Lines -- 1 : 20 min.
Barometric Lines -- 1 : 2 min.

3.3 Guide Lines for different Piping Items

3.3.1 Pipe Fittings and Bends

(a) Detailed specifications for pipe fittings and bends depending on service and size are to be found in respective piping standards.

(b) Butt welding elbows shall normally be long radius type. Bends with a minimum radius of 3 times the nominal dia shall be used in slurry lines.
(c) Intersections at angles other than $90^\circ$ shall not be used except when specially required from process considerations.

(d) Welding caps, or in large pipe sizes, semi-ellipsoidal heads shall be preferred for welded end enclosures. Where required, bolted flange covers shall be used for cleaning or to provide for future connections.

(e) The use of flanges in piping shall be limited to connections at flanged equipment, for removable sections of pipe or for pipes requiring dismantling for maintenance. Field joints may be of flanged construction to avoid field welding on joints requiring heat-treatment or examination and in pipe lines located in fire hazard areas where, after plant commissioning, no welding is permitted or welding would be difficult.

(f) Threaded or socket-welded piping shall be limited to $1 \frac{1}{2}$" and smaller. Threading may be permitted in larger size galvanized piping. All pipe threads on piping components shall be taper pipe threads in accordance with IS:554. Couplings $2\"$ and smaller with straight tapped pipe threads may be used on piping components with taper pipe threads if the design conditions do not exceed $10 \text{ kg/cm}^2$ or $200^\circ\text{C}$ and if the fluid handled is non-flammable and non-toxic. Threaded joints in piping handling flammable or toxic fluids shall be seal welded and shall be of steel. Threaded and socket welded joints shall preferably not be used where severe crevice corrosion or erosion may occur.

3.3.2 Valves

(a) **Approach**

On the basis of frequency and necessity of operation valves shall be suitably located so that they are accessible and can conveniently be operated from the grade, floor or platform or from ladder. Where the hand wheel is higher than 2 metre from the operating floor, chain operating system may be provided. (Ref.Fig 7)

(b) All lubricated plug valves shall be accessible for lubrication either from stairs, platforms, grade or shall be within reach of portable ladders.

(c) Chain wheels shall preferably not be used on screwed valves. When absolutely necessary, welding or special support shall be used to prevent undesirable unscrewing.

(d) Chains shall extend within 1.0 m of operating floor and shall be located out of walkways so that the same does not obstruct passing personnel.

(e) Where practicable and unless otherwise shown on the drawings, valve stems shall be installed in a vertical direction and shall not be installed with stems below the horizontal.
(f) Valves located underground, shall be provided with valves boxes (Pits).

(g) Swing type check valves may be used in horizontal lines and also in vertical lines having upward flow.

Piston/Ball lift type check valves may be used only in horizontal lines.

### 3.3.3 Pipe Blinds (Spectacle Blind)

(a) Pipe blinds (Spectacle Blind) shall be used in the following locations.

-- At inlet and outlet connections of equipment which periodically must be taken out of service for maintenance or inspection, without interfering with the operation of the unit, or when the omission of such blinds would present a hazard to personnel.

-- When required, at battery limits of units in process piping connected to other plant piping which may be in use during shut-down of the unit.

### 3.3.4 Relief Valves

(a) Relief or safety valves installation and piping shall be in accordance with ES 6012.

### 3.3.5 Automatic Control Valves

(a) Control Valves which require periodic servicing shall be so located that they are easily accessible.

(b) Control Valves shall not be located where they can be damaged by moving machinery, continuous vibration, steam or where the diaphragm is too near hot pipe lines, furnaces or other similar equipments.

(c) Sufficient clearance shall be allowed both beneath and above the control valve for plug and diaphragm operator removal, as per PDS:V004.

(d) Control valves with manual hand wheels shall not require a by-pass.

(e) Block valves adjacent to control valves shall be of same size as the line, unless otherwise specified.

(f) By-pass valves shall be sized for the same pressure drop as the control valve.

(g) Concentric swaged nipples, or reducers, are to be used between the block valves and the control valves.

(h) Downstream block valves also be of the higher pressure rating.

(i) Both upstream and down stream piping near pressure reducing stations in Oxygen lines should be provided with water jacket or suitable water sprinkling device in order to keep the temperature in Oxygen line within safe limits.
While using angle control valves layout will be made in such a way that outlet is in the same line as the axis of valve stem i.e. perpendicular to the plane of diaphragm. This helps to maintain streamline flow at the ventury. However, in case of a conflict between supplier’s recommendation and his requirement, the former will be honoured.

3.3.6 Double Block Valves

(a) Double valves shall be provided in following cases:-
   i) Where contamination of stream is to be avoided.
   ii) In blow-down lines from boilers
   iii) Sample lines in case of high pressure
   iv) Gauge glass connecting pipes in case of high pressure/Vacuum
   v) Isolation of Oxygen Compressors.

(g) In case of hazardous fluids it may be necessary to provide bleed valves between two block valves to ensure that no leakage occurs.

(c) Double block valves and bleed valve shall carry the higher rating specification of the connecting systems.

(d) A minimum straight length of 100 mm or five times the thickness of weld shall be provided between two Nos. welded type valves.

3.3.7 Steam Traps

(a) Reference may be made to ES6029 for typical steam trap installations. Steam traps shall be sized for normal condensate load and warming up load. The time for warming shall be taken as 20-30 minutes.

(b) Steam traps shall be located at every low point of a header system and long supply mains such that each and every portion of the header can be drained through one trap or another. In case of straight or constanly slopping headers, interval between two adjacent traps may be as high as 100 to 160 meters provided traps are sized accordingly and provided that possibility of obstructions to steam flow due to carry over of condensate through a long length is not present.

(d) Each trap shall serve only one collection point, line or piece of equipment, except for steam tracing.

(d) Piping to trap shall never be smaller than \( \frac{1}{2} \) or trap connection size.

(e) Strainers shall be installed ahead of traps and they shall be integral with the trap wherever possible.

(f) A shut-off valve shall be provided up stream of each trap and strainer. Unions or flanges shall be provided for the removal of traps.
3.3.8 Strainers and Filters

(a) Permanent type strainers shall be installed for the protection of the equipment as follows:
- In pump suction lines for screw, reciprocating, centrifugal and gear pumps.
- In all steam turbines and steam jet ejector inlet lines.
- In fuel oil supply piping to burners.
- In steam lines to essential traps.

(b) Air filters shall be provided in the air inlet line to all air compressors.

3.3.9 Thermal Expansion of Piping

(a) Wherever possible, provision for pipe expansion shall be made by changes in the direction of the pipe or by expansion loops.

(b) Expansion joints may be furnished either with plain ends for butt weld installation or with flanged ends.

(c) Where expansion joints are to be installed, about 100 mm additional length of pipe over the actual requirements on each side of the joint shall be provided to permit field adjustment when installing joint.

(d) Expansion joints may be installed with cold pull upon instruction of Engineer Incharge. The drawings shall show the amount of permitted cold pull (normally 50% of calculated expansion to be absorbed).

(e) Thrust load imposed on mechanical equipment such as pumps, turbines or compressors shall be limited to the equipment manufacturer’s recommended values. Reference may be made to manufacturer’s data/relevant API Standards for allowable forces and moments for pumps, compressors and turbine nozzles.

3.4 Guide Lines for Equipments

3.4.1 Pumps

(a) Suction and discharge piping shall be in accordance with ES:6024.

(b) Vendor’s drawings for glands, bearings, stuffing boxes, jackets, casing, vents, drain and base plate drains etc. shall be checked and necessary piping shall be provided for cooling water, steam, flushing and sealing liquids as required.

3.4.2 Compressors

(a) Strainers shall be installed in suction lines.

(b) Compressor piping should preferably be supported separately from other piping.
(c) Discharge line to surge drum should have unsupported elbow so that pipe can bend with thermal stress and relieve strain on compressor casing or cylinder.

(d) Short spool pieces should be provided in suction as well as discharge line for easy removal during maintenance of compressor. This is particularly important for centrifugal compressors having top halves that must be lifted for access to impellers.

(e) Loop and pockets should be avoided in suction piping to prevent collection of condensate that can cause great damage to compressors.

3.4.3 Turbines & Steam Driven Equipment

(a) Steam piping to turbines or other steam driven equipment shall be provided with an isolation valve at the header and except in the case of turbines, when a combination governing trip and manual throttle valve is provided, it shall be provided with a throttle valve located at the equipment. A valved bleed shall be placed upstream of the throttle valve to permit draining of the line before starting equipment.

(b) Steam exhaust piping from turbines and steam driven equipment other than that venting to the atmosphere or to a vacuum unit serving only that particular piece of equipment, shall be provided with a block valve located preferably at the header. A valved bleed shall be provided between the equipment and the valve.

(c) In instances where one vacuum unit serves two or more turbines, the exhaust piping from each turbine shall be provided with a block valve.

(d) Steam branches to turbines shall be taken from the top of the header.

3.4.4 Heat Exchchanger

(a) Exchangers using cooling water will be provided with block valves as follows:

-- Only one valve will be provided in cooling water line for those exchangers which are essential for operation of the unit.

-- Two valves, one each at inlet and outlet will be provided for those exchangers which may be taken out of line for maintenance while the unit is in operation.

(b) The levels of pipe lines to critical heat exchangers and equipment shall be such as to keep the equipment flooded. (Fig.8)

(c) When block valves are installed which will permit trapping the cold side of an exchanger unit full of liquid a relief valve shall be installed to prevent possible pressure build up.

(d) Cooling water piping to tubular exchanger units shall be arranged to ensure flooded tubes.
3.5 Auxiliary Connections

3.5.1 Vents: (for typical connection Ref. PDS P 123)

(a) Vents as per PDS P 123 (or blind flanged vents for equipments) shall be provided at high points of lines and equipment required to be hydrostatically tested. However if this vent isolation is used during normal operation from process consideration, valve will be provided.

(b) Minimum size of vent shall be in \( \frac{1}{2} \) \( " \).

3.5.2 Drains: (for typical connection Ref. PDS P 123)

(a) Valved or plugged drains shall be provided at trapped low points in piping or equipment to drain water, condensate or process liquids that must be drained during normal plant operations. Drain valves in slurry lines shall be of a type permitting rodding through e.g. Plug, Ball or Gate Valve.

(b) Minimum size of drain shall be \( \frac{1}{2} \) \( " \).

(c) Drains provided at low points of control valve stations shall be on the upstream side of Control Valve.

(d) Drains at low points of lines and equipment required to be used only for hydrostatic testing shall not be provided with valves. Instead threaded plugs (to be seal welded after testing) or blind flanges will be used.

3.5.3 Flushing Connections

Plugs or flushing connections shall be provided on all lines containing inflammable or toxic material, slurries or materials which solidify when the line is dead.

3.5.4 Sample Connections

(a) Sample connections shall be taken preferably from the side of the line.

(b) Sample connections in hot services shall be provided with sample coolers.

(c) Minimum pipe size for sample lines shall be \( \frac{1}{2} \) \( " \).

In case of dangerous & toxic media it is advisable to install more than one valve.

3.5.5 Orifice Plates

If restriction orifices are required, they shall preferably be installed in vertical line part, to enable complete drainage of the pipe lines. For the same reason orifices in horizontal part of the line shall preferably be equipped with an eccentric hole.

3.5.6 Connection to Drinking Water

No physical connection shall be made between a domestic water system and industrial piping system, vessels or other equipment. This will eliminate the possibility of contaminating drinking water.
3.6 Supports, Anchors & Guides

3.6.1 Accurate weight balance calculations shall be made to determine the required supporting force at each supporting point. Support shall be designed to withstand all static and dynamic conditions of loading to which the piping may be subjected. Load calculations shall give consideration to following:

(a) Weight of pipe, valves, flanges, fittings, insulating materials and normal fluid content.
(b) Weight of hydrostatic test fluid or cleaning fluid if normal operating fluid is lighter.
(c) Wind Load.
(d) Friction force on the trestle due to expansion of pipe.
(e) Thermal Load
(f) Force required to compress the bellow expansion joint (where applicable).
(g) Pressure thrust (only applicable where unbalanced below expansion joint is installed).

Weight balance calculations shall include a factor of reduced allowable stress or a load safety factor to allow for rigidity and/or continuity of piping system and the resultant transferring of over load to adjacent pipe support. It is suggested that this factor be 150 - 200% of theoretical load depending on line size, number and spacing of supports and operating condition.

3.6.2 Piping connected to equipment shall be designed, fabricated and installed with proper supports to facilitate servicing, inspection or removal of the equipment. Necessary clearances for installed hoists and cranes will be provided.

3.6.3 Reference may be made to PDS:PS01 for selection and application of pipe supports.

3.7 Service Connections and Utilities

¾" hose connections for steam, air and water (not drinking water) shall be provided, grouped at convenient locations in the process area for general utility purposes.

3.8 Safety Showers and Eye Baths

Safety showers operating on quick opening chain operated valve and eye baths shall be provided at convenient locations in hazardous areas of the plant.

3.9 Steam Tracing

Steam tracing shall be provided and installed for maintaining the product temperature when indicated in the flow sheet and shall be in accordance with ES 6016.
3.10 Special Requirements for Toxic, Hydrocarbon and Flammable Fluids (Like Naphtha, Methanol, Fuel, Oil, CO)

3.10.1 Cast Iron valves and fitting shall not be used for Toxic and Hydrocarbon services.

3.10.2 API 5LX pipe shall not be used for flammable or Toxic fluids within process unit limits.

3.10.3 Electrical continuity (jumper connection) shall be provided between flanges for pipe lines carry flammable fluids.
FIG. 1

150 for drainage manhole and other wet areas otherwise use 200 clearance.

Clearance 500 desired 200 minimum.

FIG. 2

MAX. SLOPE

1:2

MIN. 2000

MAX. 3000

FIG. 3

UTILITY LINES

PROCESS LINES

1.1, 1.5, 2.2, 2.5, 3 metre
NOTE:
Piping shall be such as to keep the equipment flooded
ENGINEERING STANDARD

FABRICATION, ASSEMBLY AND ERECTION OF PIPING
INDEX

1.0 Scope
2.0 Reference Standards
3.0 Welding
3.1 Welding Responsibility
3.2 Welding Qualifications
3.3 Welding Materials
3.4 Preparation for Welding
3.5 Welding Requirements
3.6 Weld Repair
4.0 Preheating
5.0 Heat Treatment
6.0 Bending and Forming
7.0 Assembly and Erection
1.0 SCOPE

1.1 This specification covers the requirements of fabrication, assembly and erection of Carbon Steel, Alloy Steel and Stainless Steel pipes and fittings. These requirements conform to ASME Code of pressure piping Process piping ASME B 31.3 - 1999. This standard is meant for easy reference by the Inspector to all requirements of fabrication, assembly and erection of pipes at one place and should not be used as purchase requirements for an enquiry or an order.

1.2 For pipes to be used for steam services, the requirements of Indian Boiler Regulations shall apply in addition to all non-conflicting requirements of this specification.

1.3 Recommendations contained in this document do not in any way release a welding contractor from his responsibility with regard to correct choice of welding materials and procedures, neither do they constitute any commitment on the part of PDIL with regard to payment of any expenses incurred.

2.0 REFERENCE STANDARDS

ASME B 31.3 -- Code for pressure piping - Process Piping
AWS A 5.1 -- Carbon Steel Electrodes for Shielded Metal Arc Welding
AWS A 5.4 -- Stainless Steel Electrodes for Shielded Metal Arc Welding
AWS A 5.5 -- Low Alloy Steel Covered Arc Welding Electrodes
AWS A 5.11 -- Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arch Welding
ASME BPV Code -- Welding Qualification Sec.IX

3.0 WELDING

3.1 Welding Responsibility

Each employer is responsible for the welding done by the personnel of his organization and, except as provided in paras 3.2.2 and 3.2.3 shall conduct the tests required to qualify welding procedures and to qualify and as necessary requalify welders and welding operators.

3.2 Welding Qualifications

3.2.1 Qualification Requirements
(a) Qualification of the welding procedures to be used and of the performance of welders and welding operators shall conform to the requirements of the BPV Code, Section IX except as modified herein.

(b) Where the base metal will not withstand the $180^\circ$ guided bend required by Section IX, a qualifying welded specimen is required to undergo the same degree of bending as the base metal, within $5^\circ$.

(c) The requirements for preheating in para 4.0 and for heat treatment in para 5.0 as well as such requirements in the engineering design, shall apply in qualifying welding procedures.

(d) When impact testing is required by this Standard or the engineering design, those requirements shall be met in qualifying welding procedures.

(e) To reduce the number of welding procedure qualifications required, P-Numbers or S-Numbers and Group Numbers are assigned in the BPV Code, Section IX, to groupings of metals generally based on composition, weldability and mechanical properties, insofar as practicable. The P-Numbers or S-Numbers for most metals are listed in Table A-1 of ASME B 31.3. See Section IX, QW/QB-422, for Group Numbers for respective P-Numbers and S-Numbers. Use of Section IX, QW-420.2 is required for this Standard.

### 3.2.2 Procedure Qualification by Others

Each employer is responsible for qualifying any welding procedure that personnel of the organization will use. Subject to the specific approval of the Inspector, welding procedures qualified by others may be used, provided that the following conditions are met.

(a) The Inspector shall be satisfied that:

1) the proposed welding procedure specification (WPS) has been prepared, qualified and executed by a responsible, recognized organization with expertise in the field of welding; and

2) the employer has not made any change in the welding procedure.

(b) The base material P-Number is either 1, 3, 4 Gr.No.1 (1¼ Cr max.), or 8; and impact testing is not required.

(c) The base metals to be joined are of the same P-Number, except that P-Nos. 1, 3 and 4 Gr.No.1 may be welded to each other as permitted by Section IX.

(d) The material to be welded is not more than 19 mm in thickness. Postweld heat treatment shall not be required.

(e) The design pressure does not exceed the ASME B 16.5, Class 300 rating for the material at design temperature; and the design temperature is in the range -29°C to 399°C, inclusive.
(f) The welding process is SMAW (Shielded Metal Arc Welding) or GTAW (Gas Tungsten Arc Welding) or a combination thereof.

(g) Welding electrodes for the SMAW process are selected from the following classifications.

<table>
<thead>
<tr>
<th>AWS A 5.1</th>
<th>AWS A 5.4</th>
<th>AWS A 5.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>E6010</td>
<td>E308-15, -16</td>
<td>E7010 - A1</td>
</tr>
<tr>
<td>E6011</td>
<td>E308L-15, -16</td>
<td>E7018 - A1</td>
</tr>
<tr>
<td>E7015</td>
<td>E309-15, -16</td>
<td>E8016 - B1</td>
</tr>
<tr>
<td>E7016</td>
<td>E310-15, -16</td>
<td>E8018 - B1</td>
</tr>
<tr>
<td>E7018</td>
<td>E-16-8-2-15, -16</td>
<td>E8015 - B2L</td>
</tr>
<tr>
<td></td>
<td>E316-15, -16</td>
<td>E8016 - B2</td>
</tr>
<tr>
<td></td>
<td>E316L-15, -16</td>
<td>E8018 - B2</td>
</tr>
<tr>
<td></td>
<td>E347-15, -16</td>
<td>E8018 - B2L</td>
</tr>
</tbody>
</table>

Recommended electrodes and bare wires for welding of certain selected pipe materials are shown in Table 1.

The figures in Table 4A & 4B are referring to the selection of welding material in Table 1 and the letters in Table 4A and 4B are referring to the selection of preheat and postweld heat temperature in Table 2 and 3 respectively. The suitability of these electrodes and wires (or materials which may be selected as alternatives) and the suitability of preheat and postweld heat temperatures shall be demonstrated in appropriate Welding Procedure Qualifications as described in ASME Section IX.

(h) By signature, the employer accepts responsibility for both the WPS and the procedure qualification record (PQR).

(i) The employer has at least one currently employed welder or welding operator who, while in his employ has satisfactorily passed a performance qualification test using the procedure and the P-Number material specified in the WPS. The performance bend test required by Section IX. QW-302 shall be used for this purpose. Qualification by radiography is not acceptable.

The responsibility of the welding contractor shall include the provision of all materials, facilities and man powers for the procedure and performance qualification tests.

3.2.3 Performance Qualification by Others

To avoid duplication of effort, an employer may accept a performance qualification made for another employer, provided that the inspector specifically approves. Acceptance is limited to qualification on piping using the same or equivalent procedure wherein the essential variables are within the limits in Section IX. The employer shall obtain a copy from the previous employer of the performance
qualification test record, showing the name of the employer, name of the welder or welding operator, procedure identification, date of successful qualification and the date that the individual last used the procedure on pressure piping.

3.2.4 Qualification Records

The employer shall maintain a self-certified record, available to the owner (and the owner’s agent) and the Inspector, of the procedures used and the welders and welding operators employed, showing the date and results of procedure and performance qualifications and the identification symbol assigned to each welder and welding operator.

3.3 Welding Materials

3.3.1 Filler Metal

Filler metal shall conform to the requirements of Section IX. A filler metal not yet incorporated in Section IX may be used with the owner’s approval if a procedure qualification test is first successfully made.

3.3.2 Weld Backing Material

Permanent backing rings are not permitted except for use in refractor lined pipes. When backing rings are used, they shall conform to the following:

(a) **Ferrous Metal Backing Rings**

   These shall be of weldable quality. Sulfur content shall not exceed 0.05%.

(b) If two abutting surfaces are to be welded to a third member used as a backing ring and one or two of the three members are ferritic and the other member or members are austenitic, the satisfactory use of such materials shall be demonstrated by welding procedure qualified as required by para 3.2.

   Backing rings may be of the continuous machined or split-band type. Some commonly used types are shown in Fig.3.3.2.

(c) **Nonferrous and Nonmetallic Backing Rings**

   Backing rings of nonferrous or nonmetallic material may be used, provided the designer approves their use and the welding procedure using them is qualified as required by para 3.2.

3.3.3 Consumable Inserts

Consumable inserts are not permitted.

3.4 Preparation for Welding

3.4.1 Cleaning
Internal and external surfaces to be thermally cut or welded shall be clean and free
paint, oil, rust, scale and other material that would be detrimental to either the weld
or the base metal when heat is applied.

Where root passes are made by GTAW (Gas Tungsten Arc Welding) or GMAW
(Gas Metal Arc Welding) processes, the internal pipe surface shall be cleared
before welding by means of grinding, brushing or equivalent for at least 10 mm
from the end of the pipe.

3.4.2 End Preparation

(a) General

1) End preparation is acceptable only if the surface is reasonably
smooth and true and slag from oxygen or arc cutting is cleaned from
thermally cut surfaces. Discoloration remaining on a thermally cut
surface is not considered detrimental oxidation.

2) End preparation for groove welds specified in ASME B 16.25 or any
other which meets the WPS, is acceptable. [For convenience, the
basic bevel angles of ASME B 16.25 and some additional J-bevel
angles are shown in Fig.3.4.2 sketches (a) and (b)].

3) The root opening is nom. 1.5 mm and shall not normally exceed 3 mm
for root passes made by GTAW process and 4 mm for root passes
made by GMAW or SMAW (Shielded Metal Arc Welding) process.

(b) Circumferential Welds

1) If component ends are trimmed as shown in Fig.3.3.2 sketch (a) or (b)
to fit backing rings or consumable inserts or as shown in Fig.3.4.3
sketch (a) or (b) to correct internal misalignment, such trimming shall
not reduce the finished wall thickness below the required minimum
wall thickness \( t_m \).

