

# **Inspection Manual for Piping**





# PIPING MANUAL

## INDEX

Sl. No.	Topics	Page No.
<b>1.0</b>	<b>Scope</b>	<b>6</b>
<b>2.0</b>	<b>Definition</b>	<b>7</b>
2.1	Pipe	7
2.2	Tubing	7
<b>3.0</b>	<b>Type of Pipes According to the Method of Manufacture</b>	<b>8</b>
3.1	Electric Resistance Welded Pipe (ERW)	8
3.2	Furnace Butt Welded Pipe	8
3.3	Electric Fusion Welded Pipe (EFSW)	8
3.4	Submerged Arc Welded Pipe (SAW)	8
3.5	Double Submerged Arc Welded Pipe	9
3.6	Spiral Welded Pipe	9
3.7	Seamless Pipes	9
3.8	Centrifugally Cast Pipes	9
3.9	Statically Cast Pipe	9
3.10	Cement Lined Pipe	9
3.11	Concrete Embedded Pipe	10
<b>4.0</b>	<b>Selection of Material</b>	<b>12</b>
4.1	Scope	12
4.2	General	12
4.3	Guidelines for Material Selection	13
4.4	Specific Requirement for Special Services Sour Gas, Hydrogen, Sulphur, Ammonia, Amines, Caustic Services etc.	17
4.5	Guideline for Pipe Specifications for Cooling Water & Fire Water Piping Systems	19
4.6	Common Materials used in Refinery	19
<b>5.0</b>	<b>Significance of Piping Class Nomenclature used by Designers and PMCs</b>	<b>46</b>
5.1	Significance for First Alphabet of Piping Class	46
5.2	Significance of Second Letter of Piping Class	46
5.3	Significance of Third Alphabet of Piping Class	48
5.4	Significance for Last Alphabet of Piping Class	48
<b>6.0</b>	<b>Necessity of Inspection</b>	<b>50</b>
<b>7.0</b>	<b>Inspection Tools</b>	<b>51</b>
<b>8.0</b>	<b>Frequency of Inspection</b>	<b>53</b>
8.1	Plant Piping	53
8.2	Offsite Piping	53
<b>9.0</b>	<b>Likely Areas of Metal Loss and Causes of Deterioration</b>	<b>55</b>
9.1	External Corrosion	55
9.2	Internal Corrosion	55
<b>10.0</b>	<b>Inspection Stages &amp; Procedures</b>	<b>59</b>

Sl. No.	Topics	Page No.
10.1	Onstream Inspection (Pipelines under Operation)	59
10.2	Inspection During Shutdown	66
10.3	Statutory Inspection	68
<b>11.0</b>	<b>Quality Assurance Plan for New Constructions</b>	<b>71</b>
11.1	Quality Assurance during Design Stage	71
11.2	Quality Assurance during Construction Stage	74
<b>12.0</b>	<b>Inspection of Piping during Fabrication</b>	<b>78</b>
12.1	Inspection of Pipes before use	78
12.2	Injurious Defects	78
12.3	Forming of Pipes	79
12.4	Welding	80
12.5	Inspection after Welding	80
12.6	Supports	81
12.7	Pressure Tests	81
12.8	Painting	86
12.9	External Corrosion Control for Buried or Submerged Pipelines	87
12.10	Insulation	88
<b>13.0</b>	<b>Retiring Limits</b>	<b>90</b>
<b>14.0</b>	<b>Pipeline Repairs and Inspection</b>	<b>91</b>
14.1	Inspection of Valves in Service	91
<b>15.0</b>	<b>Documentation</b>	<b>93</b>
<b>16.0</b>	<b>Annexures</b>	<b>95</b>
Annexure –I	Extracts from ANSI/ ASME B 31.4.1979 – On Liquid Petroleum Transportation Piping Systems	95
Annexure –II	Preservation of New Pipes in Ware House	99
Annexure-II(a)	Sample Preservation Scheme for Sulfur Recovery Unit	100
Annexure-II(b)	Idle Time Preservation Scheme for Amine Treating Unit	106
Annexure-II(c)	Procedure for Passivation of Austenitic Stainless Steel Equipment	110
Annexure-II(d)	NACE RP-0170 - On Protection of Austenitic Stainless Steel Equipment	114
Annexure-II(e)	Idle Time Preservation of Static & Rotary Equipment – OISD-171	120
Annexure –III	Dimensions of Seamless and Welded Steel Pipe	150
Annexure –IV	Equivalent Specifications of ASTM to British, French, German, Italian and Swedish Standards	153
Annexure-V	Common Paint Colour Code for Refineries	156
Annexure-VI	Standard Specification for Corrosion Protection of Wrapping Coating & Tape Coating of Under Ground Steel Pipelines	170
Annexure-VII	A Sample of Isometric of Pipeline Circuit & Data Record Cards	181
<b>17.0</b>	<b>References</b>	<b>183</b>

## **1.0 SCOPE**

This manual covers the minimum requirements for inspection on pipes and pipefitting used in petroleum refinery. Locations to be inspected, inspection tools, inspection frequency, likely location of deterioration and causes, inspection and testing procedures have been specified in the Manual.

Special emphasis was given on the quality assurance requirements in new projects and Additional Facilities (AF) jobs in view of the recent failures encountered in new projects. Critical issues of material selection and Common Paint Colour Code System have also been covered. Experience of newly completed projects is also incorporated to avoid repetitive failures on these accounts. Inspection and testing requirements of new pipeline during fabrication have also been included.

## **2.0 DEFINITION**

### **2.1 PIPE**

A pressure tight cylinder used to carry a fluid or to transmit a fluid pressure is designated "Pipe" in applicable material specifications.

Pipe manufactured in different sizes & thicknesses are commonly expressed in nominal diameter. Nominal diameter is normally the approximate internal diameter of the pipe with standard schedule thickness.

### **2.2 TUBING**

Tubing is similar to pipe but it is manufactured in different sizes of outside diameter and wall thickness. Tubing is generally seamless drawn and the stated size is the actual outside diameter. Tubes are basically meant for heat transfer and mostly fit into tube grooves, hence tubes are specified by outside diameter and wall thickness with negative tolerance on outside diameter.

### **3.0 TYPE OF PIPES ACCORDING TO THE METHOD OF MANUFACTURE**

#### **3.1 ELECTRIC RESISTANCE WELDED PIPE (ERW)**

Pipe produced in individual lengths or in continuous lengths from coiled skelp, having a longitudinal or spiral butt joint where in coalescence is produced by the heat obtained from resistance of the pipe to the flow of electric current in a circuit of which the pipe is a part, and by the application of pressure.

Care must be taken during procurement of ERW pipes as regards the code requirement. The IS-1239 and IS-3589 does not call for any mandatory requirements of NDT to ensure the quality of welding. Moreover, the hydrotest requirement can be substituted by NDT by manufacturer without informing the customer. As per API 5L the NDT requirement for quality assurance of weld is mandatory and the manufacturer have to keep 100% record of hydrotest for witness by the TPI agency. Any additional requirement should be specifically indicated in the purchase order.

#### **3.2 FURNACE BUTT WELDED PIPE**

##### **i Furnace Butt-Welded Pipe (Bell Welded)**

Pipe produced in individual lengths from cut-length skelp having its longitudinal butt joint forge welded by the mechanical pressure developed in drawing the furnace heated skelp through a cone-shaped die (commonly known as the "Welding bell") which service as a combined forming and welding die.

##### **ii Furnace Butt-Welded Pipe (Continuous Welded)**

Pipe produced in continuous lengths from coiled skelp and joint forge welded by the mechanical pressure developed in rolling the hot-formed skelp through a set of round pass welding rolls.

#### **3.3 ELECTRIC FUSION WELDED PIPE (EFSW)**

Pipe having a longitudinal or spiral butt joint wherein coalescence is produced in the preformed tube by manual or automatic electric-arc welding. The weld may be single or double and may be made with or without the use of filler metal.

#### **3.4 SUBMERGED ARC WELDED PIPE (SAW)**

The submerged arc welded pipes are made from hot rolled coils or sheets. The welding can be longitudinal or spiral. The pipe is welded internally and externally using submerged arc-welding process.



### **3.5 DOUBLE SUBMERGED ARC WELDED PIPE**

Pipe having a longitudinal or spiral butt joint produced by at least two passes, one of which is on the inside of the pipe, coalescence is produced by heating with an electric arc between the bare metal electrode or electrodes and the work. The welding is shielded by a blanket of granular, fusible material on the work. Pressure is not used and filler metal for the inside and outside welds is obtained from the electrode or electrodes or fusible material.

### **3.6 SPIRAL WELDED PIPE**

Pipe having a helical seam with either a butt, lap or lock seam-joint which is welded using either a electrical resistance, electric fusion or double submerged arc weld.

### **3.7 SEAMLESS PIPES**

Pipe produced by piercing a billet followed by rolling or drawing or both.

### **3.8 CENTRIFUGALLY CAST PIPES**

Pipe formed from the solidification of molten metal in a rotating mold. Both metal and sand moulds are used. The inherent parabolic internal pipe contour formed by the centrifugal force during solidification, is subsequently removed by boring to sound metal.

### **3.9 STATICALLY CAST PIPE**

Pipe formed by the solidification of molten metal in a sand mould.

### **3.10 CEMENT LINED PIPE**

Internal and external cement lined pipes are used in cooling water and fresh water lines to combat microbial induced corrosion in the internal surface and soil corrosion in the external surface. The cement lining is normally 25mm thick on inside and outside with wire mesh as reinforcement.

Cement lined pipes are fabricated at shop on need base and can be manufactured for higher diameter pipes only. However, precautions should be taken for handling/ fabrication of these pipes to avoid local damage or cracks on the cement lining and the lining provided at the insitu joints. While doing the welding for field joints asbestos-backing ring should be suitably provided at the internal face to avoid direct contact of water to the metal surface. For external insitu lining, normally, shuttering is made alongwith holes at top and bottom. The cement concrete mixture is injected through the bottom hole and oozing out of concrete from the top hole is observed to ensure complete filling of the annular space with concrete.

### **3.11 CONCRETE EMBEDDED PIPE**

The concrete embedded pipes are also used in cooling water service, which can take care soil side corrosion. In this system, the carbon steel pipe is encased by concrete of minimum 6" thickness to avoid soil corrosion. However, in this system the porosity of concrete cannot be avoided and may result in localized corrosion. Although, the system provides a perfect casing and can operate even with corroded pipes, but any local repair is difficult and cumbersome.

# Selection of Material



## **4.0 SELECTION OF MATERIAL**

### **4.1 SCOPE**

This specification defines the basis to be used in selecting the piping materials of construction of refinery piping.

The codes and standards followed in selecting the piping Materials:

- i) Petroleum Refinery piping – ANSI – B.31.3
- ii) Power Piping – ANSI – B.31.1
- iii) Flanges & Flanged Fittings – ASME / ANSI – B.16.5
- iv) Indian Boiler Regulation – IBR
- v) Bolts & Nuts – ANSI B.18.2.1
- vi) Valves / Flanges – ASME / ANSI B.18.2.2
- vii) Gasket – Chemical Engg. Hand Book  
– Perry's / Piping hand book-king & crocker.