2) Component ends may be bored to allow for a completely recessed
backing ring, provided the remaining net thickness of the finished
ends is not less than \( t_m \).

3) It is permissible to size pipe ends of the same nominal size to
improve alignment if wall thickness requirements are maintained.

4) Where necessary, weld metal may be deposited inside or outside of
the component to permit alignment to provide for machining to ensure
satisfactory seating of rings or inserts.

5) When a girth or miter groove weld joins components of unequal wall
thickness and one is more than 1½ times the thickness of the other
end preparation and geometry shall be in accordance with acceptable
designs for unequal wall thickness in ASME B 16.25.
3.4.3 **Alignment**

(a) **Circumferential Welds**

1) Inside surfaces of components at ends to be joined in girth or miter groove welds shall be aligned within the dimensional limits in the WPS and the engineering design.

Misalignment of pipe ends for butt welds shall not exceed 1.6 mm at any point on the bore of the pipe as shown in Fig. 3.4.3.

Alignment of girth butt joints may be achieved either by tack welding or by the use of welded yokes or pipe clamps.

2) If the external surfaces of the components are not aligned, the weld shall be tapered between them.

(b) **Longitudinal Welds**

Alignment of longitudinal groove welds (not made in accordance with ASME standard shall conform to the requirements of para 3.4.3(a).

(c) **Branch Connection Welds**

1) Branch connections which abut the outside surface of the run pipe shall be contoured for groove welds which meet the WPS requirements [see Fig.3.4.4 sketches (a) and (b)].

2) Branch connections which are inserted through a run opening shall be inserted at least as far as the inside surface of the run pipe at all points [see Fig.3.4.4 sketch (c)] and shall otherwise conform to para 3.4.3(c)(1).

3) Run openings for branch connections shall not deviate from the required contour more than the dimension m in Fig.3.4.4. In no case shall deviations of the shape of the opening cause the root spacing tolerance limits in the WPS to be exceeded. Weld metal may be added and refinished if necessary for compliance.

4) **Spacing**

The root opening of the joint shall be within the tolerance limits in the WPS.

3.5 **Welding Requirements**

3.5.1 **General**
Welds, including addition of weld metal for alignment [paras 3.4.2 (b)(4) and 3.4.3 (c)(3)], shall be made in accordance with a qualified procedure and by qualified welders or welding operators.

Each qualified welder and welding operator shall be assigned an identification symbol. Unless otherwise specified in the engineering design, each pressure containing weld or adjacent area shall be marked with the identification symbol of the welder or welding operator. In lieu of marking the weld, appropriate records shall be filed.

Tack welds at the root of the joint shall be made with filler metal equivalent to that used in the root pass. Tack welds shall be made by a qualified welder or welding operator. Tack welds shall be fused with the root pass weld, except that those which have cracked shall be removed.

For pipe wall thickness above 8 mm bridge tacking (above the root) is preferred. Bridge tacks shall be removed completely before filler passes are added.

Peening is prohibited on the root pass and final pass of a weld.

No welding shall be done if there is impingement on the weld area of rain, snow, sleet or excessive wind, or if the weld area is frosted or wet.

Root passes of all welds in inspection class 2 (see clause 5) and all welds in which either of the metals to be joined is austenitic steel shall be made using the GTAW process with inert backing gas. The inert gas shall preferably be Argon, although gas consisting of 85% N\textsubscript{2} + 15% H\textsubscript{2} may be used if argon is not available.

For pipes \(\leq 2\) inch nom. size, use GTAW for entire welding.

Welding End Valves

The welding sequence and procedure and any heat treatment for a welding end valve shall be such as to preserve the seat tightness of the valve.

**Fillet and Socket Welds**

Fillet welds (including socket welds) may vary from convex to concave. The size of a fillet weld is determined as shown in Fig.3.5.2A.

Typical weld details for slip-on and socket welding flanges are shown in Fig.3.5.2B; minimum welding dimensions for other socket welding components are shown in Fig.3.5.2C.

If slip-on flanges are single welded, the weld shall be at the hub.
3.5.3 Seal Welds

Seal welding shall be done by a qualified welder. Seal welds shall cover all exposed threads except those for seal welded thermowell connections.

3.5.4 Welded Branch Connections

(a) Figures 3.5.4A through 3.5.4E show acceptable details of branch connections with and without added reinforcement, in which the branch pipe is connected directly to the run pipe. The illustrations are typical and are not intended to exclude acceptable types of construction not shown.

(b) Figure 3.5.4D shows basic types of weld attachments used in the fabrication of branch connections. The location and minimum size of attachment welds shall conform to the requirements herein. Welds shall be calculated in accordance with para 304.3.3 of ASME B 31.3 but shall be not less than the sizes shown in Fig. 3.5.4D.

(c) The nomenclature and symbols used herein and in Fig.3.5.4D are:

\[ t_c = \text{lesser of } 0.7T_b \text{ or } 6 \text{ mm} \]
\[ T_b = \text{nominal thickness of branch} \]
\[ T_h = \text{nominal thickness of header} \]
\[ T_r = \text{nominal thickness of reinforcing pad or saddle} \]
\[ t_{min} = \text{lesser of } T_b \text{ or } T_r \]

(d) Branch connections, including branch connection fittings which abut the outside of the run or which are inserted in an opening in the run shall be attached by fully penetrated groove welds. The welds shall be finished with cover fillet welds having a throat dimension not less than \( t_c \) see Fig.3.5.4D sketches (1) and (2).

(e) A reinforcing pad or saddle shall be attached to the branch pipe by either:

1) a fully penetrated groove weld finished with a cover fillet weld having a throat dimension not less than \( t_c \); or

2) a fillet weld having a throat dimension not less than \( 0.7t_{min} \). See Fig.3.5.4D sketch (5).

(f) The outer edge of a reinforcing pad or saddle shall be attached to the run pipe by a fillet weld having a throat dimension not less than \( 0.5T_r \). See Fig. 3.5.4D sketches (3), (4) and (5).

(g) Reinforcing pads and saddles shall have a good fit with the parts to which they are attached. A vent hole shall be provided at the side (not at the crotch)
of any pad or saddle to reveal leakage in the weld between branch and run and to allow venting during welding and heat treatment. A pad or saddle may be made in more than one piece if joints between pieces have strength equivalent to pad or saddle parent metal and if each piece has a vent hole.

(h) Examination and any necessary repairs of the completed weld between branch and run shall be made before adding a pad or saddle.

3.5.5 Fabricated Laps

Figure 3.5.5 shows typical fabricated laps. Fabrication shall be in accordance with the applicable requirements of para 3.5.4.

3.5.6 Welding for Severe Cyclic Conditions

A welding procedure shall be employed which provides a smooth, regular, fully penetrated inner surface.

3.6 Weld Repair

A weld defect to be repaired shall be removed to sound metal. Repair welds shall be made using a welding procedure qualified in accordance with para 3.2.1 recognizing that the cavity to be repaired may differ in contour and dimensions from the original joint. Repair welds shall be made by welders or welding operators qualified in accordance with para 3.2.1. Preheating and heat treatment shall be as required for the original welding. See also para 3.3.3 of ES 6005.

4.0 PREHEATING

4.1 General

Preheating is used, along with heat treatment, to minimize the detrimental effects of high temperature and severe thermal gradients inherent in welding. The necessity for preheating and the temperature to be used shall be specified in the engineering design and demonstrated by procedure qualification. The requirements and recommendations herein apply to all types of welding including tack welds, repair welds and seal welds of threaded joints.

4.1.1 Requirements and Recommendations

Required and recommended minimum preheat temperatures for materials of various P-Numbers are given in Table 2. If the ambient temperature is below 10°C the recommendations in Table 2 become requirements. Preheating of all materials may be carried out by any controllable means. The thickness intended in Table 2 is that of the thicker component measured at the joint.

4.1.2 Unlisted Materials

Preheat requirements for an unlisted material shall be specified in the WPS.
4.1.3 Temperature Verification

(a) Preheat temperature shall be checked by use of temperature indicating crayons, thermocouple pyrometers or other suitable means to ensure that the temperature specified in the WPS is obtained prior to and maintained during welding.

(b) Thermocouples may be temporarily attached directly to pressure containing parts using the capacitor discharge method of welding without welding procedure and performance qualifications. After thermocouples are removed, the areas shall be visually examined for evidence of defects to be repaired.

4.1.4 Preheat Zone

The preheat zone shall extend at least 25 mm beyond each edge of the weld.

4.2 Specific Requirements

4.2.1 Dissimilar Materials

When materials having different preheat requirements are welded together, it is recommended that the higher temperature shown in Table 2 be used.

4.2.2 Interrupted Welding

If welding is interrupted the rate of cooling shall be controlled or other means shall be used to prevent detrimental effects in the piping. The preheat specified in the WPS shall be applied before welding is resumed.
## TABLE-1

### WELDING MATERIALS

<table>
<thead>
<tr>
<th>NO.</th>
<th>MATERIAL</th>
<th>COATED ELECTRODES</th>
<th>BARE WIRES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ASME SFA</td>
<td>CLASSIFICATION</td>
</tr>
<tr>
<td>1</td>
<td>C.S</td>
<td>5.1</td>
<td>E7018</td>
</tr>
<tr>
<td>2</td>
<td>C.Mo.</td>
<td>5.5</td>
<td>E7018</td>
</tr>
<tr>
<td>3</td>
<td>1 ¼ Cr.Mo</td>
<td>5.5</td>
<td>E8018-B2</td>
</tr>
<tr>
<td>4</td>
<td>2 ¼ Cr.Mo</td>
<td>5.5</td>
<td>E8018-B3</td>
</tr>
<tr>
<td>5</td>
<td>5Cr.Mo</td>
<td>5.4</td>
<td>E502-16 or -15</td>
</tr>
<tr>
<td>6</td>
<td>9Cr.Mo</td>
<td>5.4</td>
<td>E505-16 or -15</td>
</tr>
<tr>
<td>7</td>
<td>12Cr</td>
<td>5.4</td>
<td>E410-16 or -15</td>
</tr>
<tr>
<td>8</td>
<td>3 ½ Ni</td>
<td>5.5</td>
<td>To match base metal</td>
</tr>
<tr>
<td>9</td>
<td>18Cr.8Ni (308,308L)</td>
<td>5.4</td>
<td>E308-16 or -15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E308L-16 or 15</td>
</tr>
<tr>
<td>10</td>
<td>18Cr 10Ni Cb (347)</td>
<td>5.4</td>
<td>E347-16 or -15</td>
</tr>
<tr>
<td>11</td>
<td>18Cr 10Ni Mo (316 316L)</td>
<td>5.4</td>
<td>E316-16 or -15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E316L-16 or 15</td>
</tr>
<tr>
<td>12</td>
<td>25Cr 12Ni (309) Inconel</td>
<td>5.4</td>
<td>E309-16 or -15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.11</td>
<td>ENiCrFe-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Inconel 182)</td>
</tr>
<tr>
<td>13</td>
<td>Inconel</td>
<td>5.11</td>
<td>ENiCrFe-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Inconel 182)</td>
</tr>
<tr>
<td>Table 1 shall be used as indication only.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE-2

#### PREHEAT TEMPERATURES

<table>
<thead>
<tr>
<th>Heat Treatment Symbol (Note-1)</th>
<th>Base Metal P-No. or S-No.</th>
<th>Base Metal Group</th>
<th>Nominal Wall Thickness, mm</th>
<th>Specified Min. Tensile Strength, Base Metal Mpa (ksi)</th>
<th>Min. Temperature, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1</td>
<td>Carbon steel</td>
<td>&lt; 25</td>
<td>40</td>
<td>≤ 490 (71)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 25</td>
<td>All</td>
<td>All</td>
<td>80</td>
</tr>
<tr>
<td>B 3</td>
<td>Alloy steels Cr ≤ ½ %</td>
<td>&lt; 13</td>
<td>10</td>
<td>≤ 490 (71)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 13</td>
<td>All</td>
<td>All</td>
<td>80</td>
</tr>
<tr>
<td>C 4</td>
<td>Alloy steels ½ % &lt; Cr ≤ 2%</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>150</td>
</tr>
<tr>
<td>D 5A,5B,5C</td>
<td>Alloy steels 2¼ % &lt; Cr ≤ 10%</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>177</td>
</tr>
<tr>
<td>E 6</td>
<td>High alloy steels martensitic</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>150 (Note 2)</td>
</tr>
<tr>
<td>F 7</td>
<td>High alloy steels ferritic</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>High alloy steels austenitic</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>10</td>
</tr>
<tr>
<td>G 9A,9B</td>
<td>Nickel alloy steels</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>93</td>
</tr>
<tr>
<td>H 10</td>
<td>Cr-Cu steel</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>150-204</td>
</tr>
<tr>
<td>J 10I</td>
<td>27 Cr steel</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>150 (Note 3)</td>
</tr>
<tr>
<td>K 11A SG1</td>
<td>8 Ni, 9Ni steel</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>10</td>
</tr>
</tbody>
</table>
Notes:

1. P - Number or S - Number from ASME BPV Code, Section IX, QW/QB - 422
2. Maximum interpass temperature 316°C.
3. Maintain interpass temperature between 177°C - 232°C.

**TABLE - 3**

**REQUIREMENT FOR HEAT TREATMENT**

<table>
<thead>
<tr>
<th>Heat Treatment Symbol (Note-1)</th>
<th>Base Metal P-No. or S-No.</th>
<th>Base Metal Group</th>
<th>Thickness mm</th>
<th>Specified Min. Tensile Strength, Base Metal Mpa (ksi)</th>
<th>Metal. Temperature Range °C</th>
<th>Holding Time (Note 2)</th>
<th>Brinell Hardness (Note-9) Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Carbon steel</td>
<td>≤ 19</td>
<td>All</td>
<td>None</td>
<td>2.4 min./mm</td>
<td>965 - 1150</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; 19</td>
<td>All</td>
<td>595 - 650</td>
<td>Minimum 1 hr.</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>Alloy steels</td>
<td>≤ 19</td>
<td>All</td>
<td>None</td>
<td>2.4 min./mm</td>
<td>965 - 1150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cr ≤ ½ %</td>
<td>&gt; 19</td>
<td>All</td>
<td>595 - 720</td>
<td>Minimum 1 hr.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All</td>
<td>All</td>
<td>595 - 720</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>Alloy steels</td>
<td>≤ 13</td>
<td>All</td>
<td>None</td>
<td>2.4 min./mm</td>
<td>965 - 1150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ % &lt; Cr ≤ 2%</td>
<td>&gt; 13</td>
<td>All</td>
<td>705 - 745</td>
<td>Minimum 2 hr.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All</td>
<td>All</td>
<td>705 - 745</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>5A, 5B, 5C (Note-8)</td>
<td>High alloy steels martensitic</td>
<td>≤ 13</td>
<td>All</td>
<td>None</td>
<td>2.4 min./mm</td>
<td>965 - 1150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A 240 Gr.429</td>
<td>&gt; 13</td>
<td>All</td>
<td>705 - 760</td>
<td>Minimum 2 hr.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All</td>
<td>All</td>
<td>705 - 760</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>High alloy steels austenitic</td>
<td>All</td>
<td>All</td>
<td>None</td>
<td>2.4 min./mm</td>
<td>965 - 1150</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>All</td>
<td>621 - 663</td>
<td>Minimum 1 hr.</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>7</td>
<td>High alloy steels ferritic</td>
<td>All</td>
<td>All</td>
<td>None</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>G</td>
<td>9A, 9B</td>
<td>Nickel alloy steels</td>
<td>≤ 19</td>
<td>All</td>
<td>None</td>
<td>2.4 min./mm</td>
<td>965 - 1150</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; 19</td>
<td>All</td>
<td>595 - 635</td>
<td>Minimum 1 hr.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 3 (Contd.)

#### Notes:

1. **P** - Number or **S** - Number from ASME BPV Code, Section IX, QW/QB - 422
2. Holding Time in min/mm (minutes per mm thickness).
3. Cool as rapidly as possible after the hold period.
4. Cooling rate to 649°C shall be less than 56°C/hr thereafter, the cooling rate shall be fast enough to prevent embrittlement.
5. Postweld heat treatment is neither required nor prohibited, but any heat treatment applied shall be as required in the material specification.
6. Cooling rate shall be not greater than 167°C/hr upto 316°C.
7. Heat treatment shall be carried out within 14 days after welding. Hold time shall be increased by ½ hr. for each 25 mm over 25 mm thickness. Cool to 427°C at a rate < 278°C/hr. per 25 mm nominal thickness, 278°C/hr. max. Cool in still air from 427°C.
8. Heat treatment temperatures listed in this table for some P.No.4 and P.No.5 materials may be higher than the minimum tempering temperatures specified in the ASTM specifications for the base material. For higher strength normalised and tempered materials there is consequently a possibility of reducing tensile properties of the base material, particularly if long holding times at higher temperatures are used.
9. See para 331.1.7 of ASME B 31.3, reproduced below

Hardness tests of production welds and of hot bent and hot formed piping are intended to verify satisfactory heat treatment. The hardness limit applies to the weld and to the heat affected zone (HAZ) tested as close as practicable to the edge of the weld.
(a) Where a hardness limit is specified in Table 3 at least 10% of welds, hot
bends and hot formed components in each furnace heat treated batch and
100% of those locally heat treated shall be tested.

(b) When dissimilar metals are joined by welding the hardness limits specified for
the base and welding materials in Table 3 shall be met for each material.

**Welding Materials and Heat Treatment for Welding of Dissimilar Steels**

### TABLE 4A

<table>
<thead>
<tr>
<th>Ferrous Material</th>
<th>Materials</th>
<th>P No</th>
<th>310</th>
<th>316 316L</th>
<th>321 347</th>
<th>304 304L</th>
<th>3 ½ Ni</th>
<th>13Cr 405</th>
<th>13Cr 410</th>
<th>9Cr 1 Mo</th>
<th>5Cr ½Mo</th>
<th>2½Cr 1Mo</th>
<th>1 ½ Cr ½Mo</th>
<th>C-Mo</th>
<th>C.S</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S.</td>
<td>P-1</td>
<td>12A</td>
<td>12A</td>
<td>12A 12A</td>
<td>12A 12A</td>
<td>1G 1B</td>
<td>1E 1D</td>
<td>1D 1D</td>
<td>1C 1B</td>
<td>1A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.Mo</td>
<td>P-3</td>
<td>12B</td>
<td>12B</td>
<td>12B 12B</td>
<td>12B 2G</td>
<td>2B 2D</td>
<td>2D 2D</td>
<td>2D 2D</td>
<td>2C 2B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ½ Cr-½Mo</td>
<td>P-4</td>
<td>12C</td>
<td>12C</td>
<td>12C 12C</td>
<td>12D 3C</td>
<td>3C 3E</td>
<td>3D 3D</td>
<td>3D 3D</td>
<td>3C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 ½ Cr-1Mo</td>
<td>P-5</td>
<td>12D</td>
<td>12D</td>
<td>12D 12D</td>
<td>12D 4D</td>
<td>4D 4E</td>
<td>4D 4D</td>
<td>4D 4D</td>
<td>4D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Cr-½Mo</td>
<td>P-5</td>
<td>12D</td>
<td>12D</td>
<td>12D 12D</td>
<td>12D 5D</td>
<td>5D 5E</td>
<td>5D 5D</td>
<td>5D 5D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Cr-1Mo</td>
<td>P-5</td>
<td>12D</td>
<td>12D</td>
<td>12D 12D</td>
<td>12D 6D</td>
<td>6D 6D</td>
<td>6D 6D</td>
<td>6D 6D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Cr, Type 410</td>
<td>P-6</td>
<td>12E</td>
<td>12E</td>
<td>12E 12E</td>
<td>12E 7E</td>
<td>7E 7E</td>
<td>7E 7E</td>
<td>7E 7E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Cr, Type 405</td>
<td>P-7</td>
<td>12F</td>
<td>12F</td>
<td>12F 12F</td>
<td>12F 7G</td>
<td>7F 7F</td>
<td>7G 7G</td>
<td>7F 7F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 ½ Nickel</td>
<td>P-9E</td>
<td>12G</td>
<td>12G</td>
<td>12G 12G</td>
<td>12G 8G</td>
<td>8G 8G</td>
<td>8G 8G</td>
<td>8G 8G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 304, 304L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 Cr 10 Ni</td>
<td>P-8</td>
<td>10F</td>
<td>10F</td>
<td>10F 10F</td>
<td>10F 10F</td>
<td>10F 10F</td>
<td>10F 10F</td>
<td>10F 10F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 347, 321</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 316, 316L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 Cr 20Ni</td>
<td>P-8</td>
<td>16F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 4B

<table>
<thead>
<tr>
<th>Material</th>
<th>P.No.</th>
<th>Nickel</th>
<th>Monel</th>
<th>Inconel</th>
<th>Incoloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S.</td>
<td>P-1</td>
<td>13F</td>
<td>14F</td>
<td>13F</td>
<td>13F</td>
</tr>
<tr>
<td>Stainless</td>
<td>P-8</td>
<td>13F</td>
<td>13F</td>
<td>13F</td>
<td>13F</td>
</tr>
<tr>
<td>Incoloy</td>
<td>P-45</td>
<td>13F</td>
<td>13F</td>
<td>13F</td>
<td>13F</td>
</tr>
<tr>
<td>Inconel</td>
<td>P-42</td>
<td>13F</td>
<td>13F</td>
<td>13F</td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>P-41</td>
<td>15F</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The figure in each block refers to the electrode or bare wire in Table 1, while the letter refers to the preheat and post weld heat treatment shown in Table 2 and 3.

### 5.0 Heat Treatment

Heat treatment is used to avert or relieve the detrimental effects of high temperature and severe temperature gradients inherent in welding and to relieve residual stresses created by bending and forming. These are basic practices which are suitable for most welding, bending and forming operations, but not necessarily appropriate for all service conditions.

#### 5.1 General

#### 5.1.1 Heat Treatment Requirements

(a) Heat treatment shall be in accordance with the material groupings and thickness ranges in Table 3 except as provided in paras 5.2.1 and 5.2.2.

(b) Heat treatment to be used after production welding shall be specified in the WPS and shall be used in qualifying the welding procedure.

(c) The engineering design shall specify the examination and/or other production quality control (not less than the requirements of this Standard) to ensure that the final welds are of adequate quality.

(d) Heat treatment for bending and forming shall be in accordance with para 6.4.

(e) Post-weld heat treatment of Cr.Mo. steels shall be carried out using either electric or gas fired furnaces. For local heat treatment heating by torches is not permitted. Electric heating shall be used.

#### 5.1.2 Governing Thickness
When components are joined by welding, the thickness to be used in applying the heat treatment provisions of Table 5.1.1 shall be that of the thicker component measured at the joint except as follows:

(a) In the case of branch connections, metal (other than weld metal) added as reinforcement, whether an integral part of a branch fitting or attached as a reinforcing pad or saddle, shall not be considered in determining heat treatment requirements. Heat treatment is required, however, when the thickness through the weld in any plane through the branch is greater than twice the minimum material thickness requiring heat treatment, even though the thickness of the components at the joint is less than the minimum thickness. Thickness through the weld for the details shown in Fig. 3.5.4D shall be computed using the following formulas:

\[
\begin{align*}
\text{sketch (1)} &= T_b + t_c \\
\text{sketch (2)} &= T_h + t_c \\
\text{sketch (3)} &= \text{greater of } T_b + t_c \text{ or } T_r + t_c \\
\text{sketch (4)} &= T_h + T_r + t_c \\
\text{sketch (5)} &= T_b + t_c
\end{align*}
\]

(b) In the case of fillet welds at slip-on and socket welding flanges and piping connections NPS 2\(/\) and smaller for seal welding of threaded joints in piping NPS 2\(/\) and smaller and for attachment of external nonpressure parts such as lugs or other pipe supporting elements in all pipe sizes, heat treatment is required when the thickness through the weld in any plane is more than twice the minimum material thickness requiring heat treatment (even though the thickness of the components at the joint is less than that minimum thickness except as follows):

1) not required for P-No.1 materials when weld throat thickness is 16 mm or less regardless of base metal thickness;

2) not required for P-No.3,4,5 or 10A materials when weld throat thickness is 13 mm or less, regardless of base metal thickness, provided that not less than the recommended preheat is applied and the specified minimum tensile strength of the base metal is less than 490 Mpa (71 ksi);

3) not required for ferritic materials when welds are made with filler metal which does not air harden. Austenitic welding materials may be used for welds to ferritic materials when the effects of service conditions, such as differential thermal expansion due to elevated temperature or corrosion, will not adversely affect the weldment.

5.1.3 Heating and Cooling
The heating method shall provide the required metal temperature, metal temperature uniformity and temperature control and may include an enclosed furnace, local flame heating, electric resistance, electric induction or exothermic chemical reaction. The cooling method shall provide the required or desired cooling rate and may include cooling in a furnace, in air, by application of local heat or insulation or by other suitable means.

5.1.4 Temperature Verification

Heat treatment temperature shall be checked by thermocouple pyrometers or other suitable methods to ensure that the WPS requirements are met. See para 4.1.3(b) for attachment of thermocouples by the capacitor discharge method of welding.

5.1.5 Hardness Tests

Hardness tests of production welds and of hot bent and hot formed piping are intended to verify satisfactory heat treatment. The hardness limit applies to the weld and to the heat affected zone (HAZ) tested as close as practicable to the edge of the weld.

Hardness testing shall be carried out using a portable Brinnell hardness tester using a standard 10 mm ball.

(a) Where a hardness limit is specified in Table 3 at least 10% of welds, hot bends and hot formed components in each furnace heat treated batch and 100% of those locally heat treated shall be tested.

(b) When dissimilar metals are joined by welding, the hardness limits specified for the base and welding materials in Table 3 shall be met for each material.

It should be noted that hardness test is not a substitute for notch testing.

5.2 Specific Requirements

Where warranted by experience or knowledge of service conditions, alternative methods of heat treatment or exceptions to the basic heat treatment provisions of para 5.1 may be adopted as provided in paras 5.2.1 and 5.2.2.

5.2.1 Alternative Heat Treatment

Normalizing or normalizing and tempering or annealing may be applied in lieu of the required heat treatment after welding, bending or forming, provided that the mechanical properties of any affected weld and base metal meet specification requirements after such treatment and that the substitution is approved by the designer.

5.2.2 Exceptions to Basic Requirements
As indicated in para 5.0 the basic practices therein may require modification to suit service conditions in some cases. In such cases, the designer may specify more stringent requirements in the engineering design, including heat treatment and hardness limitations for lesser thickness or may specify less stringent heat treatment and hardness requirements, including none.

When provisions less stringent than those in para 5.0 are specified, the designer must demonstrate to the owner’s satisfaction the adequacy of those provisions by comparable service experience considering service temperature and its effects, frequency and intensity of thermal cycling, flexibility stress levels, probability of brittle failure and other pertinent factors. In addition, appropriate tests shall be conducted, including WPS qualification tests.

5.2.3 Dissimilar Materials

(a) Heat treatment of welded joints between dissimilar ferritic metals or between ferritic metals using dissimilar ferritic filler metal shall be at the higher of the temperature ranges in Table 3 for the materials in the joint.

(b) Heat treatment of welded joints including both ferritic and austenitic components and filler metals shall be as required for the ferritic material or materials unless otherwise specified in the engineering design.

(c) Recommended welding material and recommended heat treatment procedures to be employed when welding various combinations are shown in Table-4A and Table-4B.

(d) It should be noted that a high alloy electrode is recommended in all cases where low alloy steel is welded to austenitic steel.

5.2.4 Delayed Heat Treatment

If a weldment is allowed to cool prior to heat treatment, the rate of cooling shall be controlled or other means shall be used to prevent detrimental effects in the piping.

5.2.5 Partial Heat Treatment

When an entire piping assembly to be heat treated cannot be fitted into the furnace, it is permissible to heat treat in more than one heat, provided there is at least 300 mm overlap between successive heats and that parts of the assembly outside the furnace are protected from harmful temperature gradients.

5.2.6 Local Heat Treatment

When heat treatment is applied locally, a circumferential band of the run pipe and of the branch where applicable, shall be heated until the specified temperature range exists over the entire pipe section(s), gradually diminishing beyond a band which includes the weldment or the bent or formed section and at least 25 mm beyond the ends thereof.
6.0 BENDING AND FORMING

6.1 General

Pipe may be bent and components may be formed by any hot or cold method which is suitable for the material the fluid service and the severity of the bending or forming process. The finished surface shall be free of cracks and substantially free from buckling. Thickness after bending or forming shall be not less than that required by the design.

6.2 Bending

6.2.1 Bending Flattening

Flattening of a bend, the difference between maximum and minimum diameters at any cross section, shall not exceed 8% of nominal outside diameter for internal pressure and 3% for external pressure. Removal of metal shall not be used to achieve these requirements.

6.2.2 Bending Temperature

(a) Cold bending of ferritic materials shall be done at a temperature below the transformation range.

(b) Hot bending shall be done at a temperature above the transformation range and in any case within a temperature range consistent with the material and the intended service.

6.3 Forming

The temperature range for forming shall be consistent with material, intended service and specified heat treatment.

6.4 Required Heat Treatment

Heat treatment shall be performed in accordance with para 6.1.1 when required by the following:

6.4.1 Hot Bending and Forming

After hot bending and forming, heat treatment is required for P-Nos.3,4,5,6 and 10A materials in all thicknesses. Durations and temperatures shall be in accordance with para 5.0.

6.4.2 Cold Bending and Forming

After cold bending and forming, heat treatment is required (for all thicknesses and with temperature and duration as given in Table 5.1.1) when any of the following conditions exist:
(a) for P-Nos. 1 through 6 materials, where the maximum calculated fiber elongation after bending or forming exceeds 50% of specified basic minimum elongation (in the direction of severest forming) for the applicable specification, grade and thickness. This requirement may be waived if it can be demonstrated that the selection of pipe and the choice of bending or forming process provide assurance that in the finished condition the most severely strained material retains at least 10% elongation.

(b) for any material requiring impact testing, where the maximum calculated fiber elongation after bending or forming will exceed 5%.

(c) when specified in the engineering design.

7.0 ASSEMBLY AND ERECTION

7.1 General

7.1.1 Alignment

(a) Piping Distortions

Any distortion of piping to bring it into alignment for joint assembly which introduces a detrimental strain in equipment or piping components is prohibited.

(b) Cold Spring

Before assembling any joints to be cold sprung, guides, supports and anchors shall be examined for errors which might interfere with desired movement or lead to undesired movement. The gap or overlap of piping prior to assembly shall be checked against the drawings and corrected if necessary. Heating shall not be used to help in closing the gap because it defeats the purpose of cold springing.

(c) Flanged Joints

Before bolting up, flange faces shall be aligned to the design plane within 1 mm in 200 mm measured across any diameter; flange bolt holes shall be aligned within 3 mm maximum offset.

7.2 Flanged Joints

7.2.1 Preparation for Assembly

Any damage to the gasket seating surface which would prevent gasket seating shall be repaired or the flange shall be replaced.

7.2.2 Bolting Torque

(a) In assembling flanged joints, the gasket shall be uniformly compressed to the proper design loading.
(b) Special care shall be used in assembling flanged joints in which the flanges have widely differing mechanical properties. Tightening to a predetermined torque is recommended.

7.2.3 Bolt Length

Bolts should extend completely through their nuts. Any which fail to do so are considered acceptably engaged if the lack of complete engagement is not more than one thread.

7.2.4 Gaskets

No more than one gasket shall be used between contact faces in assembling a flanged joint.

7.3 Threaded Joints

7.3.1 Thread Compound or Lubricant

Any compound or lubricant used on threads shall be suitable for the service conditions and shall not react unfavourably with either the service fluid or the piping material.

7.3.2 Joints for Seal Welding

A threaded joint to be seal welded shall be made up without thread compound. A joint containing thread compound which leaks during leak testing may be seal welded in accordance with para 3.5.3, provided all compound is removed from exposed threads.

7.3.3 Straight Threaded Joints

Typical joints using straight threads, with sealing at a surface other than the threads, are shown in Fig.7.3.3 sketches (a), (b) and (c). Care shall be taken to avoid distorting the seat when incorporating such joints into piping assemblies by welding.

7.4 Tubing Joints

7.4.1 Flared Tubing Joints

The sealing surface of the flare shall be examined for imperfections before assembly and any flare having imperfections shall be rejected.

7.4.2 Flareless and Compression Tubing Joints

Where the manufacturer’s instructions call for a specified number of turns of the nut, these shall be counted from the point at which the nut becomes finger tight.

7.5 Caulked Joints
Caulked joints shall be installed and assembled in accordance with the manufacturer’s instructions, as modified by the engineering design. Care shall be taken to ensure adequate engagement of joint members.

7.6 Expanded Joints and Special Joints

7.6.1 General

Expanded joints and special joints shall be installed and assembled in accordance with the manufacturer’s instructions, as modified by the engineering design. Care shall be taken to ensure adequate engagement of joint members.

7.6.2 Packed Joints

Where a packed joint is used to absorb thermal expansion, proper clearance shall be provided at the bottom of the socket to permit this movement.

7.7 Cleaning of Piping

Following are some general considerations which may be evaluated in determining the need for cleaning of piping:

(a) Requirements of the service, including possible contaminants and corrosion products during fabrication, assembly, storage, erection and testing.

(b) For low temperature service, removal of moisture, oil, grease and other contaminants to prevent sticking of valves or blockage of piping and small cavities; and

(c) For strong oxidizer fluid service (e.g. oxygen or fluorine), special cleaning and inspection. Reference may be made to the Compressed Gas Association’s Pamphlet G-4.1 Cleaning Equipment for Oxygen Service.
FIG. 3.4.2 TYPICAL BUTT WELD END PREPARATION

FIG. 3.4.3 TRIMMING AND PERMITTED MISALIGNMENT

FIG. 3.4.4 PREPARATION FOR BRANCH CONNECTIONS

g = root gap per welding specification
m = the lesser of 3.2 mm (1/8 in.) or 0.5 Tp
Equal Leg Fillet Weld

**GENERAL NOTE:** The size of an equal leg fillet weld is the leg length of the largest inscribed isosceles right triangle (theoretical throat = 0.707 x size).

Unequal Leg Fillet Weld

**GENERAL NOTE:** The size of an unequal leg fillet weld is the leg lengths of the largest right triangle which can be inscribed within the weld cross section, e.g., 13 mm x 19 mm (1/2 in. x 3/4 in.).

**FIG. 3.5.2A FILLET WELD SIZE**

1. Front and back welds
2. Face and back welds
3. Socket Welding Flanges

\[ x_{\text{min}} = \text{the lesser of } 1.4T \text{ or the thickness of the hub} \]

**FIG. 3.5.2B TYPICAL DETAILS FOR DOUBLE-WELDED SLIP-ON AND SOCKET WELDING FLANGE ATTACHMENT WELDS**

\[ C_x \text{ (min.)} = 1 1/4 \ t \text{ but not less than } 3 \text{ mm (1/8 in.)} \]

**FIG. 3.5.2C MINIMUM WELDING DIMENSIONS FOR SOCKET WELDING COMPONENTS OTHER THAN FLANGES**
FIG. 3.5.4A, B, C. TYPICAL WELDED BRANCH CONNECTIONS

(1) Without Added Reinforcement
(2) With Added Reinforcement
(3) Angular Branch Without Added Reinforcement

FIG. 3.5.4D ACCEPTABLE DETAILS FOR BRANCH ATTACHMENT WELDS

(1) Contour Outlet Fitting
(2) Extruded Header Outlet

FIG. 3.5.4E ACCEPTABLE DETAILS FOR BRANCH ATTACHMENT SUITABLE FOR 100% RADIOGRAPHY
GENERAL NOTE: Laps shall be machined (front and back) or trued after welding. Plate flanges per para. 304.5 or lap joint flanges per ASME B16.5 may be used. Welds may be machined to radius as in sketch (e), if necessary to match ASME B16.5 lap joint flanges.

FIG. 3.5.5 TYPICAL FABRICATED LAPS
ENGINEERING STANDARD

INSPECTION, EXAMINATION OF WELDING OF PIPING
INDEX

1.0 Scope
2.0 Inspection
3.0 Examination
3.1 General
3.2 Responsibility for Examination
3.3 Examination Requirements
3.4 Extent of Required Examination
3.5 Supplementary Examination
4.0 Examination Personnel
5.0 Examination Procedures
6.0 Types of Examination
6.1 General
6.2 Visual Examination
6.3 Magnetic Particle Examination
6.4 Liquid Penetrant Examination
6.5 Radiographic Examination
6.6 Ultrasonic Examination
6.7 In-process Examination
1.0 SCOPE

This specification covers requirements of Inspection, Examination and Testing of welding of Carbon Steel, Alloy Steel and stainless steel pipes and fittings. These requirements conform to ASME Code of pressure piping - Process Piping ASME B 31.3 - 1999. This standard is meant for easy reference by the Inspector to all requirements of inspection, examination and testing of welding of pipes at one place and should not be used as purchase requirements for an enquiry or an order.

2.0 INSPECTION

2.1 General

This Standard distinguishes between examination (see para 3.0) and inspection. Inspection applies to functions performed for the owner by the owner’s Inspector. References in this standard to the “Inspector” are to the owner’s Inspector.

2.2 Responsibility for Inspection

It is the Owner’s responsibility, exercised through the Owner’s Inspector to verify that all required examinations and testing have been completed and to inspect the piping to the extent necessary to be satisfied that it conforms to all applicable examination requirements of the Code/Standard and of the engineering design.

2.3 Rights of the Owner’s Inspector

The Owner’s Inspector shall have access to any place where work concerned with the piping installation is being performed. This includes manufacture, fabrication, heat treatment, assembly, erection, examination and testing of the piping. They shall have the right to audit any examination, to inspect the piping using any examination method specified by the engineering design and to review all certifications and records necessary to satisfy the Owner’s responsibility stated in para 2.2.

2.4 The qualifications of the Owner’s Inspector shall be at the discretion of the Owner.

3.0 EXAMINATION

3.1 General

Examination applies to quality control functions performed by the manufacturer (for components only), fabricator or erector. Reference in this Standard to an examiner is to a person who performs quality control examinations.

3.2 Responsibility for Examination

Inspection does not relieve the manufacturer, the fabricator or the erector of the responsibility for:

(a) providing materials, components and workmanship in accordance with the requirements of the specification and of the engineering design.
(b) performing all required examinations; and
(c) preparing suitable records of examinations and tests for the Inspector’s use.

3.3 Examination Requirements

3.3.1 General

Prior to initial operation each piping installation, including components and workmanship shall be examined in accordance with the applicable requirements of para 3.0. The type and extent of any additional examination required by the engineering design and the acceptance criteria to be applied shall be specified. Joints not included in examinations required by para 3.4 or by the engineering design are accepted if they pass leak test/pressure test as per ES 6006.

(a) For P-Nos. 3, 4 and 5 materials, examination shall be performed after completion of any heat treatment.

(b) For a welded branch connection the examination of and any necessary repairs to the pressure containing weld shall be completed before any reinforcing pad or saddle is added.

3.3.2 Acceptance Criteria

Acceptance criteria shall be as stated in the engineering design and shall at least meet the applicable requirements stated below, in para 6.6.2 for ultrasonic examination of welds.

Table 3.3.2 states acceptance criteria (limits on imperfections) for welds. See Fig. 3.3.2 for typical weld imperfections.

3.3.3 Defective Components and workmanship

An examined item with one or more defects (imperfections of a type or magnitude exceeding the acceptance criteria of this Standard) shall be repaired or replaced; and the new work shall be reexamined by the same methods, to the same extent and by the same acceptance criteria as required for the original work.

3.3.4 Progressive Sampling for Examination

When required spot or random examination reveals a defect:

(a) two additional samples of the same kind (if welded or bonded joints, by the same welder, bonder, or operator) shall be given the same type of examination; and

(b) if the items examined as required by (a) above are acceptable, the defective item shall be repaired or replaced and reexamined as specified in para 3.3.3 and all items represented by these two additional samples shall be accepted; but
(c) if any of the items examined as required by (a) above reveals a defect, two further samples of the same kind shall be examined for each defective item found by that sampling; and

(d) if all the items examined as required by (c) above are acceptable, the defective item(s) shall be repaired or replaced and reexamined as specified in para 3.3.3 and all items represented by the additional sampling shall be accepted; but

(e) if any of the items examined as required by (c) above reveals a defect, all items represented by the progressive sampling shall be either;

1) repaired or replaced and reexamined as required; or

2) fully examined and repaired or replaced as necessary and reexamined as necessary to meet the requirements of this Standard.

3.4 Extent of Required Examination

3.4.1 Examination Normally Required

(Category of fluid services requiring the extent of examination as mentioned in para 3.4.1 to 3.4.4 have been defined in ASME B 31.3 and ES 6013)

Piping in **Normal Fluid Service** shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria are as stated in para 3.3.2 and in Table 3.3.2 for Normal Fluid Service unless otherwise specified.

(a) **Visual Examination**

At least the following shall be examined in accordance with para 6.2;

1) sufficient materials and components, selected at random, to satisfy the examiner that they conform to specifications and are free from defects;

2) at least 5% of fabrication. For welds, each welder’s and welding operator’s work shall be represented.

3) 100% of fabrication for longitudinal welds, except those in components made in accordance with a listed specification. See para 3.5.1(a) for examination of longitudinal welds required to have a joint factor \( E_j \) of 0.90.

4) random examination of the assembly of threaded, bolted and other joints to satisfy the examiner that they conform to the applicable requirements of assembly and erection as per para 7.0 of ES 6004. When pneumatic testing is to be performed, all threaded, bolted and other mechanical joints shall be examined.
5) random examination during erection of piping, including checking of alignment, supports and cold spring;

6) examination of erected piping for evidence of defects that would require repair or replacement and for other evident deviations from the intent of the design.

(b) **Other Examination**

1) Not less than 5% of circumferential butt and miter groove welds shall be examined fully by random radiography in accordance with para. 6.5 or by random ultrasonic examination in accordance with para 6.6. The welds to be examined shall be selected to ensure that the work product of each welder or welding operator doing the production welding is included. They shall also be selected to maximize coverage of intersections with longitudinal joints. When a circumferential weld with an intersecting longitudinal weld(s) is examined, at least the adjacent 38 mm (1 1/2 in.) of each intersecting weld shall be examined. In-process examination in accordance with para 6.7 may be substituted for all or part of the radiographic or ultrasonic examination on a weld-for-weld basis if specified in the engineering design or specifically authorized by the Inspector.

2) Not less than 5% of all brazed joints shall be examined by in-process examination in accordance with para 6.7, the joints to be examined being selected to ensure that the work of each brazer making the production joints is included.

(c) **Certificates and Records**

The examiner shall be assured, by examination of certifications, records, and other evidence that the materials and components are of the specified grades and that they have received required heat treatment, examination and testing. The examiner shall provide the Inspector with a certification that all the quality control requirements of the Code and of the engineering design have been carried out.

### 3.4.2 **Examination -- Category D Fluid Service**

Piping and piping elements for Category D Fluid Service as designated in the engineering design shall be visually examined in accordance with para 6.2 to the extent necessary to satisfy the examiner that components, materials and workmanship conform to the requirements of ASME B 31.3 Code, this standard and the engineering design. Acceptance criteria are as stated in para. 3.3.2 and in Table 3.3.2 for Category D fluid service, unless otherwise specified.
3.4.3 Examination -- Severe Cyclic Conditions

Piping to be used under severe cyclic conditions shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria are as stated in para. 3.3.2 and in Table 3.3.2, for severe cyclic conditions, unless otherwise specified.

(a) Visual Examination

The requirements of para 3.4.1(a) apply with the following exceptions

1) All fabrication shall be examined.

2) All threaded, bolted and other joints shall be examined.

3) All piping erection shall be examined to verify dimensions and alignment. Supports, guides and points of cold spring shall be checked to ensure that movement of the piping under all conditions of startup, operation and shutdown will be accommodated without undue binding or unanticipated constraint.

(b) Other Examination

All circumferential butt and miter groove welds and all fabricated branch connection welds comparable to those shown in Fig.3.5.4E of ES 6004 shall be examined by 100% radiography in accordance with para 6.5 or (if specified in the engineering design) by 100% ultrasonic examination in accordance with para 6.6. Socket welds and branch connection welds which are not radiographed shall be examined by magnetic particle or liquid penetrant methods in accordance with para 6.3 or 6.4.

(c) In-process examination in accordance with para 6.7, supplemented by appropriate nondestructive examination, may be substituted for the examination required in (b) above on a weld-for-weld basis if specified in the engineering design or specifically authorized by the Inspector.

(d) Certification and Records

The requirements of para 3.4(c) apply.

3.4.4 Examination - Category M Fluid Service

Piping to be used under Category M Fluid Service shall be examined to the extent specified herein or to any greater extent specified in the engineering design.

(a) Visual Examination

1) All fabrication shall be examined.

2) All threaded, bolted and other mechanical joints shall be examined.
(b) Other Examination

1) The random radiography/ultrasonic examination requirement of para 3.4.1(b)(1) apply except that at least 20% of circumferential butt and mitre welds and of fabricated lap and branch connection welds comparable to those shown in Fig. 3.5.4(E) and 3.5.5 sketches (d) and (e) shall be examined.

2) The in-process examination alternative permitted in para 3.4.1 (b)(1) may be specified on a weld-for-weld basis in the engineering design or by the inspector. It shall be supplemented by appropriate non-destructive examination.

3.5 Supplementary Examination

Any of the methods of examination described in para 6.0 may be specified by the engineering design to supplement the examination required by para 3.4. The extent of supplementary examination to be performed and any acceptance criteria that differ from those in para 3.3.2 shall be specified in the engineering design.

3.5.1 Spot Radiography

(a) Longitudinal Welds

Spot radiography for longitudinal groove welds required to have a weld joint factor $E_j$ of 0.90 requires examination by radiography in accordance with para 6.5 of at least 300 mm in each 30 m of weld for each welder or welding operator. Acceptance criteria are those stated in Table 3.3.2 for radiography under Normal Fluid Service.

(b) Circumferential Butt Welds and Other Welds

It is recommended that the extent of examination be not less than one shot on one in each 20 welds for each welder or welding operator. Unless otherwise specified, acceptance criteria are as stated in Table 3.3.2 for radiography under Normal Fluid Service for the type of joint examined.