### **4.2 GENERAL**

The primary objective in materials selection is the achievement of metallurgical stability to prevent failure resulting from environment, normal operation time exposure and upset conditions. The secondary objective is the economy for achievement of design life by use of appropriate materials of construction.

Materials selection for achievement of metallurgical stability shall be made on the basis of design condition and to resist possible exposures against fire, corrosion, operating condition, service etc.

The basis of material selection shall be as under:

#### **i) Design Life**

The following are the general guidelines to be considered while designing the systems.

- a) Alloy steel piping / stainless steel piping – 15 years life.
- b) Carbon steel piping – 15 years life.

#### **ii) Design Temperature**

The design temperature of the fluid in the piping is generally assumed the highest temperature of the fluid in the equipment connected with the piping concerned. However, the design temperature of piping for all services shall be generally specified by a process Engineer taking into consideration steam flushing,

regenerating etc. the design metal temperature of the piping shall conform to ANSI – B 31.3.

**iii) Design Pressure**

The design pressure of the piping system shall be not less than the pressure at the most severe condition of coincident internal / external pressure and temperature expected during the service life. For further details refer ANSI – B 31.3.

**iv) Corrosion Allowance**

The corrosion allowance shall be selected on the basis of the fluid transported, the material of the piping and the average life planned. [Table](#) –1a, b, c, d indicated in the nomenclature of piping class in Chapter-5 shows the nominal corrosion allowances for different material.

**v) Service of the System**

Service of the system is the medium, the system shall handle throughout the life time and its duration of operation.

Medium handled occasionally (life during shutdown and re-commissioning etc.) shall also to be considered.

**vi) Economics**

Economics of the material cost shall also to be considered in the selection. The possibility of usage of inferior materials with periodic replacement shall be considered against the usage of superior material without sacrificing the safety of the plant.

**vii) Effect of Environmental condition**

Effort shall be made to select material suiting well to the medium handled as well as the environmental conditions.

**4.3 GUIDELINES FOR MATERIAL SELECTION**

**4.3.1 Exposure at high temperature (above 232 °C)**

a) Materials selected for high temperature exposure shall be economic choice which will be resistant to, or provide against, the following modes of deterioration throughout the design life of the equipment:

- Overstress in the elastic range
- Stress rupture
- Unacceptable degrees of creep strain

- Graphitization
- Decarburization
- Corrosion and general oxidation
- Intergranular oxidation
- High temperature
- Sensitization to Intergranular corrosion
- Carburization
- Deterioration during shutdowns or in shutting down and starting up.
- Embrittlement attributable to high temperature exposure.

b) For corrosion and general oxidation wastage operating temperature shall be considered.

c) For the other modes of metal deterioration given in para, 4.3.1 the temperatures and pressures to be considered are design temperatures and pressures, except that for decarburization and hydrogen attack due to hydrogen in the process stream design hydrogen partial pressure shall also be considered.

d) Where hydrogen will be a constituent of hot process stream, a hydrogen-resistant material shall be selected according to API 941 and account shall be taken as to the effect of possible temperature exceeding above the design temperature during upsets where process is such that exothermic reactions can take place. In such meet the design conditions is within 35 °F (20 °C) of the appropriate curve the next higher alloy steel in the hydrogen resistant series, as shown in API 941 shall be the one selected.

As can be seen in the Nelson Curve the use of carbon ½ Mo steel has not been shown in the graph, indicating the tendency of reduction in creep properties of this material with long high temperature exposure. This has reduced the use of carbon ½ Mo in the Hydrogen and Hydrocarbon service.

e) Carbon molybdenum steel is generally used in steam services.

f) The use of 12% Cr or higher ferritic Cr steels for pressure containing parts is not permitted.

g) Where austenitic stainless steels are selected and there might be a danger of Intergranular corrosion occurring during shutdowns as a result of sensitization during service, an appropriate titanium or columbium (niobium) stabilized or extra low carbon grade shall be specified; where high temperature strength is required a similarly stabilized H grade shall be selected. For temperatures above 426 °C the extra low carbon grade shall not be used and the chemically stabilized grades shall be given a stabilizing heat when required to resist Intergranular attack.

#### 4.3.2 Exposure at Ambient & Intermediate Temperatures (from 0 °C to 232 °C)

- a) Materials selected for exposure to ambient and intermediate temperatures shall be economic choice in a form or condition which, in the particular environments, will be resistant to damage resulting from:
- Hydrogen blistering
  - Intergranular corrosion
  - Stress corrosion cracking
  - Hydrogen sulfide embrittlement
  - Fatigue
  - Corrosion fatigue
  - Caustic embrittlement
  - Deterioration at shutdown or in shutting down and starting up.
  - Chemical attack
  - Crevice corrosion
  - Galvanic corrosion
- b) Material selected for service conducive to hydrogen blistering, shall be fully silicon-killed carbon steel.
- c) Where austenitic stainless steels are selected, a titanium or columbium (niobium) stabilized low carbon grade shall be specified to resist Intergranular corrosion either in the operating condition or during shutdowns. Alternatively, if strength considerations are not important economically, the extra low carbon (0.03% max.) grade may be used.
- d) Where austenitic stainless steels are selected for service at temperatures and in environments possibly conducive to halogen trans-granular stress corrosion cracking, fully stress relieved material shall be specified. This requirement shall apply also to those services where stress corrosion could occur in heating to, or cooling from operating temperature. It does not apply to austenitic stainless steel clad or deposit lined equipment; in such case the heat treatment requirements appropriate to the backing steel shall govern. However, this heat treatment shall be selected govern. However, this heat treatment shall be selected so as to minimize sensitization effects on the stainless steel.
- e) Hardness of carbon and ferritic alloy steels and weldments exposed to wet H<sub>2</sub>S streams shall be limited to 200 BHN irrespective of the H<sub>2</sub>S concentration.

- f) Material and requirements for caustic service shall be in accordance with the graph shown in attached drawing. (Refer attached [Drawing No-1](#)).
- g) Brass materials shall be specified only when pH of the environment due to ammonia will be 7.2 or less. Above pH 7.2, 70-30 Cu-Ni or other similar alloy shall be used.

#### 4.3.3 Exposure at low temperature (Below 0 °C)

- a) Materials selected for service at (0 °C) or below shall have adequate resistance to brittle fracture and shall satisfy the appropriate impact test requirements below minus (-) 29 °C as per the relevant design code (ANSI B 31.3). Carbon steel shall be fully killed and normalized.
- b) The minimum design temperature shall be the minimum temperature of the contents during normal operation, shutdown, start-up or unit upset.
- c) The post-weld heat-treated case shall apply to all unwelded materials.

#### 4.3.4 Materials requirements – General Precautions

- a) All chromium molybdenum steels containing up to 9% chromium which are to be welded shall have a carbon content not exceeding 0.15%.
- b) Use of stainless steel shall be kept to a minimum. Where use of a less, highly alloyed material would result in sacrifice of only a small part of design life (say, up to 20%) stainless steel may be avoided. When use of such a material cannot be avoided and where there is danger of transgranular stress corrosion cracking, higher alloy materials such as the fully stabilized Incolloys shall be considered.
- c) Where naphthenic acid corrosion is anticipated, consideration shall be given to the use of a stabilized or extra low carbon grade of molybdenum bearing austenitic stainless steel such as SS 316 L, SS 321, SS 347.

Care shall be taken to ensure that austenitic stainless steels do not come into contact with Lead, Zinc, Aluminium, Copper, Tin or other low-melting metals that promote cracking. Paints containing these metals shall not be used on austenitic stainless steel. In addition, design shall be such as to avoid contamination of austenitic stainless steels by such metals during a fire.



#### 4.4 SPECIFIC REQUIREMENT FOR SPECIAL SERVICES SOUR GAS, HYDROGEN, SULPHUR, AMMONIA, AMINES, CAUSTIC SERVICES ETC.

##### 4.4.1 Resistance to Hydrogen

Resistance to hydrogen attack must be taken care while selecting materials in contact with liquids and vapours containing hydrogen at elevated temperatures and pressures. The guide used for selecting hydrogen resistant materials is API publication 941 entitled “Steels for Hydrogen Services at elevated Temperatures and Pressures in Petroleum Refineries and Petrochemicals Plants”.

A brief study of the Nelson curve on the following reveals that the principle alloying elements which impart resistance to elevated temperature hydrogen attack the chromium and molybdenum. (Refer [Drawing No -2](#) attached).

Alloy steels commonly used to resist high temperature hydrogen attack are as follows:

- |                       |   |              |
|-----------------------|---|--------------|
| a) 1-¼ Cr – ½ Mo      | - | (P-11)       |
| b) 5 Cr – ½ Mo        | - | (P-5)        |
| c) 9 Cr-1 Mo          | - | (P-9)        |
| d) 16 Cr, 12 Ni, 2 Mo | - | (S. S 316 H) |

Bakeout of hydrogen service piping should be carried out for approximately 2 to 4 hrs. at a temperature range of 650 to 800 °F before taking up any repair job. It is preferred to go for coil heating for better control in heating, soaking and cooling.

##### 4.4.2 Resistance to Sulphur

For determining materials of construction for an oil stream containing sulphur utilize the curve entitled “Average Rate Curves (Refer [Drawing No-3](#) attached) for High Temperature Sulphur Corrosion”. This curve aids in determining corrosion rates for materials in contact with sulphur bearing Hydrocarbon streams and is use Oxidizing Units and Raw Oil charge lines to Hydrodesulphurising and Hydrocracking Units.

While applying this curve, use the maximum operating temperature of the equipment involved and pick the corresponding corrosion rate for one of the materials listed, then adjust the corrosion rate with a correction factor which takes into account the weight percent sulphur. It should be noted that the reference sulphur level for this curve is 1.0 weight percent. As one can see from this curve, an increase in chromium content imparts increasing resistance to high temperature sulphur corrosion.

Carbon steel generally is specified for most equipment to the 500-550 °F (260-288 °C) temperature range, and the corrosion allowance used is 3mm. When the piping in this service are carbon steel and improved corrosion resistance is necessary, TP 410S stainless steel cladding is specified. Depending on the anticipated corrosion rates, heater tubes are usually 5 Cr – ½ Mo or 9 Cr – 1 Mo. Piping systems are usually carbon steel and 5 Cr – ½ Mo with varying corrosion allowances. Refer corrosion allowance [Table – 5](#) for large diameter piping 18” dia, usually heater transfer lines, an alternative of carbon steel clad with TP 410S stainless steel is specified.

#### 4.4.3 Resistance to sour Water Services (H<sub>2</sub>S)

- Materials shall be selected from those permitted in the NACE standard.
- Selection of materials should be for a specific sour duty condition.
- If process H<sub>2</sub>S concentration is varying, peak values shall be used.
- The resistance to general corrosion. The pH value of the process stream and the presence/ absence of corrodents such as oxygen, CO<sub>2</sub>, chlorides etc. are of particular importance.
- Mech. Properties including low temperature requirements where necessary shall be given special attention.
- Carbon steel pipe work shall be in the normalized heat-treated conditions. All materials for conventional welding (i.e. for welding with techniques other than either vertical down or any low heat input) technique shall have a carbon content of 0.23% for seam less pipes and 0.25% max. for forgings and carbon equivalent of 0.40% max. based on the formula.

$$CE = C + Mn / 6 + (Cr + Mo + V) / (Ni + Cu) / 15$$

#### 4.4.4 Resistance to Caustic and Amine

- Carbon steel is generally an acceptable material for handling caustic soda and other alkaline solutions. However, it has limitations. Higher temperature in that Stress Corrosion Cracking (SCC) can occur unless it is stress relieved, also unacceptable general corrosion can take place. (Refer [Drawing No-1](#) attached).
- For Amine service, to avoid stress corrosion cracking of welded pipes and other welds, exposed to various Amine solutions, stress relieving for all welds is required as follows:

MEA (Monoethanol amine) – For all design temperature

DEA (Diethanol amine) – For design temperature > 82 °C.