(c) Progressive Sampling for Examination

The provisions of para 3.3.4 are applicable

(d) Welds to Be Examined

The locations of welds and the points at which they are to be examined by spot radiography shall be selected or approved by the Inspector.
3.5.2 Hardness Tests

The extent of hardness testing required shall be in accordance with following para except as otherwise specified in the engineering design.

Hardness tests of production welds and of hot bent and hot formed piping are intended to verify satisfactory heat treatment. The hardness limit applies to the weld and to the heat affected zone (HAZ) tested as close as practicable (with in 2-3 mm) to the edge of the weld.

(a) Where a hardness limit is specified in Table 3 at least 10% of welds, hot bends and hot formed components in each furnace heat treated batch and 100% of those locally heat treated shall be tested.

(b) When dissimilar metals are joined by welding the hardness limits specified for the base and welding materials in Table 3 shall be met for each material.

3.5.3 Examinations to Resolve Uncertainty

Any method may be used to resolve doubtful indications. Acceptance criteria shall be those for the required examination.

4.0 EXAMINATION PERSONNEL

4.1 Personnel Qualification and Certification

Examiners shall have training and experience commensurate with the needs of the specified examinations. The employer shall certify records of the examiners employed, showing dates and results of personnel qualifications and shall maintain them and make them available to the Inspector.

4.2 Specific Requirement

For in-process examination, the examinations shall be performed by personnel other than those performing the production work.

5.0 EXAMINATION PROCEDURES

Any examination shall be performed in accordance with a written procedure that conforms to one of the methods specified in para 6.0, including special methods (see para 6.1.2). Procedures shall be written as required in the ASME BPV Code, Section V, Article 1, T-150. The employer shall certify records of the examination procedures employed, showing dates and results of procedure qualifications and shall maintain them and make them available to the Inspector.
6.0 TYPES OF EXAMINATION

6.1 General

6.1.1 Methods

Except as provided in para 6.1.2, any examination required by this Standard, by the engineering design or by the Inspector shall be performed in accordance with one of the methods specified herein.

6.1.2 Special Methods

If a method not specified herein is to be used, it and its acceptance criteria shall be specified in the engineering design in enough detail to permit qualification of the necessary procedures and examiners.

6.1.3 Definitions

The following terms apply to any type of examination

100% Examination: complete examination of all of a specified kind of item in a designated lot of piping.

Random Examination: complete examination of a percentage of a specified kind of item in a designated lot of piping.

Spot Examination: a specified partial examination of each of a specified kind of item in a designated lot of piping. e.g. of part of the length of all shop-fabricated welds in a lot of jacketed piping.

Random Spot Examination: a specified partial examination of a percentage of a specified kind of item in a designated lot of piping.

6.2 Visual Examination

6.2.1 Definition

Visual examination is observation of the portion of components, joints and other piping elements that are or can be exposed to view before, during or after manufacture, fabrication, assembly, erection, examination or testing. This examination includes verification of Code and engineering design requirements for materials, components, dimensions, joint preparation, alignment, welding, bonding, brazing, bolting, threading or other joining method, supports, assembly and erection.

6.2.2 Method

Visual examination shall be performed in accordance with the BPV Code, Section V, Article 9. Records of individual visual examinations are not required, except for those of in-process examination as specified in para 6.7.
6.3 Magnetic Particle Examination

Magnetic particle examination of welds shall be performed in accordance with ASME BPV Code, Section V, Article 7. Magnetic particle examination is not normally required for site welded joints. Liquid penetrant examinations normally preferred.

6.4 Liquid Penetrant Examination

Liquid penetrant examination of welds shall be performed in accordance with ASME BPV Code, Section V, Article 6.

6.5 Radiographic Examination

6.5.1 Method

Radiography of welds shall be performed in accordance with ASME BPV Code, Section V, Article 2.

6.5.2 Extent of Radiography

(a) **100% Radiography**

This applies only to girth and miter groove welds and to fabricated branch connection welds comparable to Fig.3.5.4E, unless otherwise specified in the engineering design.

(b) **Random Radiography**

This applies only to girth and miter groove welds.

(c) **Spot Radiography**

This requires a single exposure radiograph in accordance with para 6.5.1 at a point within a specified extent of welding. For girth, miter and branch groove welds the minimum requirement is:

1) for sizes \( \leq \) NPS \( 2\frac{1}{2}'' \), a single elliptical exposure encompassing the entire weld circumference;

2) for sizes > NPS \( 2\frac{1}{2}'' \), the lesser of 25% of the inside circumference or 152 mm.

For longitudinal welds the minimum requirement is 152 mm of weld length.

6.6 Ultrasonic Examination

6.6.1 Method

Ultrasonic examination of welds shall be performed in accordance with ASME BPV Code, Section V, Article 5, except that the alternative specified in (a) and (b) below is permitted for basic calibration blocks specified in T-542.2.1 and T-542.8.1.1.
(a) When the basic calibration blocks have not received heat treatment in accordance with T-542.1.1(c) and T-542.8.1.1, transfer methods shall be used to correlate the responses from the basic calibration block and the component. Transfer is accomplished by noting the difference between responses received from the same reference reflector in the basic calibration block and in the component and correcting for the difference.

(b) The reference reflector may be a V-notch (which must subsequently be removed), an angle beam search unit acting as a reflector or any other reflector which will aid in accomplishing the transfer.

(c) When the transfer method is chosen as an alternative, it shall be used, at the minimum:

1) for sizes $\leq$ NPS 2\textsuperscript{"}, once in each 10 welded joints examined.
2) for sizes $> NPS 2\textsuperscript{"}$ and $\leq NPS 18\textsuperscript{"}$, once in each 1.5 m of welding examined.
3) for sizes $> NPS 18\textsuperscript{"}$ once for each welded joint examined.

(d) Each type of material and each size and wall thickness shall be considered separately in applying the transfer method. In addition, the transfer method shall be used at least twice on each type of weld joint.

(e) The reference level for monitoring discontinuities shall be modified to reflect the transfer correction when the transfer method is used.

6.6.2 Acceptance Criteria

A linear-type discontinuity is unacceptable if the amplitude of the indication exceeds the reference level and its length exceeds:

(a) 6 mm for $T_w \leq 19$ mm
(b) $T_w/3$ for $19$ mm $< T_w \leq 57$ mm
(c) 19 mm for $T_w > 57$ mm

6.7 In-Process Examination

6.7.1 Definition

In-process examination comprises examination of the following, as applicable:

(a) joint preparation and cleanliness;
(b) preheating;
(c) fit-up, joint clearance and internal alignment prior to joining;
(d) variables specified by the joining procedure, including filler material; and

1) (for welding) position and electrode;
2) (for brazing) position, flux, brazing temperature, proper wetting and capillary action;
(e) (for welding) condition of the root pass after cleaning - external and where accessible, internal - aided by liquid penetrant or magnetic particle examination when specified in the engineering design;

(f) (for welding) slag removal and weld condition between passes; and

(g) appearance of the finished joint.

6.7.2 **Method**

The examination is visual, in accordance with para 6.2, unless additional methods are specified in the engineering design.
### TABLE 3.3.2

#### ACCEPTANCE CRITERIA FOR WELDS

<table>
<thead>
<tr>
<th>Kind of Implementation</th>
<th>Visual</th>
<th>Radiography</th>
<th>Girth and Miter Groove [Note (2)]</th>
<th>Longitudinal Groove [Note (3)]</th>
<th>Fillet [Note (4)]</th>
<th>Branch Connection [Note (4)]</th>
<th>Visual</th>
<th>Radiography</th>
<th>Girth and Miter Groove [Note (2)]</th>
<th>Longitudinal Groove [Note (3)]</th>
<th>Fillet [Note (4)]</th>
<th>Branch Connection [Note (4)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack</td>
<td>X</td>
<td>X</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>A</td>
<td>X</td>
</tr>
<tr>
<td>Lack of fusion</td>
<td>X</td>
<td>X</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>X</td>
<td></td>
<td>A</td>
<td>A</td>
<td>X</td>
<td>A</td>
<td>NA A</td>
</tr>
<tr>
<td>Incomplete penetration</td>
<td>X</td>
<td>X</td>
<td>B</td>
<td>A</td>
<td>NA</td>
<td>B</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Internal porosity</td>
<td>--</td>
<td>X</td>
<td>E</td>
<td>E</td>
<td>NA</td>
<td>E</td>
<td>--</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Slag inclusion, tungsten inclusion or elongated indication</td>
<td>--</td>
<td>X</td>
<td>G</td>
<td>G</td>
<td>NA</td>
<td>G</td>
<td>--</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Undercutting</td>
<td>X</td>
<td>--</td>
<td>H</td>
<td>A</td>
<td>H</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Surface porosity or exposed slag inclusion [Note (5)]</td>
<td>X</td>
<td>--</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>X</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Surface finish</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Concave root surface (suck-up)</td>
<td>X</td>
<td>X</td>
<td>K</td>
<td>K</td>
<td>NA</td>
<td>K</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Reinforcement or internal protrusion</td>
<td>X</td>
<td>--</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

**Note:**
- A: Acceptance
- X: Examine
- NA: Not Applicable
- H: High
- I: Interim
- K: Kindly
- M: Minimum
- J: Joint
- L: Lower
- M: Main
- X: X-ray
- I: Interim
- J: Joint
- L: Lower
- M: Main

**Conditions:**
- **Normal Fluid Service**
- **Severe Cyclic Conditions**
- **Category D Fluid Service**

**Examination Methods:**
- Visual
- Radiography
- Girth and Miter Groove
- Longitudinal Groove
- Fillet
- Branch Connection
### CRITERION VALUE NOTES FOR TABLE 3.3.2

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Measure</th>
<th>Acceptable Value Limits [Note (6)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Extent of imperfection</td>
<td>Zero (no evident imperfection)</td>
</tr>
<tr>
<td>B</td>
<td>Depth of incomplete penetration</td>
<td>( \leq 1 \text{ mm and } \leq 0.2 \ T_w )</td>
</tr>
<tr>
<td></td>
<td>Cumulative length of incomplete penetration</td>
<td>( \leq 38 \text{ mm in any } 150 \text{ mm weld length} )</td>
</tr>
<tr>
<td>C</td>
<td>Depth of lack of fusion and incomplete penetration</td>
<td>( \leq 0.2 \ T_w )</td>
</tr>
<tr>
<td></td>
<td>Cumulative length of lack of fusion and incomplete penetration [Note (7)]</td>
<td>( \leq 38 \text{ mm in any } 150 \text{ mm weld length} )</td>
</tr>
<tr>
<td>D</td>
<td>Size and distribution of internal porosity</td>
<td>See ASME BPV Code, Section VIII, Division 1, Appendix 4</td>
</tr>
</tbody>
</table>
| E | Size and distribution of internal porosity | For \( T_w \leq 6 \text{ mm} \) limit is same as D  
For \( T_w > 6 \text{ mm} \) limit is \( 1.5 \times D \) |
| F | Slag inclusion, tungsten inclusion or elongated indication | \( \leq T_w / 3 \) |
| | Individual length | \( \leq 2.5 \text{ mm and } \leq T_w / 3 \) |
| | Cumulative length | \( \leq T_w \text{ in any } 12 \ T_w \text{ weld length} \) |
| G | Slag inclusion, tungsten inclusion or elongated indication | \( \leq T_w / 3 \) |
| | Individual length | \( \leq 2.5 \text{ mm and } \leq T_w / 3 \) |
| | Cumulative length | \( \leq T_w \text{ in any } 12 \ T_w \text{ weld length} \) |
| H | Depth of undercut | \( \leq 1 \text{ mm and } \leq T_w / 4 \) |
| I | Depth of undercut | \( \leq 1.5 \text{ mm and } \leq (T_w / 4 \text{ or } 1 \text{ mm}) \) |
| J | Surface roughness | \( \leq 500 \text{ mm Ra per ASME B 46.1} \) |
| K | Depth of root surface concavity | Total joint thickness, incl. weld reinfr., \( \geq T_w \) |
| L | Height of reinforcement or internal protrusion [Note (8)] in any plane through the weld shall be within limits of the applicable height value in the tabulation at right, except as provided in Note (9). Weld metal shall merge smoothly into the component surfaces | For \( T_w \text{ mm} \)
| | | \( \leq 6 \text{ or } \leq 13 \)
| | | \( > 13 \text{ or } \leq 25 \)
| | | \( > 25 \text{ or } \leq 5 \)
| M | Height of reinforcement or internal protrusion [Note (8)] as described in L. Note (9) does not apply | Limit is twice the value applicable for L above. |

\( X = \text{required examination} \quad \text{NA = not applicable} \quad \text{-- = not required} \)
TABLE 3.3.21 (CONTD.)

NOTES:

(1) Criteria given are for required examination. More stringent criteria may be specified in the engineering design. See also paras 3.5 and 3.5.3.

(2) Longitudinal groove weld includes straight and spiral seam. Criteria are not intended to apply to welds made in accordance with a standard listed in Table A-1 or Table 326.1 of Code ASME B 31.3.

(3) Fillet weld includes socket and seal welds and attachment welds for slip-on flanges, branch reinforcement and supports.

(4) Branch connection weld includes pressure containing welds in branches and fabricated laps.

(5) These imperfections are evaluated only for welds ≤ 5 mm in nominal thickness.

(6) Where two limiting values are separated by “and” the lesser of the values determines acceptance. Where two sets of values are separated by “or” the larger value is acceptable. $T_w$ is the nominal wall thickness of the thinner of two components joined by a butt weld.

(7) Tightly butted unfused root faces are unacceptable.

(8) For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components; both reinforcement and internal protrusion are permitted in a weld. For fillet welds, height is measured from the theoretical throat Fig. 3.5.2A of ES 6004; internal protrusion does not apply.

(9) For welds in aluminium alloy only, internal protrusion shall not exceed the following values:
   (a) For thickness ≤ 2 mm : 1.5 mm
   (b) For thickness > 2 mm and < 6 mm : 2.5 mm

For external reinforcement and for greater thicknesses, see the tabulation for Symbol L.
ENGINEERING STANDARD

PRESSURE TESTING OF PIPING
1.0 SCOPE

All installed piping after completion of the applicable examinations, but prior to initial operation shall be pressure tested to ensure tightness in accordance with the requirements of this specification. However, piping built, in conformance with the ASME Boiler & PV code or Indian Boiler Regulation shall be pressure tested in compliance of such code or regulations.

Piping systems open to atmosphere, such as drains, vents, outlet piping for relief valves discharging to atmosphere and underground sewers shall not require any pressure testing. These lines shall be examined visually to determine that all joints are properly made up.

2.0 GENERAL REQUIREMENTS FOR LEAK/ PRESSURE TESTS

Following requirements apply to both hydraulic as well as pneumatic leak/ pressure tests.

2.1 Limitations on Pressure

(a) Stress Exceeding Yield Strength

If the test pressure would produce a nominal pressure stress or longitudinal stress in excess of yield strength at test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.

(b) Test Fluid Expansion

If a pressure test is to be maintained for a period of time and the test fluid in the system is subject to thermal expansion, precautions shall be taken to avoid excessive pressure.

(c) Preliminary Pneumatic Test

A preliminary test using air at no more than 170 kPa (25 psi) gauge pressure may be made prior to hydrostatic testing to locate major leaks.

2.2 Other Test Requirements

(a) Examination for Leaks

Test pressure during leak/pressure test shall be maintained for at least 10 min. and all joints and connections shall be examined for leaks.

(b) Heat Treatment

Leak tests shall be conducted after any heat treatment has been completed.

(c) Low Test Temperature

The possibility of brittle fracture shall be considered when conducting leak tests at metal temperatures near the ductile-brittle transition temperature.
2.3 Special Provisions for Testing

(d) Piping Subassemblies

Piping subassemblies may be tested either separately or as assembled piping.

(e) Flanged Joints

A flanged joint at which a blank is inserted to isolate other equipment during a test need not be tested.

(f) Closure Welds

The final weld connecting piping systems or components which have been successfully tested in accordance with this engineering standard need not be leak tested provided the weld is examined in process in accordance with para 344.7 of ASME B 31.3 (para 6.7 of ES:6005) and passes with 100% radiographic examination in accordance with para 344.5 of ASME B 31.3 (Para 6.5 of ES 6005) or 100% ultrasonic examination in accordance with para 344.6 of ASME B 31.3 (Para 6.6 of ES 6005).

2.4 Externally Pressured Piping

Piping subject to external pressure shall be tested at an internal gauge pressure 1.5 times the external differential pressure, but not less than 105 kPa (15 psi).

2.5 Jacketed Piping

(a) The internal line shall be leak tested on the basis of the internal or external design pressure, whichever is critical. This test must be performed before the jacket is completed if it is necessary to provide visual access to joints of the internal line.

(b) The jacket shall be leak tested on the basis of the jacket design pressure unless otherwise specified in the engineering design.

3.0 PREPARATION FOR LEAK/PRESSURE TEST

3.1 All joints, including welds and bends, shall be left uninsulated & exposed for examination during leak testing, except that joints previously tested may be insulated or covered. All joints may be primed and painted only after leak testing.

3.2 Major equipment, such as compressors, pumps, vessels and exchangers shall be isolated from pipe line during hydrostatic test. When necessary for practicability, exchangers and vessels may be included with the connected piping provided the piping test pressure is within the allowable cold pressure limits of the equipment.

3.3 All air present in the system to be tested shall be vented while admitting the test fluid.

All vent valves during filling up as well as during draining must be fully open.
3.4 Piping designed for vapour and gas shall be provided with additional temporary supports if necessary, to support the weight of test fluid.

3.5 Instruments, expansion joints, filters etc., for which the maximum permissible cold test pressures are lower than the specified hydrostatic test pressure for piping, shall be isolated and excluded from the test.

3.6 Lines containing check valves shall have source of test pressure on the up-stream side.

3.7 Valves shall not be subjected to a test pressure in excess of manufactures allowable test rating. When permitted, the installed valves shall be kept open.

3.8 Relief valves shall be excluded from the test and shall be suitably blanked off. Orifice plates in horizontal lines shall not be installed till completion of test.

Control valves shall not be field tested. All flanged control valves shall be removed before hydraulic testing of the pipe lines. Welded end control valves shall be welded after hydraulic test, cleaning and blowing.

Indicating pressure gauges mounted locally may be tested with the lines provided the test pressure is not in excess of their scale ratings.

3.9 Instrument take-off piping up to the first block valve shall be tested with piping to which it is connected. Testing of remainder of lead line uptil instrument can also be done at the same time provided instruments are blocked off from source of pressure and vented to atmosphere.

3.10 The test shall be carried out at ambient temperature and the water temperature shall not be less than 7°C.

4.0 HYDROSTATIC LEAK/ PRESSURE TEST

4.1 Test Fluid

The fluid shall be water unless there is the possibility of damage due to freezing or to adverse effects of water on the piping or the process. In that case another suitable nontoxic liquid may be used. If the liquid is flammable, its flash point shall be at least 49°C and consideration shall be given to the test environment.

4.2 Test Pressure

Except as provided in para 4.3, the hydrostatic test pressure at any point in a metallic piping system shall be as follows:

(a) Not less than 1½ times the design pressure ;

(b) For design temperature above the test temperature, the minimum test pressure shall be calculated by following equation except that the value of \( S_T / S \) shall not exceed 6.5 ;

\[
P_T = \frac{1.5PD_S}{S}\]

where

- \( P_D \) = design pressure
- \( S_T \) = test temperature
- \( S \) = design temperature
Where

\[ P_T = \text{minimum test gauge pressure} \]
\[ P = \text{internal design gauge pressure} \]
\[ S_T = \text{stress value at test temperature} \]
\[ S = \text{stress value at design temperature} \]

(c) If the test pressure as defined above would produce a stress in excess of the yield strength at test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.

4.3 Hydrostatic Test of Piping With Vessels as a System

(a) Where the test pressure of piping attached to a vessel is the same as or less than the test pressure for the vessel, the piping may be tested with the vessel at the piping test pressure.

(b) Where the test pressure of the piping exceeds the vessel test pressure, and it is not considered practicable to isolate the piping from the vessel, the piping and the vessel may be tested together at the vessel test pressure, provided the owner approves and the vessel test pressure is not less than 77% of the piping test pressure calculated in accordance with para 4.2(b).

4.4 Lines at Atmospheric Pressure

All liquid lines at atmospheric pressure (< 1 Kg/cm\(^2\)g) shall be tested hydrostatically at 2 Kg/cm\(^2\)g.

5.0 PNEUMATIC LEAK/ PRESSURE TEST

Piping may be tested pneumatically if these cannot be safely filled with water or where traces of water cannot be tolerated or if these have been previously tested hydrostatically.

5.1 Precautions

Pneumatic testing involves the hazard of released energy stored in compressed gas. Particular care must therefore be taken to minimize the chance of brittle failure during a pneumatic leak test. Test temperature is important in this regard and must be considered when the designer chooses the material of construction.

5.2 Pressure Relief Device

A pressure relief device shall be provided, having a set pressure not higher than the test pressure plus the lesser of 345 kPa (50 psi) or 10% of the test pressure.

5.3 Test Fluid

The gas used as test fluid, if not air, shall be nonflammable and nontoxic.

5.4 Test Pressure

The test pressure shall be 110% of design pressure.
5.5 Procedure

5.6 The pressure shall be gradually increased until a gage pressure which is the lesser of one-half the test pressure or 170 kPa (25 psi) is attained, at which time a preliminary check shall be made, including visual examination of joints. Thereafter, the pressure shall be gradually increased in steps until the test pressure is reached, holding the pressure at each step long enough to equalize piping strains. The pressure shall then be reduced to the design pressure before examining for leakage in accordance with para 2.2.

5.7 Lines at Atmospheric Pressure

All gas lines at atmospheric pressure ( \( \leq 1 \text{ Kg/cm}^2 \text{g} \)) shall be tested pneumatically at 0.5 Kg.cm\(^2\)g.

6.0 VACUUM SERVICES

Lines in vacuum services shall be hydrostatically tested at a minimum internal pressure of 1.5 Kg/cm\(^2\)g unless limited to a lower value by design. Where it is not possible to test hydrostatically, the pipe lines shall be tested pneumatically at 1 Kg/cm\(^2\)g.

7.0 SENSITIVE LEAK TEST

The test shall be in accordance with the Gas and Bubble Test method specified in the BPV Code, Section V, Article 10, or by another method demonstrated to have equal sensitivity. Sensitivity of the test shall be not less than \( 10^{-3} \) atm.ml/sec under test conditions.

a) The test pressure shall be at least the lesser of 105 kPa (15 psi) gage, or 25% or the design pressure.

b) The pressure shall be gradually increased until a gage pressure the lesser of one-half the test pressure or 170 kPa (25 psi) is attained, at which time a preliminary check shall be made. Then the pressure shall be gradually increased in steps until the test pressure is reached, the pressure being held long enough at each step to equalize piping strains.

8.0 REPAIRS OR ADDITIONS AFTER LEAK TESTING

If repairs or additions are made following the leak test, the affected piping shall be retested, except that for minor repairs or additions the owner may waive retest requirements when precautionary measures are taken to assure sound construction.

9.0 TEST RECORDS

Records shall be made of each piping system during the testing, including:

a) Date of Test
b) Identification of the piping tested.
c) Test Method
d) Test Pressure and duration
e) Certification of results by examiner *
f) Approval by the Inspector
# ENGINEERING STANDARD

## UNDERGROUND PIPING

<table>
<thead>
<tr>
<th>REV.</th>
<th>DATE</th>
<th>PURPOSE</th>
<th>PREPD</th>
<th>REVWD</th>
<th>APPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>JAN. 1998</td>
<td>FOR IMPLEMENTATION AND COMMENTS IF ANY</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.0 SCOPE
1.1 This specification covers the requirements for construction and installation of underground Carbon Steel buried piping.

2.0 REFERENCE STANDARDS
PDS-P-001 Tolerance for piping fabrication.
ES 6004 Welding specifications CS & Alloy Steel Piping.
ES 6006 Pressure Testing of pipes.
ES 6009 Protective coating for underground piping.
ES 6021 Fusion welds of pressure pipes – Inspection requirement

3.0 PROTECTIVE COATING
3.1 Protective coating of pipes shall be in accordance with ES 6009.
3.2 Wherever specified, cathodic protection as per the specification/procedure specified in NIT shall also be provided.

4.0 STORAGE AND HANDLING
4.1 Storage
4.1.1 Pipes shall be stored on firm and well drained ground.
4.1.2 The pipes shall be stacked/stored on timber/packs of sand bags/steel to keep them out of contact with ground.
4.1.3 Pipe fittings and valves upto size 6\" shall be stored indoors.
4.1.4 Pipe fittings and valves above size 6\" may be stored outside on wooden sleepers on firm and well drained ground. Fittings shall be stacked such that ingress of rain water is avoided and are in self draining position.
4.1.5 The valves shall be stored in closed position except those with non metallic seats (for instance butterfly valves).
4.1.6 Gate valves shall be stored in upright position while butterfly valves shall be kept with flange facing resting on wooden sleepers. All valves shall be covered with tarpulin/polythene sheets.
4.1.7 Rubber-lined valves shall be stored in shade and protected from exposure to direct sunlight.
4.1.8 Valves end coverings shall be retained in place until removal is necessitated for erection. All the valves shall be inspected and cleaned after end coverings are removed for erection.

4.1.9 Valves spindle shall be cleaned and lubricated prior to commissioning.

4.1.10 Valves shall be lifted by slinging around the body or lifting lugs provided on the body. Valves shall not be handled from hand wheels/actuators and also shall not be dragged.

4.2 Handling

4.2.1 Pipes/pipe fittings and valves shall not be allowed to drop or strike any objects which shall damage the same.

4.2.2 While handling pipes and fittings, care shall be exercised to avoid distortion, flattening, denting, scoring or any other form of damage.

4.2.3 To the extent feasible, mechanical lifting tools and tackles shall be used for handling pipes to avoid any scoring/scratching.

4.2.4 After application of protective coating, no bracelinks/ropes of any description shall be used for lifting or handling of pipes. After application of protective coating, for handling the pipes, lifting hooks made of belt length or plates curved to match the curvature of pipes or any similar device providing enough bearing area to avoid damage to the protective coating shall be used. After application of protective coating, pipes shall be lifted and lowered by use of cranes except for areas which are unaccessible for cranes.

4.2.5 Dragging of coated or uncoated pipes is prohibited.

4.2.6 In stringing pipe along the right of way, gaps shall be left between adjacent length of pipes at regular intervals and at well defined places to permit free passage of personnel or vehicle during the time interval between stringing and other construction operations.

5.0 SPECIFICATION AND CONSTRUCTION OF TRENCHES

5.1 Layout of the trenches including slope shall conform to piping layout drawings.

5.2 The cross section of trenches shall conform to Fig.1. The depth of the trench at certain locations may have to be increased in consultation with PDIL.
5.3 Excavation shall be carried out with conventional tools and machinery. The excavation in rocky areas shall be carried out by controlled blasting and/or use of drilling, rock ploughs, rippers etc.

5.4 Adequate and abundant caution shall be exercised prior to and during the blasting to prevent any damage to the property or injury to personnel. All rock scattered due to blasting shall be removed to the satisfaction of PDIL.

5.5 Soil removed during excavation shall be properly stacked and shall be used for back filling, if it meets the requirements laid down in this standard for back filling material.

5.6 Finished trench shall be free of rocks, hard clods, roots and/or other debris which would damage the coating, when the pipe is lowered into the trench.

5.7 After excavation, bed depth of 75 mm below the bottom of the pipe as shown in Fig.1 shall be ensured.

5.8 While constructing the trench at rail/road crossing, danger signals shall be provided on both sides of rail/road in accordance with Railway/State regulations. Signals shall be located a minimum of 100 meters from pipe line crossing and shall be readable from 30 meters. Barricades or guard rails may also be provided for protection of general public due to the hazardous location of the crossing.

5.9 Clearance between the pipe and any other underground structure shall be provided as indicated below, clearance between two adjacent pipes shall also be as indicated below and decided considering the higher size pipe.

<table>
<thead>
<tr>
<th>Pipe size</th>
<th>Upto 12”</th>
<th>14” to 24”</th>
<th>28”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance (mm)</td>
<td>150</td>
<td>200</td>
<td>300</td>
</tr>
</tbody>
</table>

5.10 Where drain is encountered, the trench shall be dug so that the pipe line may be laid over or under such drain with a minimum clearance of 100 mm and to such depths as may be required due to site conditions. When any drain is damaged, it shall be repaired immediately (See Fig.6).
5.11 The pipe line may pass through deep washes and creeks where supports shall be provided in consultation with PDIL. The controlling factors will be length of span, conditions of banks and hazards of leaving the line exposed. Maximum unsupported span for various sizes are shown in Table-1. It shall be checked that the combined stress due to internal pressure and external loads are within permissible limits.

**TABLE - 1**

<table>
<thead>
<tr>
<th>Pipe Size in inches</th>
<th>Span in Metre</th>
<th>Pipe Size in inches</th>
<th>Span in Metre</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>15</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>18</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>12</td>
<td>19</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>14</td>
<td>19</td>
<td>24</td>
<td>25</td>
</tr>
</tbody>
</table>

5.12 Where spans are greater length than those indicated in Table-1, intermediate supports shall be provided. However, in no case the unsupported length of pipe shall be more than that indicated in Table-1.

5.13 The crossings at railway tracks and roads shall be in accordance with the requirements of Railways or local Government authorities. Pipe casing or other suitable arrangement like culverts etc. shall be provided at crossing of roads, railway tracks, canals etc. as indicated in the drawings.

5.14 In all cases where trench has been cut across public or private roads and back filling of the trench is not completed, temporary bridge work of full width of road and of adequate strength shall be installed to ensure safety of traffic.

5.15 Crossing/diversion shall be provided wherever necessary in the opinion of PDIL to permit property owner to travel or move his stock and property.

5.16 The dimensions of the trench may have to be locally increased to facilitate welding of pipe. Field joints should be kept to a minimum.
6.0 DEWATERING

6.1 Adequate arrangement for dewatering of trenches shall be made by the contractor. The water thus pumped/bailed out shall be drained to a safe location as directed by PDIL.

6.2 The trenches shall be made free of water while preparing the bed, laying of pipes, backfilling and welding of field joints.

6.3 From safety point of view, diesel driven pumps shall be preferred.

7.0 LAYING OF PIPE

7.1 Laying of pipes in the trench shall be started only after the layout, depth and slope of the trench have been approved by PDIL.

7.2 Pipes shall be visually examined to ensure that the internal surface of the pipe is clean. No earth or rock shall remain inside the pipe. The weld preparation and adjacent pipe shall be free from dust, scale, paint and foreign material for a distance of 2T + 50 mm where T is the thickness of the pipe.

7.3 The pipes shall be visually examined for any damage to the protective coating. In case any damage is observed the same shall be further examined by spark testing to establish the extent of damage. The damaged area shall be repaired to the satisfaction of PDIL.

7.4 The open ends of sections of laid pipe shall be covered with minimum 3 mm thk. steel plates to prevent the ingress of water, skids, animals or other material which would interfere with the final cleaning of the pipe.

The covers shall be securely attached to the pipe and shall not be removed until the pipes are to be joined by welding.

7.5 All rules and regulations laid down by railway and or other related Government authorities shall be complied with while laying the pipe through rail/road crossing.

7.6 Concrete anchor blocks shall be provided at all turning points for pipe sizes 8" and above to absorb water hammer and pipe vibrations.

7.7 Anchor blocks at suitable interval should be provided to take care of buoyancy force coming on the pipe when the pipe is passing on the river bed or through water.
8.0 INSTALLATION OF CASINGS PIPE

The material of casing pipes shall be Carbon Steel.

8.1 The thickness of casing pipe shall be calculated in accordance with Annexure-I of this standard or as indicated in the drawing/work order.

8.2 The interior surface of the casing pipe must be free of rocks, dirt, clods or other material which could damage the coating on the carrier pipe.

8.3 Casing shall be installed in accordance with figures 2 & 3 and shall meet the requirements of Railway and local Government authorities.

8.4 Casing to be installed by boring. The boring shall be done with a machine which will feed the casing into the bored hole directly following the cutter head on the auger simultaneously with the boring operation. The diameter of the cutter head on the auger shall not be more than 20 mm larger than the outside diameter of the casing. The trench excavated for boring operation shall be at least 3000 mm away from the edge of road/rail track.

8.5 Casing may also be installed across highways or roads by trenching. However, when this method is used, the trench across the road shall be back-filled immediately after the casing is in place. The back fill shall be thoroughly compacted across the entire road bed. The top 300 mm of the back fill shall be gravel or crushed rock.

8.6 Casing shall have minimum clearance of 300 mm from other underground structures.

8.7 As soon as the casing is in place, the vent pipes shall be installed, the inside of the casing cleaned out and both ends capped.

The area shall be cleaned up before moving away from the work site.

9.0 WELDING

9.1 Welders to be deployed for welding shall be tested for procedure and qualification in presence of PDIL at site strictly as per ASME Sec.IX.

9.2 Welding shall be in accordance with ES6004.

9.3 Alignment and welding set up of pipe joints shall be as per ASME B 31.3 and shall be inspected by PDIL before starting the welding.

9.4 Inspection and inspection requirements for welding shall be as per ES6021.
10.0 CLEANING AND FLUSHING
10.1 The pipe line shall be, section by section, thoroughly cleaned by manual means/compressed air/mechanical means such as pigging/water as may be permitted.
10.2 Normally the complete system/installation shall be flushed/cleaned with the system fluid after the system Pumps/Compressors are taken on line. However, the suitability of the system fluid for flushing shall have PDIL approval.
10.3 Adequate and suitable arrangements for disposal of the flushing fluid shall be made before starting the flushing.
10.4 During flushing/cleaning of the piping system with system pumps/compressors on line, the complete installations shall be examined for possible leaks.

11.0 HYDRAULIC TESTING
11.1 The procedure for Hydraulic testing shall be in accordance with ES:6006 except that the specified test pressure shall be maintained on the line for a period of one hour or time taken for inspection whichever is more and no drop in pressure should occur. It is presumed that all field joints are exposed for visual inspection during hydraulic test.
11.2 The spool pieces before application of protective coating shall be subjected to hydraulic test.
11.3 In case, due to site conditions, Hydraulic testing of the complete system is not feasible, the field joints in trenches shall be 100% radiographed.

12.0 BACK FILLING & CLEAN UP
12.1 Back filling of the trench shall be started after inspection and approval of PDIL.
12.2 Before pipe is laid in the trench, sub-grade shall be made by back filling with approved material for a depth of 75 mm from the bottom of the pipe and compacted by ramming/tamping.
12.3 All trenches shall be back-filled by hand from bottom of the trench upto 300 mm above the top of the pipe with back-fill material free from cinder, ashes, refuse, vegetable or organic material, boulders, rocks, stones or other such material which may damage the protective coating of the pipe. The back filling shall be carried out in layers of 75 mm and thoroughly compacted by tamping. Back-fill material shall be deposited in the trench for its full width. The back fill material may be excavated earth, river sand, fine stone dust, sandy soil, etc. In case, adequate quantity of excavated earth is not available, back-fill material shall be hauled from other places by the contractor.

12.4 From 300 mm above the top of the pipe and upto grade level, material containing boulders upto 80 mm in their largest dimension may be used. The back-fill material may be filled by hand or by other approved mechanical methods and shall be thoroughly compacted.

12.5 While back-filling and compacting, care shall be taken to avoid any injury to the pipe and the protective coating.

12.6 Wherever excavated earth is used for back-filling, the degree of compactness shall not be less than 90% protector density as per IS 2720 Part 7 and Part 8.

12.7 The back-fill above the grade level shall be completed as indicated in Fig.4 & 5 as applicable.

12.8 Settlement of back-fill in the trench shall be achieved by means of flooding, puddling, tamping or jetting. Poking with metal rod is not permitted.

12.9 During and/or after completion of back-filling, the excess excavated material shall be carted away as per direction of PDIL. The area shall also be dressed and cleaned. All debris, erection waste etc. shall also be removed by the Contractor.

13.0 MISCELLANEOUS

13.1 The pipes and its branches emerging above the ground level shall be blanked with M.S. blanks fillet welded to them. These blanks shall be removed only at the time of connecting these lines to above ground piping.

13.2 The elevation of projected portion shall be as per piping drawing and shall be kept free from any protective coating for a distance of 150 mm from top elevation.
14.0 In case of cooling water lines, if it is difficult to drain out the water and dry out the line completely, the test water shall be allowed to remain in the header after adding the inhibitor like hexametaphosphate.

15.0 Valve pits shall be constructed as per drawing and construction shall be such as to prevent ingress of sub-soil water.

16.0 DEVIATIONS

16.1 Record of deviation/alteration from the construction drawings shall be recorded by the Contractor.

16.2 After the completion of the work, as built drawings shall be made by the Contractor and submitted to PDIL incorporating all the deviations/alterations.

17.0 MEASUREMENTS

17.1 Trench Earth Work

For the purpose of measurement

a) Cross section of the trench shall be considered as per Fig. 1.

b) Length of the trench shall be on the basis of dimensions given in piping layout drawing including the valve face to face distance.

17.2 Piping System

a) The piping measurement shall be computed from the piping layout drawings and actual measurements taken for deviation/modifications made during execution.

b) In case the erection of valves and specified special components is being measured separately, the erection dimensions of such items shall be excluded while computing the erected piping measurement.

c) The measurements shall be along centre line of piping system from end to end and shall include all fittings like flanges, bends, elbows, tees, reducers, instrument tappings etc., but shall exclude such items as per para 17.2 (b).

d) For branch connections the measurement shall be from the root of the branch.
### FIG. 1

<table>
<thead>
<tr>
<th>PIPE SIZE IN INCHES</th>
<th>N (MIN.)</th>
<th>B</th>
<th>NORMAL EXCAVATION</th>
<th>ROCK EXCAVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N1</td>
<td>N2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>700</td>
<td>1100</td>
<td>225</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>700</td>
<td>1100</td>
<td>225</td>
<td>300</td>
</tr>
<tr>
<td>6</td>
<td>700</td>
<td>1100</td>
<td>275</td>
<td>300</td>
</tr>
<tr>
<td>8</td>
<td>800</td>
<td>1200</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>800</td>
<td>1200</td>
<td>325</td>
<td>325</td>
</tr>
<tr>
<td>12</td>
<td>800</td>
<td>1200</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>14</td>
<td>800</td>
<td>1200</td>
<td>375</td>
<td>375</td>
</tr>
<tr>
<td>16</td>
<td>900</td>
<td>1300</td>
<td>375</td>
<td>375</td>
</tr>
<tr>
<td>18</td>
<td>900</td>
<td>1300</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>20</td>
<td>900</td>
<td>1300</td>
<td>425</td>
<td>425</td>
</tr>
<tr>
<td>24</td>
<td>1000</td>
<td>1400</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>32</td>
<td>1000</td>
<td>1400</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>36</td>
<td>1100</td>
<td>1500</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>40</td>
<td>1100</td>
<td>1500</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>44</td>
<td>1200</td>
<td>1600</td>
<td>675</td>
<td>675</td>
</tr>
<tr>
<td>48</td>
<td>1200</td>
<td>1600</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>56</td>
<td>1300</td>
<td>1700</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>64</td>
<td>1400</td>
<td>1800</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>72</td>
<td>1500</td>
<td>1900</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>80</td>
<td>1600</td>
<td>2000</td>
<td>1100</td>
<td>1100</td>
</tr>
</tbody>
</table>

**NOTE:**
- NOTE 5: GROUND LEVEL
- TABLE: Normal and Rock Excavation Sizes for Underground Piping
- Diagram: Ground level with pipes and dimensions.
1. N1 Apples for plant piping.
2. N2 Apples for cross country piping.
3. The dimension ‘B’ shall correspond to the diameter of end pipe.
4. The dimension ‘N’ shall correspond to largest diameter pipe.
5. Distance between two pipes shall be as per Cl. 5.9.
FIG. 2 HIGHWAY / ROAD CROSSINGS

NOTES:

1. Casing pipe shall be sealed at both ends.
2. In refilling the trench excavated for the pipe line, adjacent to road and across roads where trenching is permitted, the trench shall be promptly back filled in a proper and workman like manner.
3. Casing pipe shall be 100 mm bigger than the carrier pipe.
4. All dimensions are subject to individual state highway specification.
5. Vent pipes shall be provided only in case of gases and volatile liquids such as Ammonia, Naphtha etc.

![Diagram of rail road crossings]

**FIG. 3. RAIL ROAD CROSSINGS**

**NOTES:**
1. Casing pipe shall be sealed at both ends.
2. Pipe line shall not be laid under rail road tracks nearer than 2 m from any rail joint.
3. The trench on each side of the track shall be promptly refilled in a proper and workman like manner.

4. No pipe shall be placed on, under or within 16 m of any bridge culvert or structure.

5. Casing pipe shall be 100 mm bigger than carrier pipe.

6. Where in the opinion of the railway authorities, drainage ditches or other conditions require the pipe and casing to be buried to a greater depth, pipe shall be so installed.

7. In all case the specifications of Indian Railways shall govern.

8. Vent pipes shall be provided only in case of gases and volatile liquids such as Ammonia, Naphtha etc.
FIG. 4 BACK FILL

Back filling as per Cl-12.3

FIG. 5 BACK FILL ON SLOPING GRO

Bottom of Drain

Grade

FIG. 6 DRAIN REPAIR

Channel iron or section of pipe strong enough to support the drain bottom

Earth filled bags

Sand cement filled bags

FIG. 6 DRAIN REPAIR

Grade

450

450

250

300

75

250

450
ANNEXURE-1

Strength Calculation of underground Metallic Pipes

1.0 Following steps specifies the procedure for checking the strength of underground steel pipes and underground steel casing pipes (i.e. Burried Pipes).

2.0 Loads over Burried Pipes

3.0 Live load \((W_L)\) in Kg/cm\(^2\) shall be obtained as indicated below:

<table>
<thead>
<tr>
<th>Height of cover (m)</th>
<th>0.3</th>
<th>0.6</th>
<th>1.2</th>
<th>1.8</th>
<th>2.4</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load of truck</td>
<td>0.8</td>
<td>0.5</td>
<td>0.23</td>
<td>0.15</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Load of locomotives</td>
<td>2.6</td>
<td>2.0</td>
<td>1.5</td>
<td>1.3</td>
<td>1.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>

4.0 Dead load \((W_d)\) or Back fill load in Kg/cm\(^2\) is obtained by

\[
W_d = HP \times 10^{-4} \text{ where } H = \text{Height of cover (m)}
\]

\[
P = \text{Density of soil (Kg/m}^3)\]

5.0 Total load in Kg/cm\(^2\) is obtained by

\[
W_{td} \text{ (for deflection consideration )} = \frac{1}{2} W1 + Wd
\]

\[
W_{ts} \text{ (for strength consideration )} = W1 + Wd
\]

(Note: Traffic loads or transient loads have less effect in deflecting a flexible pipe than do permanent soil load, hence when considering deflection only a reduction factor of \(\frac{1}{2}\) is applied on \(W1\)).

6.0 Percentage deflection in vertical direction is given by

\[
\% \text{ defl}n = \frac{10 W_{td}}{A + B}
\]

Where \(A = \text{Resistance of pipe due to its mean diameter (d), thickness (t) and modules (E in Kg/cm}^2\) and is given by
And $B = 120 \, E_S$ (where $E_S$ is the modulus of elasticity of soil in Kg/cm$^2$ at overburden pressure as determined in a triaxial test). Here soil pressure acting externally on the pipe surface shall resist $W_{td}$. The enveloping forces are acting radially and the pipe ring is a confined arch under compression.

$E_S = 4 \, \text{to} \, 10 \times 10^3$ Kg/cm$^2$ in good ground above water table according to compaction.

$E_S = 2 \, \text{to} \, 5 \times 10^3$ Kg/cm$^2$ in poor ground or in good ground below water table.

7.0 When there is no soil pressure on the pipe surface, $B = 0$ and when soil pressure is acting radially over pipe surface, $A$ is negligible in comparison to $B$ and hence $A = 0$.

8.0 Percentage deflection thus obtained should not be more than 2%.

9.0 Strength consideration.

10.0 Empirical formula for Bursting strength is

$$W_{ts} \leq \sqrt{\frac{2 \pi E_s \beta \left(\frac{h}{d}\right)}{10^{-6}}}$$

11.0 Empirical formula for bending strain is given by

$$5 \times \% \text{deflection} \times \left(\frac{h}{d}\right)$$

12.0 Design consideration

13.0 In buried pipe at any depth

a) $\% \text{deflection} \leq 2\%$ (Calculated as per CL.-3.0)

b) Bursting strength ($W_{ts}$) $\leq$ value obtained as per Clause 4.1

c) Bending strain shall be less than 0.35% for non-pressure pipe and 0.2% for pressure pipe. (Calculated as per CL. - 4.2)
For safe buried pipe, above three conditions (under Clause 5.1) should be satisfied.