- For additional guidance for avoidance of corrosion of stress corrosion cracking (SCC) can be referred in API 945.

#### **4.5 GUIDELINE FOR PIPE SPECIFICATIONS FOR COOLING WATER & FIRE WATER PIPING SYSTEMS**

In the Refineries, frequent failures have been experienced in Cooling Water and Fire Water services especially in the form of seam opening in ERW pipes. It has been observed that the IS 1239 & IS 3589 quality pipes used for these services do not recommend any mandatory NDT for quality assurance of ERW pipe welding and also the Hydrostatic test can be substituted by the manufacturer. In view of this the above specifications along with other piping specifications like API 5L Gr. B, ASTM A106 Gr. B were compared and an approval for a techno-economical specification have been obtained.

As per the above, it is recommended to use pipes of API 5L Gr. B standard due to its mandatory requirement of NDT to ensure improved weld quality and documentary evidence of Hydrotest for Cooling Water (CW) and Fire Water (FW) piping systems. For lower diameter pipes upto dia. 6", seamless pipes are recommended considering lower thickness in this range, which are detrimental in case of any weld deficiencies. ERW/ EFSW pipes conforming to API 5L Gr. B are recommended for 8" to 14" diameter for improved quality of ERW welding. For diameter 16" and above, EFSW pipes are recommended considering the superior welding quality. The recommended pipe specifications for Cooling Water and Fire Water services of different diameters are given below:

<b>Diameter</b>	<b>Recommended Pipe Specification</b>
Upto 6"	Seamless Pipes Of A 106 Gr.B Or API 5L Gr.B Standards
8" to 14"	ERW/ EFSW pipes of API 5L Gr. B Standard
16" and above	EFSW pipes as per API 5L Gr. B Standard

#### **4.6 COMMON MATERIALS USED IN REFINERY**

The detailed lists of materials used in Refinery are given in [Table – 1, 2](#) and [3](#).

##### **5.1 Carbon Steel**

This is the most common material used in process plants. Carbon steels are used in most general refinery applications where killed steel quality is not required.

##### **5.2 Killed Carbon Steel**

Killed steels are defined as those, which are thoroughly deoxidized during melting process. Deoxidation is accomplished by use of silicon, manganese and aluminium additions to combine with dissolved gases, usually oxygen, during steel making. This results in cleaner, better quality steel which has fewer gas pockets and inclusions. Killed carbon steel is specified for major equipment in the following services to minimize the possibility or extent of hydrogen blistering and hydrogen embrittlement:

- a) Where hydrogen is a major component in the process stream.
- b) Where hydrogen sulfide  $H_2S$  is present with an aqueous phase or where liquid water containing  $H_2S$  is present;
- c) Process streams containing any amount of Hydrofluoric acid (HF), boron trifluoride ( $BF_3$ ) or (BF) compounds; or
- d) Monoethanolamine (MEA) and diethanolamine (DEA) in solutions of greater than 5 weight percent.

Killed steel is also used for equipment designed for temperatures greater than ( $482\text{ }^\circ\text{C}$ ) since the ASME boiler and Pressure Code does not list allowable stresses for carbon steel over  $900\text{ }^\circ\text{F}$  ( $482\text{ }^\circ\text{C}$ ).

### 5.3 Low Alloy Steels

- a) Carbon  $\frac{1}{2}$  Moly. These low alloy steels are used for moderate temperature services, moderate corrosive service and most frequently for intermediate temperatures for its resistance to hydrogen attack. They have the same maximum temperature limitation as killed steel (ASME Code –  $1000\text{ }^\circ\text{F}$ ) but the strength above  $700\text{ }^\circ\text{F}$  is substantially greater. However, while selecting this material care should be taken as the creep/ high temperature strength properties of such material deteriorates with time.
- b) 1% chrome  $\frac{1}{2}$  Moly and  $1\text{-}\frac{1}{4}$  Chrome  $\frac{1}{2}$  Moly. These alloys are used for higher resistance to hydrogen attack and sulphur corrosion. They are also used for services where temperatures are above the rated temperature for C  $\frac{1}{2}$  Mo steel.
- c)  $2\text{-}\frac{1}{4}$  Chrome 1% Moly and 3% Chrome – 1% Moly. These alloys have the same uses as  $1\text{-}\frac{1}{4}$  % Cr, but have greater resistance to hydrogen attack and higher strength at elevated temperature.
- d) 5% Chrome –  $\frac{1}{2}$ % Moly. This alloy is used most frequently for protection against combined sulphur attack at temperatures above  $550\text{ }^\circ\text{F}$ . Its resistance to hydrogen attack is better than  $2\text{-}\frac{1}{4}$  % Cr-1% Moly.
- e) 9% Chrome – 1% Moly. This alloy is generally limited to heater tubes. It has a higher resistance to high sulphur stocks at elevated temperatures. It also has a maximum allowable metal temperature in oxidizing atmospheres.

#### **5.4 Ferritic and Martensitic Stainless Steel**

- a) 12% Chrome (Types 405 and 410S) – This ferritic or Martensitic stainless steel is used primarily as a clad lining. It has excellent resistance to combined sulphur and good resistance to hydrogen sulphide at low concentrations and intermediate temperatures.
- b) 13% Chrome (Type 410) – This stainless steel is used extensively for standard trim on all process valves and pumps, and for vessel trays and tray components. It is also used for heat exchanger tubes for the same processing conditions as Type 405.

#### **5.5 Austenitic Stainless Steels**

- a) Type 304 – This is the lowest cost type of 18-8 stainless steel for protection against hydrogen and hydrogen sulphide attack at elevated temperatures. It is susceptible stress corrosion.
- b) Types 309 and 310 – These are special heat resistant austenitic stainless steels which have oxidation resistance upto about 2000°F. Their composition are 25% Cr – 12% Ni and 25% Cr – 20 Ni respectively, and are used in high temperature services and tube supports in heaters.

#### **5.6 Non Metallic Piping Materials**

- a) While using non-metallic piping, e.g. HDPE, PVC, FRP etc. designer shall take care of the Aging effect, the service temperature and pressure. Manufacturer's recommendation shall be taken into account.
- b) Based on the "Guidelines for Material Section" as per clause and 'Specific requirements for special services. As per CI 4.4." a broad guideline is drawn in [Table – 4](#). (Piping Material Selection based on Service/ Temperature).
- c) Based on [Table – 4](#), [Table – 5](#) & [Table – 6](#) "Piping Class Selection Chart" Table 5 is drawn to select a specific piping class for a particular set of service/ rating/ application.

Table – 1

## ASTM DESIGNATION OF MATERIALS

MATERIAL	PLATE	PIPE	ELECTRIC FUSION WELDED PIPE	TUBES	CASTINGS	FORGINGS	WROUGHT FITTINGS	CLADDING
Carbon Steel	A-285-GR, A, B & C	A-53 GR, A&B	A-671 GR, CA-55 A-677 GR, A45-A55	A-214 (WELDED) A-179 (SEAMLESS)	A-216 GR, WCA, WCB & WCC	A-105 A-181 CL. 60 OR 70 A-266 CL I, II, OR III	A-234 GR, WPB	
Killed Steel	A-515 GR, 55-70 A-516 GR, 55-70	A-106 GR, A&B	A-672 GR B55-70 A-672 GR, C55-C70	A-179	A-216 GR, WCA, WCB & WCC	A-105 A-181 CL 60 OR 70 A-266 CL I, II, OR III	A-234 GR, WPB	
C-1/2 Mo	A-204 GR, A, B & C	A-335 GR, P1	A-691 GR, CM 65-CM75	A-209 GR, T1	A-217 GR WC1	A-182 GR, F1 A-336 CL, F1	A-234 GR, WP1	
1 Cr-1/2Mo	A-387 GR, 12	A-335 GR, P12	A-691 GR, 1Cr	A-213 GR, T12		A-182 GR, F12 A-336 CL F12	A-234 GR WP11	
1-1/4 Cr-1/2 Mo	A-387 GR, 11	A-335 GR, P11	A-691 GR, 1-1/4Cr	A-199 GR, T11 A-213 GR, T11	A-217 GR, WC6	A-182 GR, F11 A-336 CL F11	A-234 GR, WP11	
2-1/4 Cr-1Mo	A-387 GR, 22	A-335 GR, P22	A-691 GR, 2-1/4 Cr	A-199 GR, T22 A-219 GR, T22	A-217 GR, WC9	A-182 GR, F22 A-336 CL F22	A-234 GR, WP22	
3Cr-1Mo	A-387 GR, 21	A-335 GR, P21	-	A-199 T21 A-213 GR, T21	-	A-182 GR, F21 A-336 CL, F21	-	
5 Cr-1/2 Mo	A-387 GR, 5 (Formerly A-357)	A-335 GR, P5	A-691 GR, 5Cr	A-199 GR, T5 A-213 GR, T5	A-217 GR, C5	A-182 GR, F5 A-336 CL, F5	A-234 GR, WP5	
9Cr-1Mo	A-387 GR, 9	A-335 GR, P9	A-691 GR, 9Cr.	A-199 GR, T9 A-213 GR, T9	A-217 GR, C12	A-182 GR, F9 A-336 CL F9	A-234 GR, WP9	
12Cr-TP405	A-240 TP405	A-268 GR, TP405	-	A-268 GR, TP405	-	-	-	A-263
13 Cr-TP410	A-240 TP410	A-268 GR, TP410	-	A-268 GR, TP410	A-217 GR, CA15	A-182 GR, F6 A-336 CL, F6	-	A-263
13 Cr-TP410S	A-240 TP410S		-					A-263
17 Cr- TP430	A-240 TP430	A-268 GR,	-	A-268 GR, TP		-		A-263

MATERIAL	PLATE	PIPE	ELECTRIC FUSION WELDED PIPE	TUBES	CASTINGS	FORGINGS	WROUGHT FITTINGS	CLADDING
		TP 430		430				
18 Cr-8 Ni-TP304	A-240 TP304	A-312 GR, TP304 A-376 GR, TP304	A-358 GR, 304	A-213 GR, TP304 A-249 GR, TP304	A-351 GR, CF8 A-744 CF8	A-182 GR, F304 A-336 CL, F304	A-403 GR, WP304	A-264
18 Cr-8Ni-TP304L	A-240 TP304L	A-312 GR, TP304L	A-358 GR, 304L	A-213 GR, TP304L A-249 GR, TP304L	A-351 GR, CF3 A-744 CF3	A-182 GR, F304L A-336 CL, F304L	A-403 GR, WP304L	A-264