Reference - Hand book of valves, piping and pipelines (book) by R.H. Warring
(Gulf Publishing Company, Book Divn.)
FINAL ACCEPTANCE CERTIFICATE FOR U.G.PIPING (COOLING WATER)

OWNER'S NAME : 
WORK ORDER NO. : 
DATE : 
CONTRACTING FIRM : 
CONTRACTOR'S REF. : 

SUB U.G.COOLING WATER PIPING

i) Check of layout as per piping arrangement drawing --

ii) Check of special supports/Anchor Blocks and standard supports --

iii) Check system as per P&I Drg.No. --

iv) Acceptance of X-Ray examination --

v) Acceptance of D.P. Inspection of trench joint (Root run only) --

vi) Acceptance of Heat Treatment (if any) --

vii) Hydrotesting of the system on (date) --

-- Pressure
-- Duration
-- Remarks

viii) Installation of valves
Total Number --

ix) Making of valve chamber -- Total No. -- Water Proofing

x) Check supply of items in scope of Contractor --
and its test certificate.

xi) Special Remarks

CONTRACTOR PDIL OWNER
<table>
<thead>
<tr>
<th>FORM NUMBER</th>
<th>02-0000-0021 F1 REV O</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCUMENT NO.</td>
<td>ES 6032 REV 0</td>
</tr>
<tr>
<td>SHEET</td>
<td>1 OF 8</td>
</tr>
</tbody>
</table>

**PROJECTS & DEVELOPMENT INDIA LIMITED**

**ENGINEERING STANDARD**

**FLEXIBILITY ANALYSIS BY COMPUTER PROGRAMME**

<table>
<thead>
<tr>
<th>DATE</th>
<th>ISSUED FOR IMPLEMENTATION</th>
<th>PURPOSE</th>
<th>PREPARED</th>
<th>REVIEWED</th>
<th>APPROVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-05-98</td>
<td>RPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CONTENTS

<table>
<thead>
<tr>
<th>SECTION NUMBER</th>
<th>DESCRIPTION</th>
<th>SHEET NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>INTRODUCTION</td>
<td>3</td>
</tr>
<tr>
<td>2.0</td>
<td>PURPOSE</td>
<td>3</td>
</tr>
<tr>
<td>3.0</td>
<td>REQUIREMENT OF FLEXIBILITY ANALYSIS</td>
<td>3</td>
</tr>
<tr>
<td>4.0</td>
<td>SOFTWARE FOR ANALYSIS</td>
<td>4</td>
</tr>
<tr>
<td>5.0</td>
<td>DEFINITIONS</td>
<td>4</td>
</tr>
<tr>
<td>6.0</td>
<td>PROCEDURE</td>
<td>5</td>
</tr>
<tr>
<td>7.0</td>
<td>FEEDING OF INPUT DATA IN THE COMPUTER</td>
<td>6</td>
</tr>
<tr>
<td>8.0</td>
<td>OUTPUT</td>
<td>6</td>
</tr>
<tr>
<td>9.0</td>
<td>INTERPRETATION OF RESULTS</td>
<td>7</td>
</tr>
</tbody>
</table>

LIST OF ATTACHMENTS

<table>
<thead>
<tr>
<th>ATTACHMENT NUMBER</th>
<th>DESCRIPTION</th>
<th>NUMBER OF SHEETS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION

In the computer program CAESAR-II, stress analysis is carried out taking into account the effects of thermal strain, internal pressure and self weight of the pipe simultaneously. Externally applied restraints, concentrated loads and spring effects are also taken care of in the analysis. Stress intensification factors in conformity with ANSI-B31.3 have been used for various pipe members like bends and tee joints.

2.0 PURPOSE

To ensure that the piping system have sufficient flexibility and serve the following purpose:

a) To control within acceptable limits, the piping reactions on connected equipment located between or at the terminals of the line.

b) To maintain the stresses in the pipe itself within a range to limit direct or fatigue failure of pipe line and the failure of intermediate supports and end anchors.

c) To avoid the leakage of joints due to over stressing and bending of pipe lines.

3.0 REQUIREMENT OF FLEXIBILITY ANALYSIS

No formal analysis for adequate flexibility is required in system which:

a) are duplicates of successfully operating installations or replacements without significant change of system with a satisfactory service record:

b) can readily be judged adequate by comparison with previously analysed system:

c) are of uniform size, have no more than two points of fixation, no intermediate restraints, and fall within the limitations of empirical equation as given below:

\[
\frac{D \cdot Y}{(L-U)^2} < 208.0
\]

Where:

\(D\) = Outside diameter of pipe, (mm)

\(Y\) = Resultant of total displacement strains, (mm) to be absorbed by the piping system.

\(L\) = Developed length of piping between anchors, (m).
U = Anchor distances, straight line between anchors, (m).

Pipe lines which do not fall within the above categories equate flexibility analysis. Such pipe lines can again be categorized into non-critical and critical. For non-critical piping, analysis without consideration of the self weight / internal pressure of the pipe may be sufficient as far as the safety of the pipe line is concerned. However, analysis with self weight of the pipe would be useful in finalising the supports. All process pipe lines below 400°C and not being directly connected to sensitive equipment nozzles like turbines, pumps etc. can be designated as being non-critical.

Critical pipe lines can be designated as those which are of high temperature service (> 400°C) or those which are directly connected to sensitive equipment nozzles. Flexibility analysis of such pipes should be done as follows:

All the supports should be decided. Approximate loads being taken up by various springs should be estimated.

Flexibility analysis should be done with thermal expansion, self weight as well as internal pressure. Maximum calculated stress should be compared with allowable stress range.

4.0 SOFTWARE FOR ANALYSIS

CAESAR-II-VERSION 3.21a

5.0 DEFINITIONS

5.1 CO-ORDINATE AXES

These are three mutually perpendicular directions along the plant main axes and vertical. These are represented by X, Y & Z.

5.2 ORIGIN

It is the reference point w.r.t. which distances along the Co-ordinate axes are measured for defining the location of other points.

5.3 END ANCHOR

The equipment nozzles where the pipe lines are connected or the fixed points are referred as end anchors for the pipe line. Every end anchor is either starting or terminating point of one branch. Anchors which have movement due to thermal expansion, are called moving anchor. When end anchor has no movement in any direction, it is termed 'fixed anchor'.

5.4 NODE OR BRANCH POINTS
All such points where a pipe bifurcates are called node or branch points. All support points are also node points.

5.5 RESTRAINT:

Any restriction on free movement or rotation of pipe is termed as restraint.

6.0 PROCEDURE:

6.1 Design Requirement

6.1.1 All lines falling under the following categories shall require flexibility analysis:

pipe size 3"-8" & temp > 100°C
>10" & temp > 80°C

6.1.2 Wherever possible provision for pipe expansion shall be made by changes in the direction of the pipe or by expansion loops.

6.2 MINIMUM INPUT:

a) Dimensioned isometric drawing of the system showing distance between various nodes.

b) Pipe size (NB/OD, thk/sch.), Material, Insulation thickness and density, Operating Pressure, Design temp, Allowable stress of piping material at the design temp, valve weight, fluid density, etc.

c) Axial/ transverse stiffness and weight of bellow expansion joints, if used.

6.3 REQUIRED INPUT:

Besides the data mentioned under 6.2 following are required.

a) Nozzle movement due to thermal expansion/contraction.

b) Concentrated mass if any.

c) Externally applied force, moment and movement at any point.

6.4 DESIRABLE INPUT

Besides the data mentioned under 6.2 and 6.3, following are required.

a) Actual valve weight received from vendor.

b) Displacement of nozzles (Pumps/Turbines) received from vendor.
c) Allowable forces and moments on nozzles for Pumps/ Turbines.

d) Axial/transverse stiffness of bellow expansion joints received from vendor.

e) Process operating philosophy of the plant. This is necessary to analyze the system under different working condition where it is subjected to varying operating condition.

7.0 FEEDING OF INPUT DATA IN THE COMPUTER:

a) First of all, Node numbers are marked on the Isometric drawing.

b) Pipe routing as shown in the dimensioned Isometric drawing, is fed in the computer starting from the first node to the last node.

c) Restraints are fed as marked on the Isometric.

d) Nozzle movements are fed wherever required.

e) Anchor points are properly fed.

f) Operating Pressure, Temp., Material, Allowable stress, pipe size, thickness, Insulation thk. and density, corrosion allowance, fluid density etc, are fed.

g) Spring supports, wherever required, are fed.

8.0 OUTPUT

After feeding the input data, the programme is run for static analysis processor.

8.1 Following cases are analysed.

a) Sustained load case

b) Expansion load case

c) Operating load case

8.2 Following report options are available.

a) Displacements

b) Restraints

c) Restraint summary
d) Global element forces

e) Local element forces

f) Stresses

h) Sorted stresses

i) Hanger tables

9.0 INTERPRETATION OF RESULTS:

a) First of all, the calculated stress is compared with the allowable stress.

b) Forces and moments on restraints are reviewed whether these are within permissible limits. Forces and moments on equipment nozzles are given special attention particularly for pumps and Turbines and any other critical equipment. In case of heavy restraint force and any node, support at that point is to be reviewed.

c) Displacements are reviewed for

- Supports should not leave the structure.
- Pipe should not hit the neighbouring pipe.
- Any other abnormal movement.

d) Stresses on flanged joints are reviewed to see that joints are not over stressed to avoid leakage. Checking is done as per the procedure laid down in "Flange Leakage/ Stress calculation".

e) Finally the pipe is passed for flexibility if following conditions are satisfied.

i) Calculated stress at any point is less than the allowable stress obtained from the code ANSI B31.3.

ii) Forces and moments on restraints are within reasonable permissible limit.

iii) Joints are not over stressed.

iv) Displacements are within reasonable limits.
v) Forces & moments on mechanical equipment such as pumps, turbines or compressors are limited to the equipment manufacturer's recommended values. These forces and moments may also be checked from "Equipment check" (Rotating equipment).
TECHNICAL SPECIFICATION

FOR

PAINT & PROTECTIVE COATINGS

ON STEEL SURFACES
<table>
<thead>
<tr>
<th>Section Number</th>
<th>Description</th>
<th>Sheet Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>GENERAL</td>
<td>4</td>
</tr>
<tr>
<td>1.1</td>
<td>Scope</td>
<td>4</td>
</tr>
<tr>
<td>1.2</td>
<td>Definitions</td>
<td>4</td>
</tr>
<tr>
<td>1.3</td>
<td>Safety Regulations</td>
<td>4</td>
</tr>
<tr>
<td>1.4</td>
<td>Material Safety Data Sheet</td>
<td>4</td>
</tr>
<tr>
<td>1.5</td>
<td>Materials</td>
<td>4</td>
</tr>
<tr>
<td>2.0</td>
<td>CODES AND STANDARDS</td>
<td>5</td>
</tr>
<tr>
<td>2.1</td>
<td>Indian Standards</td>
<td>5</td>
</tr>
<tr>
<td>2.2</td>
<td>International Standards</td>
<td>5</td>
</tr>
<tr>
<td>2.3</td>
<td>Other Standards</td>
<td>5</td>
</tr>
<tr>
<td>3.0</td>
<td>SURFACE PREPARATION</td>
<td>5</td>
</tr>
<tr>
<td>3.1</td>
<td>Metal Surface Preparation</td>
<td>5</td>
</tr>
<tr>
<td>3.1.1</td>
<td>Safety</td>
<td>5</td>
</tr>
<tr>
<td>3.1.2</td>
<td>Pre-cleaning</td>
<td>6</td>
</tr>
<tr>
<td>3.1.3</td>
<td>Surface Decontamination</td>
<td>6</td>
</tr>
<tr>
<td>3.1.4</td>
<td>Abrasive Blasting</td>
<td>6</td>
</tr>
<tr>
<td>3.1.5</td>
<td>Alternate Methods of Surface Preparation</td>
<td>7</td>
</tr>
<tr>
<td>4.0</td>
<td>APPLICATION</td>
<td>8</td>
</tr>
<tr>
<td>4.1</td>
<td>General</td>
<td>8</td>
</tr>
<tr>
<td>4.1.1</td>
<td>General Requirements for Shop Application</td>
<td>8</td>
</tr>
<tr>
<td>4.1.2</td>
<td>General Requirements for Site Application</td>
<td>9</td>
</tr>
<tr>
<td>4.1.3</td>
<td>Qualifications and Materials</td>
<td>9</td>
</tr>
<tr>
<td>4.1.4</td>
<td>Handling and Transport</td>
<td>9</td>
</tr>
<tr>
<td>4.2</td>
<td>Application of Coatings</td>
<td>10</td>
</tr>
<tr>
<td>4.2.1</td>
<td>General</td>
<td>10</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Atmospheric Conditions</td>
<td>10</td>
</tr>
<tr>
<td>4.2.3</td>
<td>Conventional or Airless Spray</td>
<td>11</td>
</tr>
<tr>
<td>4.2.4</td>
<td>Brush Application</td>
<td>11</td>
</tr>
<tr>
<td>4.2.5</td>
<td>Roller Application</td>
<td>11</td>
</tr>
<tr>
<td>4.2.6</td>
<td>Thickness of Coatings</td>
<td>11</td>
</tr>
<tr>
<td>4.2.7</td>
<td>Multiple Coat Applications (Except Wet-on-Wet)</td>
<td>11</td>
</tr>
<tr>
<td>Section Number</td>
<td>Description</td>
<td>Sheet Number</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>4.2.8</td>
<td>Protective Coating for Fasteners</td>
<td>12</td>
</tr>
<tr>
<td>4.3</td>
<td>Hot Dip Galvanising</td>
<td>12</td>
</tr>
<tr>
<td>4.4</td>
<td>Damaged or Inaccessible Surfaces</td>
<td>13</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Damaged Paint Surface</td>
<td>13</td>
</tr>
<tr>
<td>4.4.2</td>
<td>Damaged Galvanised Surfaces</td>
<td>13</td>
</tr>
<tr>
<td>4.4.3</td>
<td>Inaccessible Surfaces</td>
<td>13</td>
</tr>
<tr>
<td>4.5</td>
<td>Surfaces Not to be Coated</td>
<td>14</td>
</tr>
<tr>
<td>4.6</td>
<td>Wash-up</td>
<td>14</td>
</tr>
<tr>
<td>4.7</td>
<td>Touch-up Painting</td>
<td>14</td>
</tr>
<tr>
<td>4.8</td>
<td>Paint Storage</td>
<td>14</td>
</tr>
<tr>
<td>5.0</td>
<td>COATING SYSTEM SELECTION</td>
<td>15</td>
</tr>
<tr>
<td>6.0</td>
<td>MACHINERY, ELECTRICAL AND INSTUMENT EQUIPMENT</td>
<td>21</td>
</tr>
<tr>
<td>6.1</td>
<td>Machinery</td>
<td>21</td>
</tr>
<tr>
<td>6.2</td>
<td>Electrical And Instrument Equipment</td>
<td>21</td>
</tr>
<tr>
<td>7.0</td>
<td>COLOURS</td>
<td>21</td>
</tr>
<tr>
<td>8.0</td>
<td>PARTICULAR DESCRIPTION</td>
<td>23</td>
</tr>
<tr>
<td>9.0</td>
<td>INSPECTION &amp; TESTING</td>
<td>24</td>
</tr>
<tr>
<td>10.0</td>
<td>ADHESION TEST RESULTS</td>
<td>25</td>
</tr>
<tr>
<td>11.0</td>
<td>SUBMISSION OF DATA</td>
<td>25</td>
</tr>
<tr>
<td>12.0</td>
<td>LETTER AND NUMBER INSCRIPTION</td>
<td>25</td>
</tr>
<tr>
<td>13.0</td>
<td>COLOUR BAND FOR PIPING</td>
<td>26</td>
</tr>
<tr>
<td>14.0</td>
<td>LIST OF MANUFACTURER</td>
<td>26</td>
</tr>
</tbody>
</table>

ATTACHMENTS

ANNEXURE- I  Brand Names of approved Paints

ANNEXURE- II  Technical data Sheet of approved Paint Manufacturer
1.0 GENERAL

1.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of mechanical equipment, structural steelwork, plate work, tankage, guards, pipe work, handrails and associated metal surfaces, which will be exposed to atmospheric for industrial plants.

1.2 Definitions

C.S  -  Carbon steel and low chrome (1-1/4 Cr through 9 Cr) alloys
S.S  -  Stainless steel, such as 304,316, 321, 347,
Non-ferrous -  Copper, aluminium, and their alloys.
High Alloy  -  Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
DFT  -  Dry Film thickness, the thickness of the dried or curved paint or coating film.

1.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

1.4 Material Safety Data Sheets

The latest issue of the coating manufacturer’s product datasheet, application instructions, and Material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

1.5 Materials

All paints and paint materials shall be obtained from the company’s approved manufacturer’s list. All materials shall be supplied in the manufacturer’s containers, durably and legibly marked as follows.

- Specification number
- Colour reference number
- Method of application
- Batch number
- Date of Manufacture
- Shelf life expiry date
- Manufacturer’s name or recognised trade mark.
2.0 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

2.1 Indian Standards:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS-5: 1994</td>
<td>Colors for ready mixed paints and enamels.</td>
</tr>
<tr>
<td>IS-2379: 1990</td>
<td>Color codes for identification of pipe lines.</td>
</tr>
<tr>
<td>IS-2629: 1985</td>
<td>Recommended practice for hot-dip galvanizing on iron and steel.</td>
</tr>
<tr>
<td>IS-8629: 1977</td>
<td>Code of practice for protection of iron and steel structures from</td>
</tr>
<tr>
<td></td>
<td>atmospheric corrosion.</td>
</tr>
<tr>
<td>IS:110</td>
<td>Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for</td>
</tr>
<tr>
<td></td>
<td>Over Primers</td>
</tr>
<tr>
<td>IS:101</td>
<td>Methods of test for ready mixed paints &amp; enamels.</td>
</tr>
</tbody>
</table>

2.2 Other Standards:

2.2.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988 (Surface preparations standards for Painting Steel Surface). This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

2.2.1 DIN: 53151 Standards for Adhesion test.

2.3 The paint manufacturer’s, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

a) Instructions for storage to avoid exposure as well as extremes of temperature.

b) Surface preparation prior to painting.

c) Mixing and thinning.

d) Application of paints and the recommended limit on time intervals between coats.

3.0 SURFACE PREPARATION

3.1 Metal Surface Preparation

3.1.1 Safety
All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

### 3.1.2 Pre-cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating.

### 3.1.3 Surface Decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired.

Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces.

Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer’s recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m² of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

- Sodium chloride, less than 50 microgram / cm²;
- Soluble iron salts, less than 7 microgram / cm²; and
- pH between 6 – 8

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

### 3.1.4 Abrasive Blasting

All C.S. materials shall be abrasive blast cleaned in accordance with Codes (Ref. Clause 2.0). To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination). When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1 ) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.
Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3°C above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed.

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/Cm² using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

### 3.1.5 Alternate Methods of Surface Preparation

When open air blasting is not permitted on site, or when space limitations or surface configurations preclude blasting, the alternate cleaning methods listed below may be used with prior approval. Alternate cleaning methods shall consider the degree of surface cleanliness and roughness profile required by the specified coating system.

- Vacuum or suction head abrasive blast-cleaning,
- Wet jet abrasive blast-cleaning,
- Compressed-air wet abrasive blast cleaning,
- Pressurized liquid blast-cleaning,
- Power tool cleaning,
- Hand or power tool cleaning,
Hand and/or power tool cleaning shall only be used for spot repair where abrasive blasting is not permitted or is impractical, and on items which could be damaged by abrasive blasting. Power tool cleaning shall not be carried out with tools which polish the surface, e.g. power wire brushes.

The surfaces of equipments and prefabricated piping etc. which are received at site Primerised or with finish paints, depending upon their conditions, shall be touched up and painted at site. For these surfaces sand blasting is not envisaged and these surfaces shall be prepared using power brushes, buffing or scraping, so as to achieve a surface finish to St-3 as per SIS-05-5900. After wash-up the area to be touched up shall be jointly marked, measured and recorded for payment purposes. The type of system & nos. of coat (primer and/or finish paint) to be applied after touch up, which shall be decided by OWNER/CONSULTANT in writing before taking up the job.

When paint is to be applied on damaged painted surfaces of equipments all loose and flaking paint work should be removed to a firm feathered edge. Rusted spots should be cleaned by one of the methods specified in the clauses 4.4.1 & 4.4.2 above. In case the previous paint work is not compatible to the specified one the entire coating must be removed.

It shall be ensured that sand blasted surface/machine cleaned surface is not contaminated with oil and grease. Water shall also not be allowed to come in contact with sand blasted surface.

4.0 APPLICATION

4.1 General

The final specification of paint systems to be used to suit the exposure conditions of equipment and steelwork, shall be as specified on the scope of work, equipment data sheets or the drawings.

All coatings shall be in accordance with Indian / International Standards, the coating manufacturer’s product data sheets and application instructions and the requirements contained in this specification.

4.1.1 General Requirements for Shop Application

All structural steelwork shall be surface prepared for painting and have the paint system applied before installation.

In all cases, where surfaces will be inaccessible after shop assembly, they shall be prepared and have the paint system applied before assembly is carried out. Drying times between successive coats shall be at least those recommended by the manufacturer.

All known field weld areas shall be given the specified abrasive blast surface preparation but left uncoated for a distance of 50mm from the weld line. Such areas shall be given the appropriate touch-up treatment after installation.

The manufacturer’s directions for preparation and application of coatings shall be followed to ensure that the durability of the coating system is not impaired.

The Contractor shall submit the full details of the proposed surface preparation and paint systems prior to the commencement of any surface preparation.
4.1.2 General Requirements for Site Application

Paint shall be stored only in accordance with the manufacturer's instructions.

All materials used for the specific system being applied shall be products supplied by one manufacturer and details of such product shall be submitted for approval before commencement of work.

The contents of cans shall be thoroughly stirred before being poured into paint pots and shall be thinned only in the specified proportions in accordance with the manufacturer's instructions.

Finish coats may be applied by spraying except where any over spray is likely to affect finished surfaces or where spraying constitutes a health hazard to workmen in the other areas. Brush and roller application will require multiple coats to achieve the specified dry film thickness.

Brush application may be used only with the approval of the company.

Roller application shall only be used on relatively large surface areas (i.e. > 50m²) and only if spraying is not an option.

The Contractor shall complete the application of any one type of paint or each coat thereof, before beginning the next coat on that section.

In cases nominated as critical, the application of each coat shall be approved before application of the next coat can proceed, in accordance with 'hold' points nominated in the Inspection and Test Plans (ITPs)

All fittings within any given area are to be painted with the same system as the area unless otherwise specified.

Where 2 coat of finish paint are indicated they shall be applied in two different shades to ensure that two coat are applied.

Paint shall not be applied in rain, snow, fog or mist or when the relative humidity is such as to cause condensation on metal surface.

The CONTRACTOR must ensure the availability of a specialist from the paint manufacturer, at SITE during pendency of CONTRACT within his quoted rates to ensure the quality of painting & procedure. Addition of drying agents, pigments or other substances is not allowed unless specifically prescribed or approved by paint manufacturer's specialist.

Name plates/tags attached to the equipments/machineries shall not be painted or removed during painting job. Failing to comply with above, the CONTRACTOR may be required to replace name plates/tags at his cost.

4.1.3 Qualifications and Materials

All surface preparation, coatings application and inspection, shall be carried out by personnel experienced in that particular field. Contractors shall submit the names of subcontractors to be employed for the specific work together with the brand names of coating materials for approval prior to commencement of application.
4.1.4 Handling and Transport

All pipe work, steelwork and equipment that have been finish coated shall be handled with care to preserve the coating in the best practical condition.

Painted materials shall not be handled until the coating has completely cured and dried hard. Supports in contact with coated steel during transport and storage shall be covered with a soft material to prevent damage to the coating. Appropriate materials shall be used during transportation between coated steelwork and holding down chains to prevent damage to the coating.

4.2 Application of Coatings

4.2.1 General

The application method and type of equipment to be used shall be suitable for the paint specified and the surface being painted.

Paints and thinners shall be brought to the point of usage in unopened original containers bearing the manufacturer's brand name and colour designation and ready-mixed unless otherwise specified. Two-pack systems shall be mixed at the site of application to the paint manufacturer's recommendations. The mixed amount prepared shall be no more than the amount that can be applied during the stated pot life.

Paint shall be applied so that an even film of uniform thickness, tint and consistency covers the entire surface and is free of pin holes, runs, sags or excessive brush marks. Film finish shall be equal to that of first class brushwork. Unless it is practical to do so colour shades for primer, intermediate coat and finish coat must be different to identify each coat without any ambiguity.

Paint ingredients shall be kept properly mixed during paint application.

Equipment shall be kept clean to ensure dirt, dried paint and other foreign materials are not deposited in the paint film. Any cleaning solvents left in the equipment shall be completely removed before painting.

To ensure the required film thickness is achieved on angles, welds, sharp external edges, nuts and bolts, a coat shall be applied to such items/locations immediately prior to the application of each coating to the whole area.

Care shall be taken to ensure paint application into all joints and crevices.

The contact surfaces between steelwork to be fastened by means of friction grip bolting shall be abrasive blast cleaned and prime coated only, prior to erection.

4.2.2 Atmospheric conditions

Surface preparation and coating shall not be carried out in inclement weather and shall be carried out such that the surface being coated is free of moisture, wind-borne or blast cleaning dust.

Coatings shall not be applied if:
- The relative humidity exceeds 85%.
- The ambient temperature is less than 5°C (depending on local condition).
- The metal temperature is less than 3°C above the dew point.
- There is likely hood of an unfavourable change in weather conditions within two hours after painting.

As a general rule, sufficient ventilation, dehumidification and heating capacity to cope with local climatic conditions must be secured before any coating-related work is started.

In any case, humidity, ambient and surface temperature conditions at the time of paint application, and curing and drying time before application of the next coat, shall be in accordance with the paint manufacturer’s recommendations. These conditions shall be recorded in the Inspection Test Record (ITR) by the Contractor and be available for review.

4.2.3 Conventional or Airless Spray

Spray equipment shall be equipped with accurate pressure regulators and gauges. Spray gun nozzles and needles shall be those recommended by the paint manufacturer.

Air from the spray gun shall be clean and dry with no traces of oil or moisture.

Coatings shall be wet on contacting the painted surface. Areas of dry spray shall be removed and the correct system re-applied.

4.2.4 Brush Application

The method of "laying-off" shall be suited to the paint specified and shall ensure minimum brush marking.

4.2.5 Roller Application

A uniform method of application shall be adopted when painting large areas. The rolling direction shall minimise paint joint build up. Edges and areas subject to possible roller damage shall be brush-painted prior to rolling.

4.2.6 Thickness of Coatings

The maximum thickness DFT in any one application shall not exceed that specified in Technical specifications/recommended by the paint manufacturer.

Wet film thickness gauges shall be used to make frequent checks on the applied wet film. The Contractor shall maintain at the site of painting operations, a dry film thickness tester of an approved type with a valid current calibration.

Coating thickness checks in accordance with reference code shall be performed, and the Contractor shall undertake remedial action if the measured thickness is less than specified.

Build up of each material to required thickness shall be made prior to the application of the subsequent coat; final film build shall be the minimum specified.

4.2.7 Multiple Coat Applications (Except Wet-On-Wet)

Before successive paint coats are applied, intermediate coats shall be inspected for surface contamination. The presence of any grease or oil, shall be removed by a suitable solvent, and any salt and dirt adhering to the surface shall be removed by scrubbing with a solution of non-
toxic detergent (except those prescribed by the manufacturer as "wet-on-wet"). Removal of contaminants shall only be performed after an intermediate coat has had sufficient time to cure.

The surface shall then be pressure hosed or dusted down by brush to disturb and remove deposits not apparent on visual inspection.

Coatings shall be applied only under the following conditions:
- The surface has been cleaned and is dry;
- The manufacturer's stated minimum time for re-coat has elapsed;
- The manufacturer's stated maximum time for re-coat has not elapsed. If the maximum time has elapsed then pre-treatment shall be in accordance with the paint manufacturer's recommendations; and
  Damaged areas in preceding coat have been made good in accordance with this Specification.

When multiple coat of finish paint are indicated, they shall be applied in different shades to ensure that multiple coats have been applied.

4.2.8 Protective Coatings for Fasteners

Black and galvanised erection bolts and galvanised holding down bolts shall be prepared and painted in accordance with Section 4.4 of this Specification.

Black high tensile bolts shall be painted after erection to the same paint system specification as the surrounding structural steel.

4.3 Hot Dip Galvanising

All galvanising shall be carried out by the hot dipping process and conform to the requirements of IS-2629:1985 and uniformity of coating shall confirm to IS 2633:1986.

All welding slag shall be removed by chipping, wire brushing, flame cleaning or abrasive blast cleaning where necessary.

For temporary identification, either water-soluble marking paints or detachable metal labels shall be used. For permanent identification, figures shall be heavily punched or embossed by the fabricator.

For galvanised items after pickling, the work shall be inspected and any defects that render the work unsuitable for galvanising shall be repaired. After such repairs, the work shall again be cleaned by pickling.

The coating mass of zinc shall be as specified on equipment data sheets and the Drawings. Galvanised coatings shall be tested by the methods described in referred code.

After galvanising all material shall be cooled to air temperature in such a manner that no embrittlement occurs.

Galvanised coatings shall be smooth, uniform, adherent and free from stains, surface imperfections and inclusions.
All gratings and fixtures including nuts, bolts and washers that are required to be galvanised, shall be hot dipped galvanised and all nut threads shall be re-tapped after galvanising and a lubricant applied on Cold working of galvanised steelwork shall be avoided.

4.4 Damaged or Inaccessible Surfaces

4.4.1 Damaged Paint Surface

Repair of damaged painted surfaces, as well as painting of galvanised and black bolts, and galvanised holding down bolts after erection shall comply with this Clause. The treatment shall be:

- Pre-clean the damaged or unpainted areas in accordance with Section 4.2.1 of this Specification;
- Disc or hand sand to clean bright metal;
- Inorganic zinc primers subject to mechanical damage or weld etc shall be power tool cleaned
- Feather backs by sandpapering or whip blasting the original coatings surrounding the damaged area over a 50mm distance. A rough surface shall be obtained on epoxy coatings;
- Clean surface to remove all dust;
- Conduct surface contaminant test in accordance with Section 4.2.2 of this document; and

Build up a new paint system over the affected area with paints equal to those originally used and having the same dry film thickness for each coat. As an exception, damaged inorganic zinc primers shall be repaired with epoxy organic zinc rich paint and shall be applied within four hours of blast cleaning.

The new coatings shall overlap the original coating over the 50mm prepared distance and shall be colour matched to the specified colour of the original coating.

4.4.2 Damaged Galvanised Surfaces

Damaged areas caused by oxy-cutting, welding or physical impact shall be treated as follows:

- Prepare the surface by removing any weld slag followed by vigorous power wire brushing of the coating surrounding the damaged area over a 50mm distance;
- Clean surface to remove all dust; and
- Apply two coats of organic zinc-rich primer to a minimum DFT of 100 microns.

The area to be reinstated shall be colour matched to the surrounding finish colour with 40 microns of aluminium paint to the manufacturer's written instructions.

4.4.3 Inaccessible Surfaces

Surfaces that will be inaccessible after erection of other elements of the structure, shall be fully painted prior to the installation of the obstructing item.

4.5 Surfaces Not To Be Coated

The following surfaces shall not be blasted or coated unless specifically directed:
Machined surfaces, bearings, seals, grease fittings, adjusting screws and name plates, and identification tags.

- Valve stems;
- Raised faces on pipe and equipment flanges;
- Electrical cabling;
- Instrumentation, gauges and sight glasses;
- Titanium, stainless steel and non-metallic surfaces; and

Field weld margins, 50mm either side of weld, on tankage and piping, prior to welding.

The rear face of piping flanges shall be shop prime coated only. Flange holes for fasteners shall be fully coated.

4.6 Wash-Up

All surface of equipments/prefabricated piping etc. Primerised / painted at Vendor shop and received at site if required shall be washed up as follow:

a) Washing with clean water (Pressure 7 Kg/cm²) using suitable nozzles. During washing, broomcorn brushes shall be used to remove foreign matter.

b) Solvent washing, if required, to remove traces of wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates of oil, grease etc. Wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates.

4.7 Touch-Up Painting

Prior to the application of any coat, all damage to the previous coat(s) shall be touched-up. Damage to finished work shall be thoroughly cleaned and re-coated.

Surface preparation shall be done as per clause no. 3.0.........................

Items supplied with the manufacturer’s standard coating system shall be touched-up with the same generic coating system or recoated.

4.8 Paint Storage

The following must be ensured:

a) All paints and painting material shall be stored only in such rooms assigned for the purpose. All necessary precaution shall be taken to prevent fire. The Storage building shall preferably be separate from adjacent buildings. A sign-board bearing the Words "PAINT STORAGE- NO NAKED LIGHT" shall be clearly displayed outside. The building shall be properly ventilated and shall be adequately protected with fire fighting equipment.

b) Storage shall be far away from heated surface open flames, sparks & well protected from sun rays.

c) Ambient temperature at which paints are stored shall be intimated to paint manufacturer & their advice sought regarding precautions to be taken if any,
regarding flammability, explosiveness & toxicity.

d) Maximum allowed storage time for various paint materials shall be clearly indicated on individual containers. Materials which have passed expiry date shall not be used.

e) Paints in non-original containers and/or in containers without seals, shall not be used.

### 5.0 COATING SYSTEM SELECTION

**Coating Systems for Structures Piping and Equipment**

The following Table 1 shall be used as a general guide for the selection of a paint system suitable for a particular plant area application. Paint systems specified on equipment data sheets and the Drawings shall take precedence over the general paint system area applications listed in Table 1

**TABLE - 1**

<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Application</th>
<th>Surface Preparation</th>
<th>Generic Coating System</th>
<th>Minimum DFT</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Structural Steel work with operating temp. Up to 90°C (Steel structures, Piping support, uninsulated CS piping, flanges, valves, stairways, walkways etc. except grating).</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no.4.70</td>
<td>Primer: Two coats of two pack zinc rich epoxy polyamide cured Primer. Finish coat: Three coats of two packs. Polyamide Cured Epoxy.</td>
<td>Primer: 35 microns For each coat (Total-70microns). Finish: 40 microns for each coat (Total-120 microns).</td>
<td>Total dry film thickness of paint system: 190 microns.</td>
</tr>
<tr>
<td>02</td>
<td>Uninsulated CS piping, flanges, valves with operating temp. From 90°C to 200°C.</td>
<td>Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.</td>
<td>Primer: 75 microns Finish: 25 microns for each coat Total - 50 microns.</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>03</td>
<td>Uninsulated CS piping, flanges, valves with operating temp. Over 200°C.</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no.4.70.</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of Heat Resisting Silicon Aluminium Paint.</td>
<td>Primer: 75 microns Finish: 20 microns for each coat Total - 40 microns.</td>
<td>Total dry film thickness of paint system: 115 microns.</td>
</tr>
</tbody>
</table>

**NOTE**: Only for valves where it will be impossible to blast cleaning, four to five coats of Heat Resisting, ready mixed Aluminium Paint will be applied on surface without inorganic zinc primer and surface preparation to grade Sa-2 ½ of Swedish Standard SIS-05-5900 (Latest).
<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Application</th>
<th>Surface Preparation</th>
<th>Generic Coating System</th>
<th>Minimum DFT</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>Insulated CS piping, flanges, valves with operating temp up to $90^\circ$ C</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>Primer: One coat of high temperature phenolic epoxy Finish Coat : One coat of high temperature phenolic epoxy</td>
<td>Primer :100 microns Finish : 100 micron</td>
<td>Total dry film thickness of paint system: 200 microns.</td>
</tr>
<tr>
<td>05</td>
<td>Insulated CS piping, flanges, valves with operating temp. From $90^\circ$ C to $200^\circ$ C.</td>
<td>Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>Primer: One coat of high temperature phenolic epoxy Finish coat : One coat of high temperature phenolic epoxy</td>
<td>Primer: 100 microns Finish: 100 micron</td>
<td>Total dry film thickness of paint system:200 microns</td>
</tr>
</tbody>
</table>

**NOTE**: Only for valves where it will be impossible to blast cleaning, four to five coats of Heat Resisting Silicon Aluminium Paint will be applied on surface without inorganic zinc primer and surface preparation to grade Sa-2 ½ of Swedish Standard SIS-05-5900 (Latest).

| 06      | Insulated CS piping, flanges, valves with operating temp. Over $200^\circ$ C. | Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no.4.70. | Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: One coat of Heat resisting Silicon Aluminium paint. | Primer: 75 microns Finish: 25 micron | Total dry film thickness of paint system:100 microns. |

**NOTE**: Only for valves where it will be impossible to blast cleaning, four to five coats of Heat Resisting ready mixed Aluminium Paint will be applied on surface without inorganic zinc primer and surface preparation to grade Sa-2 ½ of Swedish Standard SIS-05-5900 (Latest).

| 07      | Uninsulated CS equipment with operating temp. Up to $90^\circ$ C, to be treated at Manufacturer’s shop. | Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no.4.70. | Primer: Two coats of two pack zinc rich epoxy polyamide cured Primer. Finish coat : Three coats of two pack Polyamide Cured Epoxy | Primer: 35 micron for each coat. Total – 70 microns. Finish: N.A Finish: 40 microns for each coat Total - 120 microns. | Total dry film thickness of paint system: 190 microns. |

<p>| 08      | Uninsulated CS equipment with operating temp. From $91^\circ$ C to $200^\circ$C, to be treated | Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05- | Primer: One coat of Ethyl Silicate zinc rich with solvent. | Primer: 75 microns Finish: | Total dry film thickness of paint system: 125 microns. |</p>
<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Application</th>
<th>Surface Preparation</th>
<th>Generic Coating System</th>
<th>Minimum DFT</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>09</td>
<td>Uninsulated CS equipment with operating temp. Over 200°C, to be treated at Manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of Heat Resisting Silicon Aluminium Paint.</td>
<td>25 microns for each coat Total - 50 microns.</td>
<td>Total dry film thickness of paint system: 115 microns.</td>
</tr>
<tr>
<td>10</td>
<td>Insulated CS equipment with operating temp. Up to 90°C, to be treated at Manufacturer’s shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy</td>
<td>Primer: 100 micron Finish: 100 micron</td>
<td>Total dry film thickness of paint system: 200 microns.</td>
</tr>
<tr>
<td>11</td>
<td>Insulated CS equipment with operating temp. From 91°C to 200°C, to be treated at Manufacturer’s shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy</td>
<td>Primer: 100 micron Finish: 100 micron</td>
<td>Total dry film thickness of paint system: 200 microns.</td>
</tr>
<tr>
<td>12</td>
<td>Insulated CS equipment with operating temp. Over 200°C, to be treated at Manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: One coat of Heat resisting Silicon Aluminium paint.</td>
<td>Primer: 75 microns Finish: 25 microns</td>
<td>Total dry film thickness of paint system: 100 microns.</td>
</tr>
<tr>
<td>13</td>
<td>Stainless steel pipe flanges, valves, equipments with operating temp. Up to 200°C</td>
<td>Lightly Blast cleaned as per grade Sa-1.0, of Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy</td>
<td>Primer: 100 microns Finish: 100 microns</td>
<td>Total dry film thickness of paint system: 200 microns.</td>
</tr>
<tr>
<td>14</td>
<td>Surface of structural steel for furnaces, external</td>
<td>Blast cleaning to near white metal grade 2</td>
<td>Primer: One coat of Ethyl Silicate</td>
<td>Primer: 75 microns</td>
<td>Total dry film thickness of paint system: 200 microns.</td>
</tr>
<tr>
<td>Ref No.</td>
<td>Application</td>
<td>Surface Preparation</td>
<td>Generic Coating System</td>
<td>Minimum DFT</td>
<td>Remarks</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>---------------------</td>
<td>------------------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>15</td>
<td>For external surfaces of flue ducts, metal stacks, and similar with operating temp. Above 200°C.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of Heat Resisting Silicone Aluminium Paint.</td>
<td>Primer: 75 microns for each coat. Finish: 40 microns for each coat Total - 120 microns.</td>
<td>Total dry film thickness of paint system: 190 microns.</td>
</tr>
<tr>
<td>16</td>
<td>For surfaces of air cooler heads not galvanized with operating temperature up to 90°C, treated at manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: Two coats of two pack zinc rich epoxy polyamide cured Primer. Finish coat: Three coats of two pack. Polyamide Cured Epoxy.</td>
<td>Primer: 35 micron for each coat. Finish: 40 microns for each coat Total - 120 microns.</td>
<td>Total dry film thickness of paint system: 190 microns.</td>
</tr>
<tr>
<td>17</td>
<td>For surfaces of air cooler heads not galvanized with operating temperature up to 91°C TO 200°C, treated at manufacturer’s shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.</td>
<td>Primer: 75 microns for each coat. Finish: 25 microns for each coat Total - 50 microns.</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
</tbody>
</table>

**NOTE:** All surfaces shall be galvanized at manufacturer’s shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer’s shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.

**STORAGE TANKS**

<p>| a) Acid / Alkali CS Storage Tank (External Surface) | Blast cleaning to near white metal grade 2 | Primer: Two coats of two pack zinc | Primer: 35 micron for each coat | Total dry film thickness of paint system: 125 microns. |</p>
<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Application</th>
<th>Surface Preparation</th>
<th>Generic Coating System</th>
<th>Minimum DFT</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>including all stair ways)</td>
<td>½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.</td>
<td>rich epoxy polyamide cured Primer. Finish coat: Three coats of two packs. Polyamide Cured Epoxy.</td>
<td>coat. Total – 70 microns. Finish: 40 microns for each coat Total - 120 microns.</td>
<td>paint system: 190 microns.</td>
</tr>
<tr>
<td>b)</td>
<td>CS Storage Tanks, Excluding indicated in Sl. No. (a)</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of epoxy amine cured tank liner.</td>
<td>Primer: 75 microns Finish: 30 microns for each coat Total - 60 microns.</td>
<td>Total dry film thickness of paint system: 135 microns.</td>
</tr>
<tr>
<td>19</td>
<td>Cold Insulated Carbon Steel and low alloy Steel (1-1/4 Cr through 9 Cr) Piping and Equipment.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: One coat of Epoxy Coal Tar paint with solvent.</td>
<td>Primer: 75 microns Finish: 40 microns</td>
<td>Total dry film thickness of paint system: 115 microns.</td>
</tr>
<tr>
<td>20</td>
<td>Cold Insulated high alloy Steel piping and Equipment</td>
<td>Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy</td>
<td>Primer: 100 microns Finish: 100 microns</td>
<td>Total dry film thickness of paint system: 200 microns</td>
</tr>
<tr>
<td>21</td>
<td>Cold insulated Stainless Steel piping and equipments</td>
<td>Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy</td>
<td>Primer: 100 microns Finish: 100 microns for each coat</td>
<td>Total dry film thickness of paint system: 200 microns</td>
</tr>
<tr>
<td>22</td>
<td>Surface (CS) with Equipment with temp. Indicating paint from 220°C to 240°C treated at Manufacturer’s shop</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat : Two</td>
<td>Primer: 75 microns Finish: 25 microns for</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>Ref No.</td>
<td>Application</td>
<td>Surface Preparation</td>
<td>Generic Coating System</td>
<td>Minimum DFT</td>
<td>Remarks</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>---------------------</td>
<td>-------------------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>23</td>
<td>PACKAGE:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Surface (CS) with operating temperature upto 90°C treated at Manufacturer’s shop</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: Two coats of two pack zinc rich epoxy polyamide cured Primer. Finish coat: Three coats of two packs Polyamide Cured Epoxy.</td>
<td>Primer: 35 micron for each coat. Total – 70 microns. Finish: 40 microns for each coat Total - 120 microns.</td>
<td>Total dry film thickness of paint system: 190 microns.</td>
</tr>
<tr>
<td>b)</td>
<td>Surfaces (CS) with operating temperature upto 91°C TO 200°C, treated at manufacturer’s shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.</td>
<td>Primer: 75 microns Finish: 25 microns for each coat Total - 50 microns.</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>c)</td>
<td>Surface (CS) with operating temp. Over 200°C, treated at manufacturer’s shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of Heat Resisting Silicone Aluminium Paint.</td>
<td>Primer: 75 microns Finish: 20 microns for each coat Total - 40 microns.</td>
<td>Total dry film thickness of paint system: 115 microns.</td>
</tr>
<tr>
<td>d)</td>
<td>Package in Carbon Steel and low Alloy Steel (1-1/2 Cr through 9 Cr) with cold insulated surface treated at manufacturer’s shop</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: One coat of Epoxy Coal Tar paint with solvent.</td>
<td>Primer: 75 microns Finish: 40 microns</td>
<td>Total dry film thickness of paint system: 115 microns.</td>
</tr>
<tr>
<td>e)</td>
<td>Package in Cold Insulated high alloy Steel.</td>
<td>Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy</td>
<td>Primer: 100 microns Finish: 100 microns</td>
<td>Total dry film thickness of paint system: 200 microns</td>
</tr>
<tr>
<td>f)</td>
<td>Package in Cold insulated</td>
<td>Lightly Blast cleaned</td>
<td>Primer: One coat</td>
<td>Primer: 100</td>
<td>Total dry film</td>
</tr>
<tr>
<td>Ref No.</td>
<td>Application</td>
<td>Surface Preparation</td>
<td>Generic Coating System</td>
<td>Minimum DFT</td>
<td>Remarks</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Stainless Steel.</td>
<td>as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70</td>
<td>of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy</td>
<td>microns Finishes: 100 microns</td>
<td>thickness of paint system: 200 microns</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>For external surface of shell, roof of CS tanks, with operating temp. Upto 110°C</td>
<td>Blast cleaning to near white metal grade 2 1/2, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.</td>
<td>Primer: 75 microns Finish: 25 microns for each coat Total: 50 microns.</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>25</td>
<td>For down external surfaces(CS) below only of the fixed tanks, bottom &amp; shell shall be treated as follows:</td>
<td>Blast cleaning to near white metal grade 2 1/2, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>Primer : None Finish Coat: Two coats of Epoxy Coal Tar Solvent base.</td>
<td>200 microns for each coat Total: 400 microns.</td>
<td>Total dry film thickness of paint system: 400 microns.</td>
</tr>
<tr>
<td>26</td>
<td>CS Equipment and associated piping subject to cyclic, intermittent or regeneration operating condition (e.g. Molecular Sieve Driers) subjected to very severe corrosion with wide operating temperature range.</td>
<td>Blast cleaning to near white metal grade 3, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.</td>
<td>Primer: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal Finish Coat: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal.</td>
<td>Primer: 125 microns Finish: 125 microns</td>
<td>Total dry film thickness of paint system 250 microns.</td>
</tr>
</tbody>
</table>

### 6.0 MACHINERY, ELECTRICAL AND INSTRUMENT EQUIPMENT:

#### 6.1 Machinery

Steel surfaces shall be treated with complete paint system at Manufacturer’s shop. The paint system shall be according to Manufacturer’s Std. However, suitable for operating condition and the environmental condition where the machinery will operate. Where necessary machinery shall be restored at site by Contractor with suitable finish.
6.2 **Electrical and Instrument Equipment**

Steel surfaces shall be treated with complete paint system at Manufacturer’s shop. The paint system shall be according to Manufacturer’s Std., however suitable for operating condition and the environmental condition where the electrical and instrument equipment will operate. Where necessary Electrical and Instrument Equipment shall be restored at site by Contractor with suitable finish.