Table – 2

## ASTM DESIGNATION OF MATERIALS

MATERIAL	PLATE	PIPE	ELECTRIC FUSION WELDED PIPE	TUBES	CASTINGS	FORGINGS	WROUGHT FITTINGS	CLADDING
18Cr-8 Ni-TP304H	A-240 TP304H	A-312 GR, TP304H A-376 GR, TP304H	A-358 GR, 304H	A-213 GR, TP304H A-249 GR, TP304H	-	A-182 GR, F304H A-336 CL F304H	A403 GR, WP304H	A-264
16Cr-12 Ni-2 Mo TP316	A-240 TP316	A-312 GR, TP316 A-376 GR, TP316	A-358 GR, 316	A-213 GR, TP316 A-249 GR, TP316	A-351 GR, CF8M A-744 CF8M	A-182 GR, F316 A-336 CL F316	A-403 GR, WP316	A264
16Cr-12 Ni-2Mo TP316L	A-240 TP316L	A-312 GR, TP316L	A-358 GR, 316L	A-213 GR, TP316L A-249 GR, TP316L	A-351 GR, CF8M A-744 GR CF8M	A-182 GR, F316L A-336 CL F316L	A-403 GR, WP316L	A-264
16Cr-12 Ni-2Mo TP316H	A-240 TP316H	A-312 GR, TP316H A-376 GR, TP316H	A-358 GR, 316H	A-213 GR, TP316H A-249 GR, TP316H	-	A-182 GR, F316H A-336 CL F316H	A-403 GR, WP316H	A-264
18Cr- 13 Ni-3Mo TP317	A-240 TP317	A-312 GR, TP317		A-249 GR, TP317	A-351 GR, CG-8M A-744 GR, CG-8M	A-182 GR, F317 (Bar Stock)	A-403 GR, WP317	A-264
18Cr- 13 Ni-3Mo TP317L	A-240 TP317L	A-312 GR, TP317L	-	-	-	-	A-403 GR, WP317L	A-264
18Cr- 10 Ni-Ti TP321	A-240 TP321	A-312 GR, TP321 A-376 GR, TP321	A-358 GR, 321	A-213 GR, TP321 A-246 GR, TP321		A-182 GR, F321 A-336 CL F321	A-403 GR, WP321	A-264
18Cr- 10 Ni-Ti TP321H	A-240 TP321H	A-312 GR, TP321H A-376 GR, TP321H	-	A-213 GR, TP321H A-249GR, TP321H		A-182 GR, F321H A-336 CL F321H	A-403 GR, WP321H	A-264
18Cr- 10 Ni-Cb TP347	A-240 TP347	A-312 GR, TP347 A-376 GR, TP347	A-358 GR, 347	A-213 GR, TP347 A-249 GR, TP347	A-351 GR, CF8C A-744 GR, CF8C	A-182 GR, F347 A-336 CL F347	A-403 GR, WP347	A-264
18Cr- 10 Ni-Cb TP347H	A-240 TP347H	A-312 GR, TP347H A-376	-	A-213 GR, TP347H A-249 GR, TP347H		A-182 GR, F347H A-336	A-403 GR, WP347H	A-264



MATERIAL	PLATE	PIPE	ELECTRIC FUSION WELDED PIPE	TUBES	CASTINGS	FORGINGS	WROUGHT FITTINGS	CLADDING
		GR, TP347H				CL F347H		
23 Cr-12 Ni TP309	A-240 TP309S	A-312 GR, TP309S	A-358 GR, 309S	A-213 GR, TP309	A-351 GR, CH-20		A-403 GR, WP309	A264
25 Cr-20 Ni TP310	A-240 TP310S	A-312 GR, TP310S	A-358 GR, 310S	A-212 GR, TP310 A-249 GR	A-351 GR, CK-20	A-182 GR, F310	A-403 GR, WP310	A264
Inconal 600 (Ni-Cr-Fe)	B-168	B-167 B-517		B-163 Alloy Ni-Cr-Fe-B-516		B-564 Alloy Ni-Cr-Fe B-166 (Bar Stock)	B-366 GR / WPNCI	A-265
Inconal 800 (Ni-Cr-Fe)	B-169	B-407 B-514		B-163 Alloy Ni-Cr-Fe-B-515		B-564 Alloy Ni-Cr-Fe B-408 (Bar Stock)	B-366 GR / WPNCI	A-265
Alloy 20 (Cr-Ni-Fe-Mo-Cu-Cb)	B-463	B464	B-474	B-468	A-351 GR, CN-7M A-744 GR, CN-7M	B-462	B-366 GR, WP20CB	A-265
Admiralty Brass.	B-171 No. C44300 C44400 C44400			R-111 No. C44300 C44400 C44500				

Table – 3

**ASTM DESIGNATION OF MATERIALS**

MATERIAL	PLATE	PIPE	ELECTRIC FUSION WELDED PIPE	TUBES	CASTINGS	FORGINGS	WROUGHT FITTINGS	CLADDING
Naval Brass	B-171 No. C46400							
Al. Brass B				B-111 No. C68700				
Al. Bronze D	B-171 No. C61400			B-111 No. C61400				B-432
90-10-Cu-Ni	B-171 No. C70600	B-466 No. C70600	B-111 No. C70600					B-432
80-20-Cu-Ni		B-466 No. C71000	B-111 No. C71000					
70-30-Cu-Ni	B-171 No. C71500	B-466 No. C71500	B-111 No. C71000					B-432
Monel (Ni-Cu)	B-127	B-165		B-163 Alloy Ni-Cu	A-494A-GR, M-31-1	B-564 Alloy Ni-Cu B-164 (Bar Stock)	P-366 Gr. WPNC	A-265
Hastelloy-B (Ni-MO)	B-333	B-622 Alloy Ni-Mo	R-619 Alloy Ni-Mo		A-494 N-12MV	R335 (Alloy Rod)	R-366 Gr. WPHB.	A-265
Hastelloy-C (Ni-Mo-Cr.)	B-575	R-622 Alloy Low C Ni-Mo-Cr	B-619 Alloy LowC Ni-Mo-Cr		A-494 CR, CW-12MW	B-574 (Alloy Rod)	B-366 GR, WPHC	A-265
Al. 3003	B-209 Alloy 3003	B-241 Alloy 3003 B-210 Alloy 3003	B-324 Alloy 3003			B-247 Alloy 3003	R-361 Alloy WP 3003	
Titanium.	B-265	B-337	B-338		B-367	B-381	B-363	

\* ASTM A53 Gr. A&B CAN BE REPLACED BY API 5L Gr. A & B ALSO

Table – 4

**PIPING MATERIAL SELECTION BASED ON SERVICE / TEMPERATURE**

SERVICE	TEMP. RANGE °C	CARBON STEEL	ALLOY STEEL			
			LOW	INTER MEDIATE ALLOY	HIGH ALLOY	NON METALLIC
Hydrocarbon						
Low temp.	0-250	A				
Med Temperature	250-400	A	D			
High Temp.	400-550		D	F		
Very High Temp.	550-700			F, G	K, M	
Steam & BFW	0-400	A				
	400-450		B, D	E		
AIR	0-250	A, J				
Gas	-80 to -45			H		
	-45 to -250				K, M, N	
Flue Gas	0-650	A			K	
Acids	0-60	A, Y			K, P	S, Z, V
Chemical						
Low Temp.	0-250	A			K, N	S
Water						
Cooling	0-120	A				
Acidic	0-120	A				Z
Sour	0-120	A				
Sea		A			W	

**Legend:**

A	– CARBON
B	– CARBON MOLY
C	– 1% CR – ½ MOLY
D	– 1-1/4% CR. – ½ MOLY.
E	– 2-1/4% CR. – 1 MOLY.
F	– 5% CR. – ½% MOLY.
G	– 9% CR. 1% MOLY
H	– 3-1/2% NI
I, J, K	– S. S. TYPE 304, 304H, 304L
M	– STABILIZED S. S. 316, 316H, 321, 347
N	– 316 L
P	– MONEL / INCONEL / INCOLOY
Q	– HASTALLOY
R	– LEAD
S	– PVC
T	– C. I. / SILICON IRON
V	– FRP
W	– CUPRO – NICKEL
Y	– LINED STEEL
Z	– HDPE

The above alphabets are also the last alphabets in piping class.

Table – 5

**PIPING CLASS SELECTION CHART  
(BASED ON SERVICE APPLICATION PRESSURE)  
TO BE READ IN CONJUNCTION WITH TABLE NO. 1**

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
<b>I. PROCESS</b>							
1.	CRUDE	150#	RF	OFF SITE LOW PRESSURE	1.5	A10A	API 5L Gr. B/ A106 Gr. B
	“	150#	RF	LOW PR. (UNITS)	1.5/3.0	A1A/A9A	“
	“	300#	RF	PREHEAT EXCHANGERS / DESALTER – MED. PRESSURE	1.5/3.0	B1A/B9A	“
	“	600#	RF	HIGH PRESSURE & MED. TEMPERATURE	3.0	D9A	“
2.	DECOKING LINE	300#	RF	CRUDE FURNACES MED. PRESSURE	3.0	B9A	API 5L Gr. B/ A106 Gr. B
3.	NAPHTHA	150#	RF	LOW PRESSURE & MED. PRESSURE	1.5	A1A	API5LGr.B/ A106 Gr. B
	“	300	RF	MED. PRESSURE & LOW TEMPERATURE	1.5	B1A	“
4.	KEROSENE	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A1A	API 5L Gr. B/ A106 Gr. B
	“	150#	RF	LOW PRESSURE & MED. TEMPERATURE	3.0	A9A	“
	“	300#	RF	MED. PRESSURE & MED. TEMPERATURE	1.5	D1A/B9A	“
	“	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	“
5.	VAC. TOWER OVHD VAPOUR	150	RF	LOW PRESSURE & MED. TEMPERATURE	1.5	A1A	API 5L Gr. B/ A106 Gr. B
6.	DIESEL	300#	RF	MED. PRESSURE & MED. TEMPERATURE	1.5	B1A/B9A	API 5L Gr. B/ A106 Gr. 8

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
	"	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	A335 Gr. P5
	"	150#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	A4F	A335 Gr. P5
7.	LVGO	150#	RF	LOW PRESSURE & MED. TEMPERATURE	1.5	A1A	API 5L Gr. B/ A106 Gr. B
	"	300#	RF	"	1.5	B1A	"
8.	HVGO	300#	RF	MED. PRESSURE & MED. TEMPERATURE	1.5/3.0	B1A/B9A	API 5L Gr. B/ A106 Gr. B
	"	300#	RF	"	3.0	B4F	A335 Gr. P5
	"	150#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	A4F	"
9.	RCO	150#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	A4F	A335 Gr. P5
	"	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	"
10.	VAC. RESIDUE	150#	RF	LOW PRESSURE & MED. TEMPERATURE	3.0	A9A	API 5L Gr.B/ A 106 Gr. B
	"	300#	RF	MED. PRESSURE & MED. TEMPERATURE	3.0	B9A	"
	"	150#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	A4F	A335 Gr. P5
	"	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	"
10A.	VB TAR	150#	RF	LOW PRESSURE & MED. TEMPERATURE	3.0	A9A	API 5L Gr. B/ A106 Gr. B
	"	300#	RF	MED. PRESSURE & MED. TEMPERATURE	3.0	B9A	"
	"	150#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	A4F	A335 Gr. P5
	"	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	"

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
11.	SLOP DISTILLATE	150#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	A4F	A335 Gr. P5
	"	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	"
12.	SLOP OIL	150#	RF	FROM HOT WELL LOW PRESSURE	4.5	A6A	API 5L Gr. B/ A106 Gr. B
13.	TC TAR	150#	RF	LOW PRESSURE	1.5/3.0	A1A/A9A	"
	"	300#	RF	MED. PRESSURE	3.0	B9A	"
14.	CBD	150#	RF	LOW PRESSURE	1.5	A1A	"
15.	FLUSHING OIL	150#	RF	LOW PRESSURE	1.5	A1A	"
16.	CATALYST	150#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	A14A	API 5L Gr.B
	"	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	1.5	B4K	A312 Gr. TP304H
17.	REACTOR OVHD	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4D	A335 Gr. P11
	REACTOR BYPAS	300#	RF	"	6.0	B3F	A335 Gr. P5
18.	CYCLE OIL	300#	RF	"	3.0	B4F	A335 Gr. P5
	HY. CYCLE OIL	300#	RF	MED. PRESSURE & MED. TEMPERATURE	3.0	B9A	AP1 5L Gr.B/ A106 Gr. B
	HY. CYCLE OIL	150#	RF	LOW PRESSURE & MED. TEMPERATURE	3.0	A9A	API5L Gr. B/ A106 Gr. B
	LT. CYCLE OIL	150#	RF	"	1.5	A1A	"
19.	FRACTIONATOR BOTTOM	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	6.0	B3F	A335 Gr. P5
	MAIN CIRCULATION OIL	300#	RF	"	6.0	B11A	API 5L Gr.B/ A106 Gr.B
20.	MAIN COLUMN O /	150#	RF	LOW PRESSURE	3.0	A9A	"
21.	MAIN COLUMN RE	150#	RF	"	1.5	A1A	"
22.	TORCH OIL (RAW OIL)	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	A335 Gr.P5/ API 5L Gr.B
	"	300#	RF	MED. PRESSURE & MED. TEMPERATURE	3.0	B9A	A106 Gr. B

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
23.	SLURRY OIL	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	6.0	B3F	A 335 Gr. P5
24.	CLARIFIED OIL	300#	RF	“	6.0	B3F	“
	“	300#	RF	MED. PRESSURE & MED. TEMPERATURE	3.0	B9A	API 5L Gr. B/ A106 Gr. B
25.	BLOW DOWN	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A3A	IS: 1239/ IS: 3589
	“	300#	RF	MED. PRESSURE & LOW TEMPERATURE	1.5	B1A	API 5L Gr.B/ A 106 Gr. B
26.	GASOLINE	150#	RF	FCCU LOW PRESSURE & LOW TEMPERATURE	1.5 / 3.0	A1A / A9A	“
	“	300#	RF	FCCU MED. PRESSURE & LOW TEMPERATURE	1.5	B1A	“
27.	DISULFIDE OIL	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5 3.0	A1A/ A9A	“
	“	300#	RF	LOW/ MED. PRESSURE & LOW TEMPERATURE	3.0	B9A	“
28.	SUPERIOR KEROS	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A10A	“
29.	PROPYLENE	300#	RF	MED. PRESSURE & LOW TEMPERATURE	1.5/ 3.0	B1A/ B7A	“
30.	C4 & C5	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A1A	“
	“	300#	RF	MED. PRESSURE & LOW TEMPERATURE	1.5	B1A	“
31.	HEXANE	150#	RF	“	1.5	A1A	“
32.	REFFINATE & EXTRACT	150#	RF	LOW PRESSURE & MED. TEMPERATURE	1.5	A1A	“
33.	WAX PLANT FEED	150#	RF	LOW PRESSURE & LOW TEMPERATURE	3.0	A9A	API 5L Gr.B/ A 106 Gr. B
34.	OIL + MIBK	150#	RF	LOW PRESSURE & LOW TEMPERATURE	3.0	A9A	API 5L Gr.B/ A 106 Gr. B



SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B9A	"
35.	WAX + MIBK	150#	RF	LOW PRESSURE & LOW TEMPERATURE	3.0	A9A	"
36.	INERT GAS + MIB	150#	RF	"	3.0	A9A	"
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B9A	"
37.	WAX + CLAY	150#	RF	LOW PRESSURE & MED. TEMPERATURE	3.0	A9A	"
38.	AIR + CLAY	150#	RF	"	3.0	A9A	"
39.	WAX	150#	RF	"	3.0	A9A	"
40.	WAX + SLURRY	150#	RF	"	3.0	A9A	"
41.	SPENT CLAY	150#	RF	"	3.0	A9A	"
42.	OIL	150#	RF	"	3.0	A9A	"
43.	LPG VAPOUR	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A.10A	"
	SATURATED LPG	150#	RF	"	1.5	A10A	"
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	1.5	B1A	"
	CRACKED LPG	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A1A	"
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	1.5	B1A	"
44.	FUEL OIL	300#	RF	BURNERS	1.5/3.0	B1A/ B9A	"
	FUEL OIL (OFFSIT)	150#	RF	OFFSITES	1.5	A10A	"
45.	REF. FUEL OIL	150#	RF	OFFSITES	3.0	A9A	"
46.	HYDROGEN BEAR HYDROCARBON	150#	RF	-	1.5	A5A	"
	"	300#	RF	-	1.5	B5A	"
	"	600#	RF	-	1.5	D5A	"

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
<b>II. ACID &amp; CHEMICALS</b>							
1.	DEMULSIFIER	300#	RF	MED. PRESSURE & LOW TEMPERATURE	1.5/ 3.0	B1A/ B9A	API 5L Gr. B/ A106 Gr. B
2.	AMMONIA	150#	RF	LOW TEMPERATURE & LOW PRESSURE	3.0	A9A	"
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B9A	"
3.	CAUSTIC (10-30 Be) MAX/100	150#	RF	LOW PRESSURE & LOW TEMPERATURE	3.0	A19A	"
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B19A	"
	CAUSTIC + AMMC MIXTURE	300#	RF	"	3.0	B19A	"
4.	CORROSION INHIBITOR	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5/ 3.0	A1A/ A9A	"
	"	150#	RF	LOW PRESSURE & AMINE TREATING UNIT	1.5	A6K	A312 Gr. TP 304L
5.	PHOSPHATE	300#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B9A	API 5L Gr.B/ A 106 Gr. B
6.	RICH DEA	150#	RF	LOW PRESSURE & LOW TEMPERATURE	3.0	A19A	"
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B19A	"
7.	LEAN DEA	150#	RF	LOW PRESSURE & LOW TEMPERATURE	3.0	A19A	"
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B19A	"
8.	MEA	150#	RF	LOW/MED. PRESSURE & LOW TEMPERATURE	1.5/ 3.0	A1A/A19A	"
9.	ANTI FOAMING AGENT	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A1A	"
10.	SULPHURIC ACID	150#	RF	LOW PRESSURE & LOW	1.5	A8A	API 5L Gr. B

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
				TEMPERATURE & CORROSIVE			
11.	CHLORINE & DIL. H2SO4	150#	FF	-	NIL	A1Z	HDPE/ASTM D3035 Gr. PE 3406 CLC
12.	WET SOLVENT	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A1A	API 5L Gr.B/ A 106 Gr. B
13.	LEAN SOLVENT	150#	RF	LOW PRESSURE & MED. TEMPERATURE	1.5	A1A	"
	"	300#	RF	MED. PRESSURE & MED. TEMPERATURE	1.5	B1A	"
14.	SODIUM CARBON SOLUTION	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A3A	IS: 1239/ IS: 3589
15.	ODORANT	300#	RF	LPG STORAGE	1.5	B1A	"
16.	MEROX WASTE	150#	RF	W.W.T.P.	3.0	A9A	"
17.	POLYELECTROLY SOLUTION	150#	RF	W.W.T.P. / ETP/ TTP	NIL	A1Z	HDPE / ASTM D3035 Gr. P 3406 CLC
	"	150#	RF	"	NIL	A1K	A312 Gr. TP 304L
18.	FERROUS SULPH / SOLUTION	150#	RF	"	NIL	A1Z	HDPE / ASTM D3035 Gr. P 3406 CLC
	"	150#	RF	"	NIL	A1K	A312 Gr. TP 304L
19.	DILUTE ACID	150#	RF	"	NIL	A1Z	HDPE / ASTM D3035 Gr. P 3406 CLC
	"	150#	RF	"	NIL	A1K	A312 Gr. TP 304L
20.	ALUM. SOLUTION	150#	RF	"	NIL	A1Z	HDPE / ASTM D3035 Gr. P 3406 CLC
	"	150#	RF	"	NIL	A1K	A312 Gr. TP 304L
21.	UREA SOLUTION	150#	RF	"	NIL	A1Z	HDPE / ASTM D3035 Gr. P 3406 CLC
	"	150#	RF	"	NIL	A1K	A312 Gr. TP 304L
22.	D. A. P. SOLUTION	150#	RF	"	NIL	A1Z	HDPE / ASTM D3035 Gr. P 3406 CLC
	"	150#	RF	"	NIL	A1K	A312 Gr. TP 304L
23.	OIL EFFLUENT	150#	RF	"	NIL	"	CAST IRON

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
24.	HCL	150#	RF	DM WATER PLANT	NIL	"	FRP
	HCL	150#	RF	"	NIL	A1Z	HDPE / ASTM D3035 Gr. P 3406 CLC 7 OF 10
<b>III. AIR &amp; GAS</b>							
1.	INSTRUMENT AIR	150#	RF	"	NIL	J3A	IS:2939
2.	PLANT AIR	150#	RF	"	1.5/3.0	A3A/A14A	API 5L Gr. B
	"	300#	RF	REGENERATOR BOTTOM	1.5	B4K	A 312 Gr. TP 304H
3.	FLUE GAS	300#	RF	REGENERATOR – ORIFICE CHAMBER-CO-BOILER	1.5	B4K	"
4.	FUEL GAS	150#	RF	"	1.5	A1A	API 5L Gr.B/ A 106 Gr. B
5.	SPONGE GAS	150#	RF	FCCU	1.5	A1A	"
6.	FLARE	150#	RF	"	1.5	A1A/ A10A	"
7.	FCCU SOUR GAS	150#	RF	"	1.5	A1A	"
8.	ATU SOUR GAS	150#	RF	"	1.5	A6K	A312 Gr. TP304 L
9.	FCCU OFF GAS	150#	RF	"	1.5	A1A	API 5L Gr.B/ A 106 Gr. B
10.	FCCU SWEET GAS	150#	RF	"	1.5	A1A	"
11.	ACID GAS	150#	RF	"	1.5/ 4.5	A1A/ A6A	"
12.	INERT GAS	150#	RF	-	1.5	A3A	"
13.	TAIL GAS	150#	RF	SULPHUR PLANT	3.0	A9A	"
14.	HYDROGEN	150#	RF	"	1.5	A5A	"
	"	300#	RF	"	1.5	B5A	"
	"	600#	RF	"	1.5	D5A	"
15.	NITRAGEN	150#	RF	"	1.5	A1A	API 5L Gr.B/ A 106 Gr. B
	"	150#	RF	"	1.5	A3A	IS: 1239
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	1.5	B1A	API 5L Gr.B/ A 106 Gr. B
<b>IV. STEAM</b>							
1.	LP STEAM	150#	RF	LOW PRESSURE & LOW	1.0	A2A	A106 Gr. B