7.0 **COLOURS:**

These shall be as required by specification and in particular for:

<table>
<thead>
<tr>
<th>Description</th>
<th>Colour</th>
<th>Ra1</th>
<th>Correspond. Asian Paint colors to be defined – See Note-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping with temperature less than 90°C</td>
<td>GREY</td>
<td>7035</td>
<td></td>
</tr>
<tr>
<td>Piping, hot surface, flue gas ducts and stacks with temperature above 90°C</td>
<td>SMOOTH ALUMINIUM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling Water Piping</td>
<td>SEA GREEN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire fighting Piping</td>
<td>Red 3002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structures upto 2 MT</td>
<td>BLACK 9005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structures above 2 MT</td>
<td>GREY 7010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stair cases – ladders</td>
<td>BLACK 9005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkwais</td>
<td>GREY 7010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handrails assemblies</td>
<td>YELLOW 1004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>GREY 7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot equipment</td>
<td>SMOOTH ALUMINIUM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire fighting equipment</td>
<td>RED 3002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valves in general</td>
<td>GREY 7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot valves</td>
<td>SMOOTH ALUMINIUM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety and Fire fighting valves</td>
<td>RED 3002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valves handwheels</td>
<td>BLACK 9005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Rotary Machines</td>
<td>SKY BLUE 5012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Static Machines</td>
<td>GREY 7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery (compressors &amp; pumps) with operating temperature less than 90°C</td>
<td>GREY 7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery (compressors &amp; pumps) with operating temperature above 90°C</td>
<td>SMOOTH ALUMINIUM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FURNACES**

- Cassing and connected steel SMOOTH ALUMINIUM
### TECHNICAL SPECIFICATIONS
FOR PAINT & PROTECTIVE COATINGS

#### Description | Colour | Ra1 | Correspond. Asian Paint colors to be defined – See Note-2
--- | --- | --- | ---
works | | | |
- Steel work not connected to casing | SMOOTH | ALUMINIUM | “
**AIR COOLER**
- High Temperature Surfaces (Temp. > 90°C) | SMOOTH | ALUMINIUM | |
- Low Temperature surface (Temp. < 90°C) | GREY | 7035 | “
- Flare < 90°C | GREY | 7035 | “
- Flare > 90°C | SMOOTH | ALUMINIUM | “
**TANKS**
- Shell of fixed roof | WHITE | 9010 | “
- Roof of fixed roof tank | WHITE | 9010 | “
- T-301 | SMOOTH | ALUMINIUM | “
- T-303 | WHITE | 9010 | “

**NOTE-1:** The colours shall be according to IS2379:1990/International STD. RAL or BS, proposed by Contractor or Manufacturer

### 8.0 PARTICULAR DESCRIPTION

The abrasive to be used shall be chloride-free siliceous sand (marine sand excluded) or metal grit.

Primerized surface shall be faultless and shall not have mud-cracking, dripping over thickness and dry sprays.

Blast cleaning and painting shall not be carried out on wet surfaces. Blast cleaning shall not be done when surfaces temperatures are less than 3°C above dew point of below 5°C.

No acid washes or other cleaning solutions or solvents shall be used on metal surfaces after they have been blasted.

The surface preparation of all steel surfaces to be coated shall be free of all mill scale, rust corrosion product, oxides, paint, oil or other foreign matter

Only dry sand blasting procedures will be allowed. The compressed air supply used for blasting shall be free of detrimental amounts of water and oil. Adequate separator and traps shall be provided and these shall be kept emptied of water and oil.

All welded areas and appurtenances shall be given special attention for removal of welding flux in crevices. Welding splatter, slivers, laminations and underlying mill scale exposed during sand blasting shall be removed or repaired.

The blast-cleaned or power brushing surfaces shall be coated with primer within four hours of surface preparation.
No primer or intermediate or finishing coating shall be applied without prior notification to the Company.

The application of the products shall be carried out in strict compliance with the paint manufacturer’s recommendation.

The Contractor shall provide suitable protection for all adjacent plants or equipment from airbone during spraying and sand blasting.

9.0 INSPECTION AND TESTING

The inspection and testing requirements outlined in this section shall be performed for shop and site applied coating systems.

Preference shall be given to manufacturers and applicators that are quality certified to ISO 9001: 2000.

Documentation of coating material manufacturers and applicators shall include daily inspection reports, equipment reports, and shall clearly identify and trace materials supply and testing performed on coated items and areas.

Inspection and Test Plans (ITPs), and quality control procedures used for application of coating systems shall form part of the Method Statement and shall be submitted for approval by the Principal prior to commencement of work.

The applicator shall appoint a certified inspector of coatings for inspection and testing of coating systems.

Tests of coated areas and items shall form part of the ITPs.

- Surface Preparation in accordance to Swedish Standard SIS-05-5900 (Latest).
- Blast Cleaning profile shall be checked using a suitable profile meter – Acceptable profile shall be 25-30 microns.
- Check of time of top coating and drying in accordance with the direction of the paint manufacturer.
- Check of dry film thickness by suitable non-destructive Instrument such as “MIKROTEST”, “DIAMETER” or equivalent.
- Before any coating work is preformed on the site, the contractor shall ensure that any works applied by others is acceptable.

Any defect that are discovered, are to be notified in writing to the owner before proceeding with the contract work. To ensure the good execution of painting work following test shall be performed:

- Surface Preparation
- Surface contaminant tests
- Surface profile tests
- Coating thickness tests
- Tests for cure of coatings
- Adhesion tests
- Continuity testing
- Iron contamination
- Chloride contamination
- Dust Contamination

All Inspection and Test Records (ITRs) shall be submitted with the Manufacturer’s Data Report (MDR) at the conclusion of the job.

Defective coated areas shall be suitably marked for rectification work to be performed in compliance with this specification.

Access shall be granted for inspection of all paint work, and witnessing of test work. This shall not however relieve the Contractor of their own QA/QC responsibilities.

10.0 ADHESION TEST RESULTS

For all type of primer the Contractor shall guarantee the Classification of Adhesion Test Results as per DIN 53151. The acceptable Rate Adhesion Test Results shall be for sandblasted and primerized surfaces upto GT2.

For primer plus finishing coat(s) the Contractor shall guarantee the Classification of Adhesion Test Results as per DIN 53151. The acceptable Rate Adhesion Test Results shall be for sandblasted and painted surfaces upto GT2.

After test, the surface must be repaired according to the system applied.

11.0 SUBMISSION OF DATA

Contractor shall submit in phase of bid the original technical data sheet and system for all material supplied by him to apply for the permanent works and test report for the paint in compliance to IS101. This material shall be subject to Owner’s approval.

12.0 LETTER AND NUMBER INSCRIPTION

Inscriptions letters, as herebelow indicated, shall be made on equipments, piping, storage tanks, machinery etc.

12.1 Geometric forms and dimensions

Letters and numbers dimensions shall be orientativaly fixed according to following:

(A – Dimension of side of unitary elements of grid)

a) Storage Tanks A – 60 mm
b) Equipments and piping with O.D. above 600 mm A– 40 mm and
c) Equipments and pipings with O.D. from 300 to 600 mm and for machinery of great dimensions A – 20 mm
d) Equipments and pipings with O.D. less than 300 mm and for machinery with small dimensions A – 10 mm

12.2 Inscription’s Colours
Inscriptions shall be Black ENI 901 (RAL 9005) on light base
Inscriptions shall be White ENI 101 (RAL 9010) on dark base

12.3 **Spaces and Interspaces**

Spaces between words and assemblage of numbers shall have dimensions equal to 2A
Interspaces between letters or numbers shall have dimensions equal to A.

13.0 **Colour Band for piping** :-

As a rule minimum width of colour band shall confirm to the following Table:-

<table>
<thead>
<tr>
<th>Nominal pipe Size</th>
<th>Width L (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot; &amp; below</td>
<td>25</td>
</tr>
<tr>
<td>4&quot; NB-6&quot; NB</td>
<td>50</td>
</tr>
<tr>
<td>8&quot; NB-12&quot;NB</td>
<td>75</td>
</tr>
<tr>
<td>14&quot; OD &amp; above</td>
<td>100</td>
</tr>
</tbody>
</table>

14.0 **LIST OF MANUFACTURERS** :

1. M/s Berger Paints
2. M/s Asian Paints
3. M/s GRAUER & WEIL (I) LTD, (Unit-Bombay Paints)
## INDEX OF CONTENTS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SCOPE</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>GENERAL</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>MATERIALS</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>CLEANING</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>APPLICATION</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>INSPECTION AND TEST</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>REPAIRS TO COATING</td>
<td>5</td>
</tr>
</tbody>
</table>
1.0 SCOPE

This specification covers the requirements for application and inspection of protective coating for underground steel piping.

2.0 GENERAL

2.1 Protective coating shall consists of a coating system employing Primer, Inner Wrap and Outer Wrap.

2.2 The coating system shall be mechanically applied by an approved type of wrapping machine utilizing constant tension brakes except at tie-in welds, repair patches and at other locations where mechanical application is not practicable. Wrapping machine shall normally be used for pipe size 10\" and above. For pipe sizes below 10\" wrapping shall be done manually.

2.3 Coating and wrapping materials shall be handled, transported, stored and applied strictly in accordance with the manufacturer’s instruction.

3.0 MATERIALS

Materials for line coating and wrapping shall be of Tape coating system (Polyethylene backed tape with butyl rubber based adhesive system) as described below :-

(A) **Primer**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Rubber and Synthetic Resins</td>
</tr>
<tr>
<td>Solvent</td>
<td>Heptane</td>
</tr>
<tr>
<td>Total Solids</td>
<td>20%</td>
</tr>
<tr>
<td>Weight / Gallon</td>
<td>6.4 lbs (0.77 kg)</td>
</tr>
<tr>
<td>Viscosity</td>
<td>Thin Syrup</td>
</tr>
<tr>
<td>Flash Point</td>
<td>+ 10°F (-12°C)</td>
</tr>
<tr>
<td>Color</td>
<td>Black</td>
</tr>
<tr>
<td>Shelf Life</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

(B) **Inner Wrap**

- BACKING: Polyethylene, high/low density Colour: Black
- ADHESIVE: Butyl Rubber, Synthetic Resin

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Thickness</td>
<td>20 mils</td>
</tr>
<tr>
<td>Backing Thickness</td>
<td>12 mils</td>
</tr>
</tbody>
</table>
Adhesive Thickness     8 mils
Tensile Strength    30 ib/in width
Elongation     200%
Adhesion to Primed Steel  200 oz/in width

ELECTRICAL AND MOISTURE RESISTANCE:-
Dielectric Strength    22
Insulation Resistance    1,000,000 megohms
Water Vapor Transmission Rate   < 0.2g / 100 in²/24hr

TEMPERATURE RANGE :-
Normal Application (ambient)   -30° to 160°F (-34° to 71°C)
Normal Service (operating temperature)  -30° to 185°F (-34° to 85°C)

TEST METHODS:  (Latest Version)
1. ASTM – 1000  2.   ASTM D-257  3.   ASTM E-398

(C) Outer Wrap
BACKING:
Polyethylene, low density. Colour : White

ADHESIVE:
Butyl Rubber, Synthetic Resin

PHYSICAL PROPERTIES
Total Thickness     20 mils
Backer Thickness     15 mils
Adhesive Thickness     5 mils
Tensile Strength   25 ib/in width
Elongation     200%

TEMPERATURE RANGE :-
Normal application (ambient)   -30° to 160°F (34° to 71°C)
Normal Service (operating temperature)  -30° to 185°F (34° to 85°C)

TEST METHODS
1. ASTM D – 1000

4.0 CLEANING
4.1 The external surface of all piping shall be thoroughly cleaned before application of the protective coating by shot blasting to the specification ISO 8501-1: 1988 SA 2.5.

4.2 The cleaning process shall remove all oil, grease, loose mill scale, weld spatter, weld slug, rust, paint, dirt, dust, weeds and any other foreign matter from the pipe external surface.

4.3 Oil and grease shall be removed using suitable solvent.

4.4 Mechanical cleaning wherever applicable (field joints and tie-in joints) shall be carried out by means of portable power driven wire brushes, flexible sanding discs etc. which are capable of producing a surface finish to SA-3.

4.4 Mechanical cleaning machines shall not employ knives or other tools which may produce notches or gauges on the pipe surface and shall be fitted with a device to prevent of foreign matter on the pipe surface.

4.5 Mechanical cleaning machines shall be maintained in correct adjustment and replacement tools shall be available throughout the cleaning process.

4.6 The cleaning method employed shall not result in visible thinning of the pipe wall.

4.7 Cleaning shall be carried out immediately before application of the priming coat. If, before the priming coat is applied, the outside of the pipe becomes contaminated with any foreign matter, the outside surface shall be re-cleaned.

5.0 APPLICATION

5.1 Prime Coat

a) After Surface Preparation as detailed above, apply one coat of Zink Rich Epoxy primer (50-75micron) allow it to dry.

b) Apply Polyken primer #1027 (in shop) / primer # 1029 (at site) WFT 60 micron.

c) Primer shall be thoroughly stirred before drawing from the drum. The approved thinners may only be added to the primer an proper mixing and blending of thinner when primer thinner is essential

d) Primer shall be applied to the piping system by means of rollers or brushes. The priming coat shall be continuous and free form holidays, runs and globules, and special care shall be taken to ensure continuity of primer film at welds.

e) Primer shall be applied at an average rate of 0.12 litre per square meter to give dry film thickness of between 0.05 and 0.08mm.

f) Primed pipe shall be protected from contamination by moisture, dust and foreign matters before application of the tape wraps.

5.2 Tape Wrapping

a) Immediately after application of the primer, the piping shall be coated with Inner Tape Wrap and Outer Tape Wrap. Before applying inner tape wrap, it shall be ensured that the Polyken primer is wet condition. The tape wraps shall be applied with constant tension controlled to provide a uniform, tightly adhering coating free of wrinkles, packers, voids or breaks. Minimum tension shall be 0.1 kg per mm of tape width.

b) The tape wrapping shall be provided with the following minimum overlap under conditions stated:
CONDITION MIN. OVERLAP
(i) Tape is applied on the line with a mechanical wrap – around machine with constant tension brakes in normal soil conditions.
(ii) Tape is applied on irregular sections of the line with hand wrap machines.
(iii) Same as (i) above except pipe is laid in swampy areas where water is standing in the ditch (no concrete coating)
(iv) Pipe is laid in swampy areas but is Weight coated:
   20 mils Inner Wrap 1 inch
   40 mil Outer Wrap 1 inch
   Applied as in (i) above.

5.3 Polyken wrapped pipes shall not be exposed to direct sun light over a long time. It shall be ensured that Polyken coated pipe spools are covered to ward off damage due to exposure to sun light.

5.4 The details of Polyken tapes to be used as given below.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Tape Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>3” and below</td>
<td>2”</td>
</tr>
<tr>
<td>4” to 6”</td>
<td>4”</td>
</tr>
<tr>
<td>Above 6”</td>
<td>6”</td>
</tr>
</tbody>
</table>

6.0 INSPECTION AND TEST

6.1 All coating shall be subjected to 100% visual inspection and 100% inspection with an electrical holiday detector (6000 – 8000 volts) before being lowered into the trench or before back filling the existing UG pipe line.

6.2 Visual inspection shall ensure that the coating is continuous that the overlap is correctly maintained and that there are no wrinkles in the tape.

6.3 The Holiday Detector shall be used to check that there is a continuous coating over the pipe surface. Particular attention shall be given to bends and to areas where the tape has been spliced or repaired.

6.4 The holiday detector setting shall be checked at least twice per day while it is in use.

6.5 The Holiday Detector shall be operated strictly in accordance with the manufacturer’s instruction at all times.

6.6 At no time shall the Holiday Detector be permitted to remain stationary around a coated pipeline with the operating voltage switched on.

6.7 All defects, whether discovered visually or by means of the Holiday Detector, shall be clearly marked.
6.8 After acceptance of holiday test, the coated pipes shall be transported to site. Proper care shall be taken during handling /transportation. The coated pipes always be kept on sand bags during transportation.

6.9 Holiday test shall be conducted again at site and after acceptance the coated pipes shall be lifted / lowered in to the trench using nylon belts.

7.0 REPAIRS TO COATING

7.1 All defects in the coating shall be made good immediately after their detection.

7.2 Holidays (Pin holes / minor defect)
After cleaning the affected area Inner tape wrap and Outer tape wrap shall be carried out over the affected area on the existing wrapping by ensuring that wrapping covers the extended surface area around the defect (Min 150mm). Use Holiday detector for locating pinholes / other defects before erection of pipe in trench / back filling of existing pipe line.

7.3 Holidays or localized defects in the Inner Tape Wrap shall be repaired by the following procedures :
(a) Strip off Outer Wrap from affected area after ensuring that completed coating on either side is properly secured.
(b) Strip off Inner Wrap and primer from the affected area and thoroughly clean the pipe surface.
(c) Re-prime in accordance with this specification.
(d) Apply patch of Inner Wrap not smaller than 150mm s 150mm.
(e) Test for repaired Inner Wrap with Holiday Detector before replacing OuterWrap.
(f) Replace Outer Wrap and secure firmly.
(g) Conduct holiday test before erection of the pipe in trench / back filling of existing pipe.

7.4 For field joints (tie-in joints) application of Zinc Rich Epoxy primer may not be required. Polyken pipe line primer #1029 shall be applied after surface preparation by using power brush. Inner & Outer tape wrap to be subsequently applied ensuring overlapping as mentioned earlier. Conduct holiday testing for locating any defect.

7.5 For tie-in joints / flanges / valves or where the existing Denso Anti Corrosion tape is to be repaired / joining with the new Polyken tape, Mastic filler 939 (Butyl Rubber based) shall be used as a filler material and Polyken Inner / outer tape wrap shall be applied over the wet mastic. Conduct Holiday testing for locating any defect.
TECHNICAL SCOPE
FOR
SUPPLY OF
RUBBER EXPANSION BELLOWS

NATIONAL FERTILIZERS LTD.
VIJAIPUR
1.0 GENERAL

1.1 Supply of items shall be done as per Bill of Quantity, codes, standards, drawings/documents approved by Owner/Consultant and attached specifications of this document.

1.2 The words “client” or “purchaser” or “owner” or “consultant” appearing in the Technical Specification or Design Specification or Technical Standard or any attachment, shall mean Owner or its authorized representative.

1.3 Where conflict occurs, the order of precedence shall be as below:

Statutory Regulations,
National, International and Industry Standards and Codes of Practices,
Licensor’s Specification,
Other Specifications or Standard

1.4 Bidder shall submit Quality Assurance plan (QAP) / Inspection Test Plan (ITP) for approval of Owner / Third Party Inspection Agency.

1.5 All inspection shall be done as per Quality Assurance plan (QAP) / Inspection Test Plan (ITP) approved by Owner / Third party Inspection Agency.

1.6 Various stages of inspection shall be carried out by bidder internally. Final inspection of Expansion bellows shall be done by Third Party Inspection (TPI) agency along with review of test certificates.

1.7 The TPI shall be carried out by any of the approved agencies LRIS / BV / TUV.

1.8 Shore hardness of rubber shall be 65 +/- 5 degree shore A.

1.9 All Rubber expansion joints shall be suitable for installation on horizontal piping system.

1.10 Each sheet of Technical Condition of supply and specification sheets should be duly signed and stamped by competent authority and shall be enclosed along with offer without which the offer shall be considered incomplete.

1.11 Any deviations from the clause stipulated here in the Code and other enquiry documents shall be clearly mentioned in a separate “Deviation List” with proper Ref. No. In the absence of any such indications, it shall be assumed that the offer complies with all the requirements in totality and such assumptions shall be strictly binding on the supplier.

1.12 The vendor shall furnish tentative drawing, along with offer, incorporating the following details therein: -
   a) Type of bellow.
   b) Permissible Axial expansion, Axial compression & Lateral deflection at design pressure.
   c) Material of construction for various parts.
2.0 MATERIAL

2.1 Expansion Joint assembly shall include Bellow (Neoprene rubber with details as provided), Bolt & Nuts (IS-1367), Control rod (IS-1367), Stretcher Plate (carbon steel, hot dip galvanized) & Retainer Ring (carbon steel, hot dip galvanized). Equivalent material specification for metallic parts shall be acceptable.

2.2 Expansion bellow shall be constructed with High grade abrasion resistant Neoprene rubber reinforced with adequate no. of plies of heavy cotton duct nylon cord / Rayon cord impregnated with rubber compound and further reinforced with metal rings and steel wires covering entire carcass with integrated end Rubber Flanges. The outer cover and inner tube of the bellow shall be of Neoprene rubber and further painted with chlorinated rubber based paint.

2.3 The retainer rings (min. 10 mm thickness) shall be drilled to match flanges of respective expansion bellow of drawings for pumps as enclosed.

2.4 The stretcher plate thickness shall be suitably designed for respective expansion bellow.

3.0 TESTING

3.1 All testing charges shall be included in individual prices of the items. If third party inspection charges are not indicated, it shall be assumed that it is included in the offer. If third party inspection charges are extra, it should be indicated as percentage basis of individual item. In no case third party inspection charges should be indicated as lump-sum amount.

3.2 Testing of materials shall be as below:
   a) Chemical analysis of steel parts.
   b) Mechanical test of steel parts (Retainer ring, Stretcher Plate, control rod & boltings).
   c) Tensile test & elongation at break for Neoprene Rubber as per IS-3400.
   d) Hydraulic Test at 1.5 times the design pressure of the fluid.
   e) Vacuum Test at 700 mm of Hg.
   f) Deflection test to check Axial expansion (10 mm), Axial compression (15 mm) & Lateral deflection (10 mm) at design pressure.
   g) Qualitative analysis test for Polymer Identification on Neoprene Rubber, as per IS-3400.
   h) Shore hardness (65 +/- 5 degree shore A) measurement for Neoprene Rubber.

4.0 DOCUMENTATION

4.1 The manufacturer shall furnish drawings and documents for purchaser's approval as detailed below. Detail design calculations shall be submitted by the manufacturer to purchaser for approval. Following documents shall be submitted to purchaser.
   a) Detailed fabrication schedule
   b) Welding Procedure Test Certificate
   c) Inspection Certificate
   d) Data report for Radiographs, Stress Relieving, etc., if any.
   e) Copies of Mill Test Reports
   f) Fabrication drawings of Bellows.

4.2 The bellows shall be supplied with 8 copies of the Mill Test Certificates indicating the following and duly signed by the Inspecting Authority along with supply of materials.
   a) Purchase Order No.
   b) Material Specification and Grade
   c) Size (NPS) and Sch. No. /Thickness
   d) Quantity
   e) Heat and Lot No.
   f) Results of chemical analysis of steel parts.
5.0 MARKING

5.1 All the items shall be marked as per relevant Std. on a metal tag attached to each item using low stress die stamping method.

6.0 PRESERVING & PACKING

6.1 After final inspection and before shipments, bellows shall be cleaned from both inside and outside all shop dirt, grease, oil and other foreign materials.

6.2 Rubber Expansion bellows shall be provided with sufficient temporary ties and bracing for maintaining proper face to face dimension during transit and installation. They shall be removed after installation of bellows.

6.3 Shipping bars (temporary ties and bracings) shall be painted yellow.

6.4 External carbon steel surface shall be wire brushed and primed with a single coat of red lead.

6.5 All machined surface shall be properly protected from rust and mechanical injury during transit and storage at site.

6.6 The packing case shall be clearly marked with purchase order number and shall include complete packing list of all the items contained in the case.

7.0 GUARANTEE

7.1 All items shall be guaranteed against poor workmanship and defective material as mentioned in the Commercial terms and conditions.