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
				TEMPERATURE			
2.	LP CONDENSATE	150#	RF	"	1.0	A2A	"
3.	MP STEAM	300#	RF	MED. PRESSURE & MED. TEMPERATURE	1.0	B2A	"
4.	MP CONDENSATE	300#	RF	"	1.0	B2A	"
5.	HP STEAM	600#	RF	HIGH PRESSURE & MED. TEMPERATURE	1.0	D2A	"
6.	HP CONDENSATE	600#	RF	"	1.0	D2A	"
7.	STRIPPING STEAM	300#	RF	REACTOR MED. PRESSURE STRIPPER	1.0	B2A/ B2D	A 106 Gr. B/ A335 Gr. P11
<b>V. TRANSFERLINES</b>							
1.	CRUDE TRANSFER	150#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	A4F	A335 Gr. P5
2.	PLATFORMATE TRANSFER	300#	RF	HIGH PRESSURE & HIGH TEMPERATURE	3.0	B4D	A335 Gr. P11
3.	KEROSENE TRANSFER	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4D	"
4.	DIESEL TRANSFER	600#	RF	HIGH PRESSURE & HIGH TEMPERATURE	3.0	D4F	A 335 Gr. P5
5.	CRACKED GAS OIL	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	"
6.	MIDDLE DISTILLATE TRANSFER	150#	RF	LOW PRESSURE & MED. TEMPERATURE	1.5	A1A	API 5L Gr. B/ A106 Gr. B
7.	LUBE TRANSFER	600#	RF	HIGH PRESSURE & HIGH TEMPERATURE	3.0	D4F	A335 Gr. P5
8.	SULPHUR TRANSF.	150#	RF	LOW PRESSURE & MED. TEMPERATURE	1.5	A1A	API 5L Gr. B/ A106 Gr. B
9.	VAC. TOWER BOTT. TRANSFER	900#	RTJ	HIGH PRESSURE & HIGH TEMPERATURE	3.0	E4F	A335 Gr. P5
10.	FOOTS OIL TRANSFER	300#	RF	LOW PRESSURE & HIGH TEMPERATURE	3.0	B9A	API 5L Gr.B/ A 106 Gr. B

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
11.	CRUBE TRANSFER	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4F	A 335 Gr. P5
12.	VGO TRANSFER	300#	RF	"	3.0	B4F	"
13.	HYDROGEN TRANSFER	300#	RF	MED. PRESSURE & HIGH TEMPERATURE	3.0	B4B	A335 Gr. P1
<b>VI. WATERLINES</b>							
1.	DESALTER WATER	150#	RF	LOW PRESSURE & LOW TEMPERATURE	3.0	A9A	API 5L Gr.B/ A 106 Gr. B
	"	3.00#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B9A	"
2.	SOUR WATER	150#	RF	LOW PRESSURE & LOW TEMPERATURE	3.0	A9A	API 5L Gr.B/ A 106 Gr. B
	"	300#	RF	MED. PRESSURE & LOW TEMPERATURE	3.0	B9A	"
3.	COOLING WATER	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A3A	API 5L Gr. B/ A 106 Gr. B As detailed in Sl. No. 4.5
4.	COOLING SEA < 50 mm WATER	150#	RF	PUMP GLAND COOLING	-	J5A	API 5L Gr. B
	" 80 mm N/B TO 600 mm N/b	150#	RF	COOLING WATER / FIRE WATER MAINS	-	J5A	IS 1239/ IS 3589 (CEMENT LINED)
5.	SERVICE WATER	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A3A	IS: 1239/ IS : 3589
6.	BOILER FEED WATER (IBR)	300#	RF	MED. PRESSURE & LOW TEMPERATURE	1.0	B2A	A 106 Gr. B
	"	600#	RF	HIGH PRESSURE & LOW TEMPERATURE	1.0	D2A	"
	"	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.0	A2A	"
7.	DM WATER	150#	RF	LOW PRESSURE & LOW TEMPERATURE	1.5	A3A	IS: 1239/ IS: 3589

SL. NO.	SERVICE	FLANGE		APPLICATION	CORR. ALL. mm	PIPING CLASS	MATERIAL
		RATING	FACING				
8.	TEMPERED WATER	150#	RF	"	1.5	A3A	IS: 1239/ IS: 3589
9.	RAW WATER	150#	RF	"	1.5	A3A	"
10.	DRINKING WATER	150#	RF	-	NIL	J4A	IS: 123(Galv.)
11.	FIRE WATER	150#	RF	-	1.5	A3A	API 5L Gr. B/ A 106 Gr. B As detailed in Sl. No. 4.5
12.	CHROMATE WATER	150#	RF	-	1.5	A3A	"
13.	OILY SEWER WASTE	150#	RF	O.W.S SYSTEM	1.5	A3A	"
14.	ACID WATER	150#	RF	D.M. WATER PLANT	1.5	A3A	"

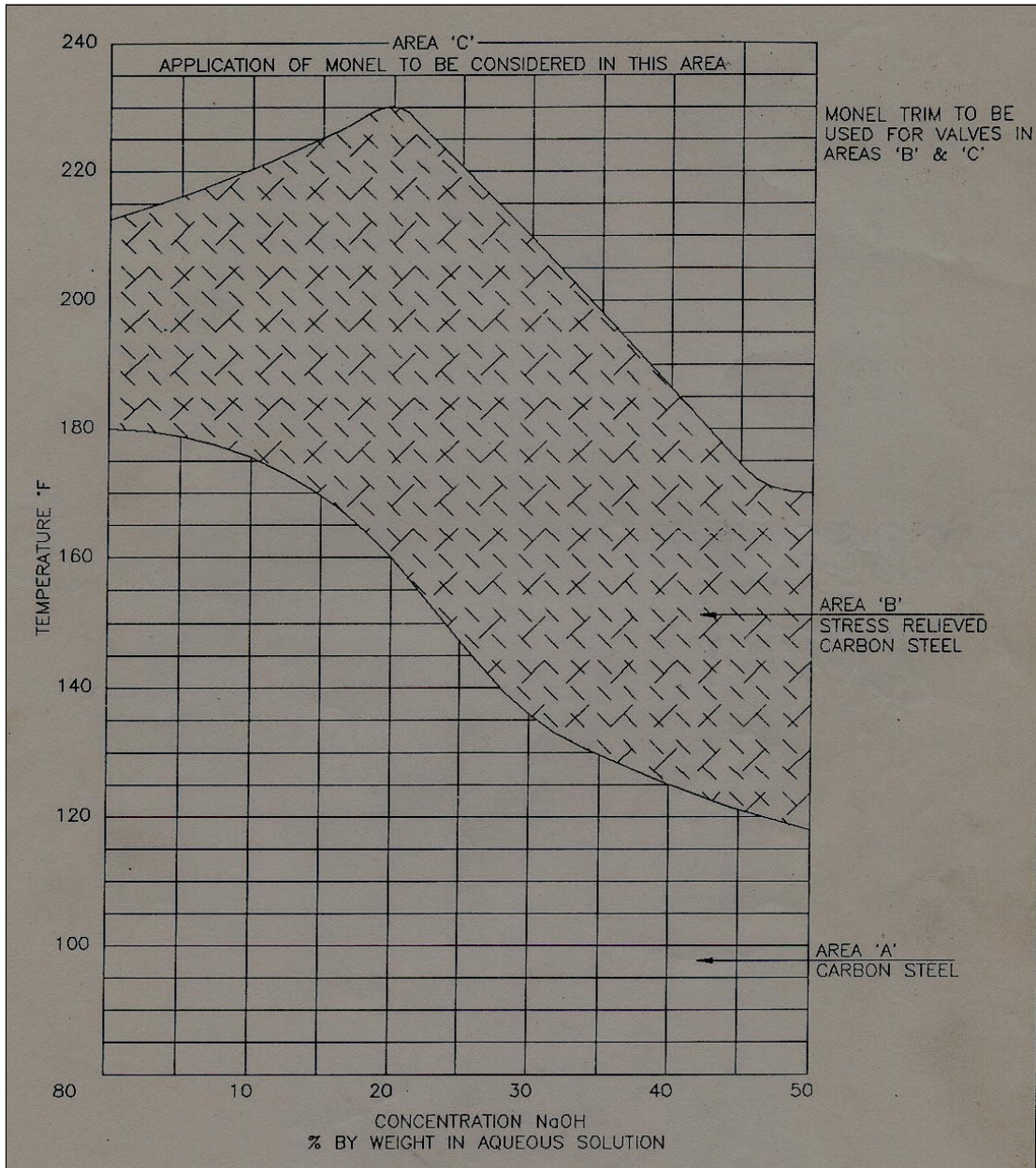
Table – 6

### STANDARD GRADES – COMPARISON TABLE

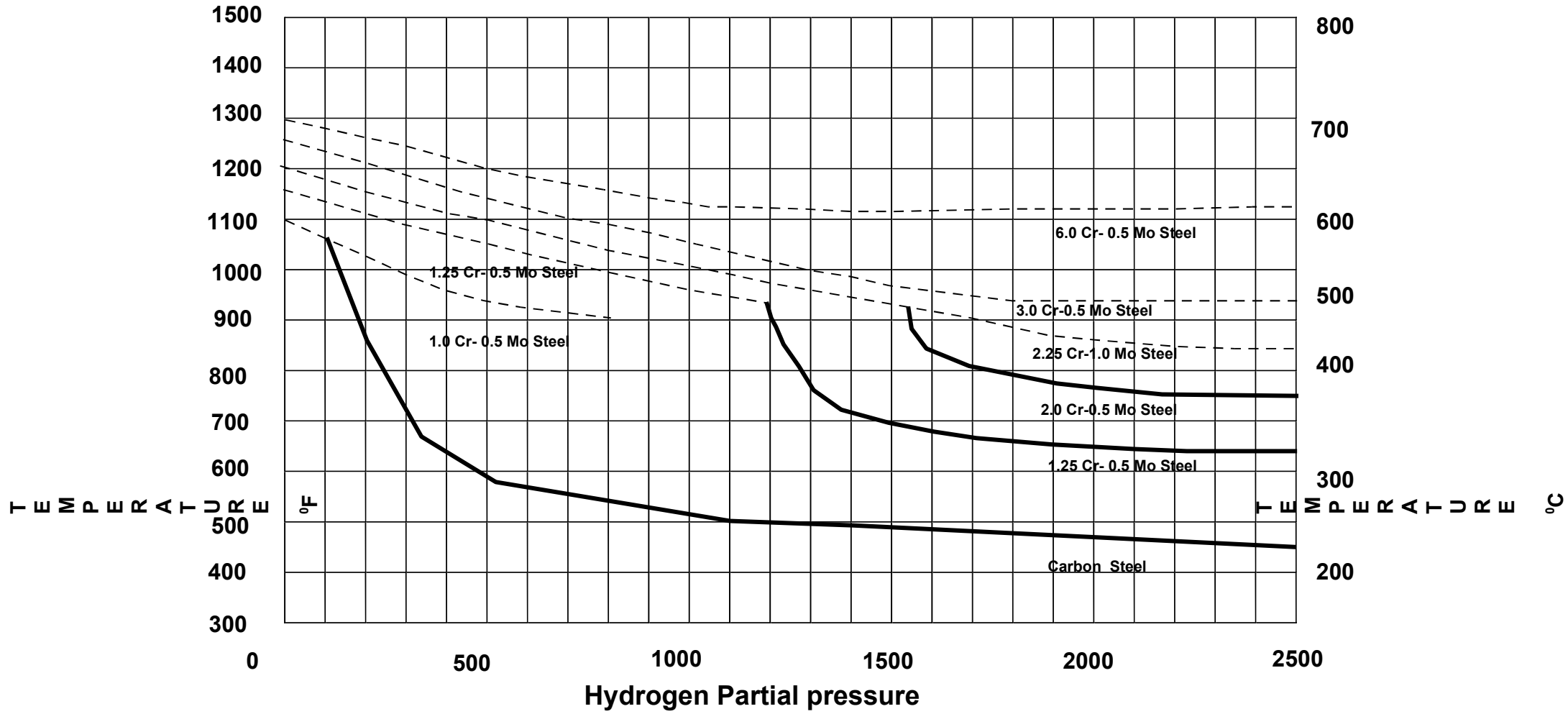
SI. No.	MATERIAL	ASTM	DIN	GERMAN MAT. NO.	BS GRADE	
1.	Carbon Steel	A 179	ST 35.8/1	1.0305	3602/1	CFS 360
2.	Carbon Steel	A 192	ST 35.8/1	1.0305	3059/2	CFS/HFS 360
3.	Carbon Steel	A 210 Gr. A1	ST 45.8/1	1.0405	3602/1	CFS/HFS 410
4.	Carbon Steel	A 210 Gr. C	17 Mn 4	1.0481	3602/1	CFS HFS 460
5.	Carbon Steel	A 106 Gr. B	ST 45.8/1	1.0305	3602/1	HFC 360
6.	Low Alloy Steel	A 209 T1	16 Mo5	1.5423	3606	245
7.	Low Alloy Steel	A 213 / A 199 T11/T12	13CrMo 44	1.7335	3604	621
8.	Low Alloy Steel	A 213 / A 199 T22	10 CrMo 910	1.7380	3059	622-440
9.	Low Alloy Steel	A 213 / A 199 T5	12 CrMo 195	1.7362	3604	625
10.	Low Alloy Steel	A 213 / A 199 T9	X12 CrMo 91	1.7386	3059/3604	629-470
11.	Low Alloy Steel	A 335 P1 / A 161 T1	16 Mo5	1.5423	3606	245
12.	Low Alloy Steel	A 335P11/ P12/ A200T11/ T1	13 CrMo 44	1.7335	3604	620-460
13.	Low Alloy Steel	A 335 P22/ A200 T22	10 CrMo 910	1.7380	3604	622
14.	Low Alloy Steel	A 335 P5 / A200 T5	12 CrMo 195	1.7362	3606	625
15.	Low Alloy Steel	A 335 P5 / A200 T5	X12 CrMo 91	1.7386	3059/2	629-590
16.	Stainless Steel	A 213/ A312 TP 304	X5 CrNi 189	1.4301	970	304 S 15
17.	Stainless Steel	A 213/ A312 TP 304L	X2 CrNi 189	1.4306	970	304 S 12
18.	Stainless Steel	A 213/ A312 TP 321	X10 CrNiTi 189	1.4541	970	321 S 12
19.	Stainless Steel	A 213/ A312 TP 316	X5 CrNiMo 1810	1.4401	970	316 S 16
20.	Stainless Steel	A 213/ A312 TP 316L	X2 CrNiMo 1810	1.4404	970	316 S 12
21.	Stainless Steel	A 213/ A312 TP 347	X10 CrNiNb 189	1.4550	970	347 S 17
22.	Stainless Steel	A 213/ A312 TP 316T1	X10 CrNiMoTi 1810	1.4571	970	320 S 17
23.	Stainless Steel	A289/ A790 UNS S31803	X2 CrNiMo 11225	1.4462		
24.	Stainless Steel	B 677 Alloy 904 L	X2 NiCrMo Cu 25205	1.4535		
25.	Nickel	B-161 Ni 200	Ni 99.2	2.4066	3074	NA 11
26.	Nickel	B 161 Ni 201	Ni 99.2	2.4068	3074	NA 12
27.	Nickel – Copper	B 163 N 04400	NiCu30Fe	2.4360	3074	NA 13
28.	Nickel – Chrom – Iron	B 163 N 06600	NiCr15Fe	2.4816	3074	NA 14



SI. No.	MATERIAL	ASTM	DIN	GERMAN MAT. NO.	BS GRADE	
29.	Nickel – Chrom – Iron	B 161 N 08825	NiCr21Mo	2.4858	3074	NA 16
30.		B 468 N 08020				
31.	Nickel – Chrom – Iron	B 163 N 08820	X10NiCrAlTi 3220	1.4876	3074	NA 15
32.	Copper Alloy	B 75 / B 111 No. 122	Si – Cu	2.0090	2871	C 106
33.	Copper Alloy	B 75 / B 111 No. 142	Cu As P	2.1491	2871	C107
34.	Copper Alloy	B 111 Ca. No. 443	CuZn28Sn	2.0470	2871	CZ 111
35.	Copper Alloy	B 111 Ca. No. 687	CuZn20Al	2.0460	2871	CZ 110
36.	Copper Alloy	B 111 Ca. No. 608	CuA15AS	2.0918	2871	
37.	Copper Alloy	B 111 Ca. No. 706	CuNi10Fe	2.0872	2871	CN 102
38.	Copper Alloy	B 111 Ca. No. 715	CuNi30Fe	2.0882	2871	CN 107
39.	Aluminium Alloys	Alloy 1050 / 1050A	A1 99.5	3.0255	1050A (1B)	
40.	Aluminium Alloys	Alloy 5754	A1Mg3	3.3535	(N5)	
41.	Aluminium Alloys	Alloy 3003	A1MnCu	3.0517		
42.	Aluminium Alloys	Alloy 5083	A1Mg4.5Mn	3.3547	5083 (N8)	

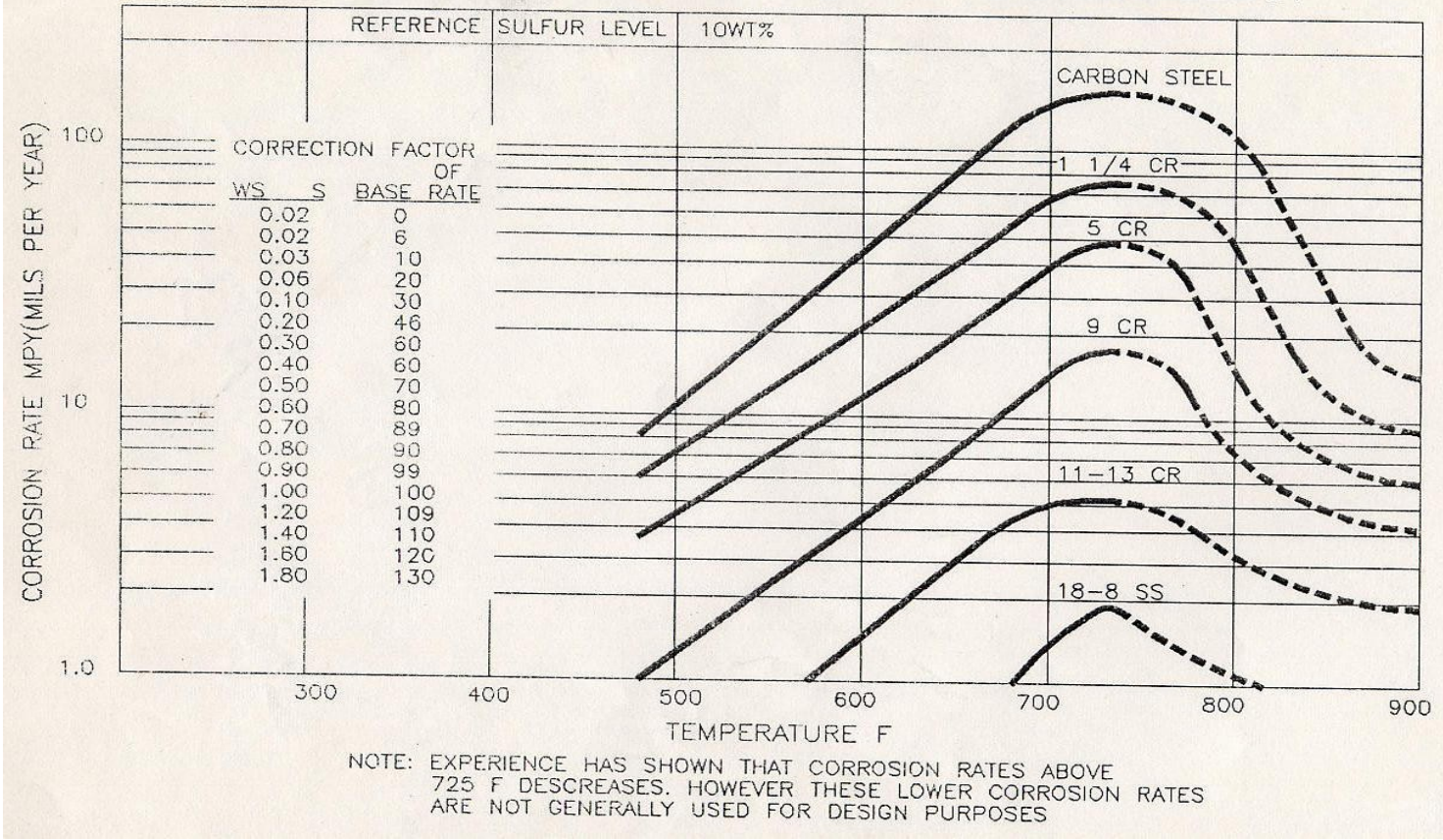


**Drawing No-1**  
**Temperature Vs. concentration limits for caustic Service**



Drawing No -2:  
Nelson Curve

# AVERAGE RATE CURVES FOR HIGH TEMPERATURE SULFUR CORROSION



**Drawing No-3**  
**Curve showing material properties for high temperature sulfur corrosion**

## 5.0 SIGNIFICANCE OF PIPING CLASS NOMENCLATURE USED BY DESIGNERS AND PMCS

In Refineries, EIL piping class is most commonly used. Therefore, the significance of each letter of the piping class is elaborated below:

### 5.1 SIGNIFICANCE FOR FIRST ALPHABET OF PIPING CLASS

e.g. PIPING CLASS – A – 1 – A – lh  
                                  |  
                                  150#

A – 150#  
B – 300#  
C – 400#  
D – 600#  
E – 900#  
F – 1500#  
G – 2500#  
J – 125/ 150#

### 5.2 SIGNIFICANCE OF SECOND LETTER OF PIPING CLASS

e.g. PIPING CLASS – A – 1 – CA – lh  
  |  
  CA

**Corrosion Allowance Table**  
[CA = Corrosion Allowance in mm]

Table 1 a (Carbon Steel) – A

No.	Details
1.	CA = 1.5
2.	CA = 1.0 (IBR)
3.	CA = 1.5 (CAT 'D' FLUIDS)
4.	CA = 1.5 (LTCS)
5.	CA = 1.5 (H <sub>2</sub> SERVICE)
6.	CA = 4.5
7.	CA = 3.0
8.	CA = 1.5 (CONC. H <sub>2</sub> SO <sub>4</sub> )
9.	CA = 3.0
10.	CA = 1.5 (OFFSITE)
11.	CA = 6.0
12.	NOT ALLOTTED
13.	NOT ALLOTTED
14.	CA = 3.0 (SPECIAL FOR FCC CATALYST)
15.	NOT ALLOTTED
16.	CA = 4.5 (NACE)
17.	NOT ALLOTTED

18.	NOT ALLOTTED
19.	CA = 3.0 (STRESS RELIEVED)
20.	NOT ALLOTTED

**TABLE 1 b (ALLOY STEEL) -B, C, D, E, F, H**

No.	Details
1.	CA = 1.5
2.	CA = 1.0 (IBR)
3.	CA = 6.0
4.	CA = 3.0
5.	CA = 1.5 (H2 SERVICE)
6.	CA = 4.5

**TABLE 1 c (SS 304 / 304L / 304H) -K**

No.	Details
1.	CA = NIL (SS 304)
2.	CA = NIL (SS 304 – CRYO)
3.	CA = NIL (SS 304H)
4.	CA = 1.5 (SS 304H)
5.	CA = 3.0 (SS 304H)
6.	CA = 1.5 (SS 304L)
7.	CA = NIL (SS 304L)

**TABLE 1 d (SS 316 / 316H / 321 / 347) – M**

No.	Details
1.	CA = NIL (SS 316)
2.	CA = 1.5 (SS 316)
3.	CA = 1.5 (SS 321)
4.	CA = NIL (SS 321)
5.	CA = NIL (SS 316H)
6.	CA = NIL (SS 316H-BW)
7.	CA = NIL (SS 347)
8.	CA = 1.5 (SS 347)

**TABLE 1 e (SS 316L) – N**

No.	Details
1.	CA = NIL
2.	CA = 1.5
3.	CA = NIL (VACUUM)

### 5.3 SIGNIFICANCE OF THIRD ALPHABET OF PIPING CLASS

e.g. PIPING CLASS – A – 1 – A – lh

|  
Material grade

#### Material List

A	– CARBON
B	– CARBON MOLY
C	– 1% CR – ½ MOLY
D	– 1-1/4% CR. – ½ MOLY.
E	– 2-1/4% CR. – 1 MOLY.
F	– 5% CR. – ½% MOLY.
G	– 9% CR. 1% MOLY
H	– 3-1/2% NI
I, J, K	– S. S. TYPE 304, 304H, 304L
M	– STABILIZED S. S. 316, 316H, 321, 347
N	– 316 L
P	– MONEL / INCONEL / INCOLOY
Q	– HASTALLOY
R	– LEAD
S	– PVC
T	– C. I. / SILICON IRON
V	– FRP
W	– CUPRO – NICKEL
Y	– LINED STEEL
Z	– HDPE

The above alphabets are also the last alphabets in piping class.

### 5.4 SIGNIFICANCE FOR LAST ALPHABET OF PIPING CLASS

e.g. PIPING CLASS – A – 1 – A – lh

|  
Insulation details

Nomenclature	Description
lh	Insulation for heat conservation
lt	Insulation for steam traced line
ls	Insulation for personal safety
lc	Cold insulation for anti condensation
le	Insulation for electrical traced line
lj	Insulation for jacketed line
lk	Insulation for dual insulation lines

In general, SS foil of 0.1mm thickness is used below the insulation on SS piping operating at higher temperature (approximately above 250 °C) and aluminium foil of 0.25mm thickness is used for lower temperatures to minimize chances of chloride leaching and aluminium embrittlement in SS piping.



## **6.0 NECESSITY OF INSPECTION**

Inspection of the piping should be carried out for the following: -

1. Need to ensure proper use of quality of raw material and fabrication to achieve desired level of reliability of the piping system and commissioning of the new facility with minimum failures.
2. To evaluate present physical condition of the pipelines for their soundness to continue in service.
3. To keep the concerned operating & maintenance personnel fully informed as to the condition of the various pipelines.
4. To determine the causes of deterioration and advise economical solution to the problem.
5. To recommend short term and long term repairs & replacements to ensure further run on the basis of economics & safety.
6. To initiate procurement action of materials to meet the repair / replacement needs.
7. To ensure that all the pipelines are being inspected as per schedule to fulfill the statutory requirements as applicable.

## 7.0 INSPECTION TOOLS

Review of document folder including the details of raw material quality certificates and release note including third party inspection certificates to ensure the quality. The most practical tools and instruments which are generally used for pipeline inspection are as under:

SI. No	Types of NDT	Types of Deterioration
1.	Inspector's Hammer	General thinning & localized thinning
2.	Ultrasonic Thickness Meter	General thinning & thickness record for life calculation
3.	Ultrasonic Flaw Detector	Flaw detection in welding and lamination in plates
4.	Pit Depth Gauge	Pitting depth measurement
5.	Measuring Tape	Measurement of dimensions & sagging, bowing etc.
6.	Radiography equipment	Weld defect
7.	Boro-scope / Fiber scope	Tube Internal inspection
8.	Holiday Detector	Paint holiday measurement
9.	Small Mirror	Assistance to visual inspection at unapproachable areas
10.	Dye Penetrant Testing Kit/ Magnetic Particle Testing Kit/ Wet Fluorescent Magnetic Particle Testing Kit	Surface & subsurface defects. Even suitable for tight fatigue cracks by WFMPI
11.	Magnifying Glass	Enlarging small pits, defects, cracks for inspection
12.	Inside and Outside Calipers	OD measurement to assess bulging
13.	Poldi Hardness Tester	Hardness measurement after SR
14.	Paint & Coating Thickness Gauges	Paint thickness monitoring
15.	Cu – CuSO <sub>4</sub> / Ag-AgCl half cell and volt-meter	Ensure soil to pipe potential for adequate cathodic protection
16.	Corrosometer	Online corrosion monitoring
17.	Online corrosion probes	Corrosion monitoring by weight loss method during shutdown
18.	Petroscanner/ Infrared or optical pyrometer	Measurement of temperature from distance
19.	Safety Torch	Improved visibility for inspection
20.	Scraper/ Emery paper/ Wire brush	Surface cleaning for inspection
21.	Magnet	Identification of ferromagnetic material
22.	Thermal Cryons,	Temperature control for

	(Temperature indicating chalk).	preheat and interpass temperature during welding
23.	Temperature indicating paint	To monitor surface temperature
24.	Intelligent pigging	Health assessment of underground cross-country pipelines

## 8.0 FREQUENCY OF INSPECTION

### 8.1 PLANT PIPING

Experience will reveal the rate of corrosion and replacement which could be planned for pipes carrying various process liquids, vapour gases like ammonia, air, steam condensate, water etc. The interval between inspections will depend upon the degree of corrosiveness or erosive-ness of the flowing fluid, remaining corrosion allowance, atmosphere prevailing around the piping, potentiality of a fire or explosion in case of leak or failure, importance of piping to operations and the statutory requirements.

Generally in a refinery, inspection of the process piping in the units is done in the capital maintenance shutdown of the units. However, seeing the corrosion rate and type of deterioration, the frequency of inspection of process piping can be reduced or increased suitably.

The frequency of piping inspection should be at least half of the calculated remaining life of the piping. This is derived by calculating the corrosion rate and remaining thickness to reach retiring thickness for the specific service.

### 8.2 OFFSITE PIPING

Pipelines where complete inspection history and construction and design details are available, the frequency of inspection as per OISD norms is given as under:

#### 8.2.1 Maximum Inspection Frequency as per OISD for Offsite Piping (Above Ground)

<b>Service</b>	<b>Frequency of Insp. In Yrs.</b>
<b>1. Hydrocarbon Service</b>	
Crude	8 (3 years for crudes having high sulphur & salts)
Flue Gas / Flare Gas	6
LPG	6
MS/ Naphtha	5
ATF/ SK/ HSD/ LDO/ Gas Oil	8
FO/ RCO/ Bitumen	4
<b>2. Utility Pipelines</b>	
Fresh Water/ Fire Water	5
Re-circulating Water	3
Steam / Air / DM Water / Caustic	8
NH <sub>3</sub> , SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub> , MEK	2
Phenol (Anhyd.), Furfural, DEA	5

## **8.2.2 Underground Pipelines**

### **Cathodically Protected Lines**

The underground pipelines having wrapping and coating and impressed current cathodic protection should be inspected whenever current leaks are observed and any damage to the coating is suspected. The damage to the coating can be located using Pearson survey. However, Pearson survey should be carried out once in 2/3 years to determine areas of pipeline coating damages. If satisfactory results are not obtained with Pearson survey, Differential Ground Voltage Gradient (DGVG) survey can also be carried out for assessment of underground pipeline coating.

### **Lines Without Cathodic Protection (Having Wrapping & Coating only)**

Condition of wrapping & coating of the underground pipelines without cathodic protection should be checked by Pearson Survey preferably once in a year but not later than three years. However, these lines should be visually inspected once in 4 years for ascertaining the condition of external wrapping and coating.

## **8.2.3 Corrosive & Costal Pipelines**

Piping in the installations which are in the coastal areas or near the corrosive environment shall be inspected visually once in a year.

## **8.2.4 Newly Constructed Pipelines**

Inspection and thickness data for newly constructed pipelines should be collected at the earliest but within two years of their construction. This will work as a base for establishing the metal loss rate of these piping.

*NB:*

*Frequency shall be reviewed for individual cases depending upon the past experience and criticality and inspection shall be done accordingly.*

## **9.0 LIKELY AREAS OF METAL LOSS AND CAUSES OF DETERIORATION**

### **9.1 EXTERNAL CORROSION**

1. Piping above ground is subjected to atmospheric corrosion.
2. Pipelines touching the ground are subjected to corrosion due to dampness of the soil.
3. External corrosion can take place at the pipe supports where gap exists between piping and supports due to crevice corrosion.
4. Deterioration takes place on the pipe supports locations where relative movement between pipe and pipe support takes place.
5. Buried pipelines are subjected to soil corrosion externally for bare pipes and at locations of damaged wrapping coatings for coated pipes.
6. Underground pipelines are prone to external corrosion due to stray currents.
7. Lines passing through the culverts, storm water drains, marshy lands are prone to corrosion due to differential aeration.
8. Impingement attack may take place on the pipelines in the vicinity of leaky pipelines.
9. Insulated lines where weather shielding is damaged or insulation is damaged; the pipes are subjected to external corrosion. This is termed as Corrosion Under Insulation (CUI). This is very severe in coastal areas and areas having high rainfall.
10. Concrete lined pipelines are subjected to corrosion due to damage and cracks in the concrete.
11. Austenitic stainless steel lines where chlorides can leach from external thermal insulation due to rain/water are prone to stress corrosion cracking.

### **9.2 INTERNAL CORROSION**

Usually a greater loss of metal thickness will be observed near a restriction in the line or a change in line direction because of the effects of turbulence or velocity. For this reason, it is required to inspect at pipe bends, elbows, tees and at restrictions (such as orifice plates and throttling valves) and also downstream of these fittings. Areas prone to corrosion, erosion and other forms of deterioration are:

1. Points at which condensation of acid gases and/or water is likely to occur.
2. Points at which acid-carryover from process operations is likely to occur.
3. Points at which naphthenic or other organic acids may be present in the process steam.
4. Points at which high sulfur streams of moderate to high temperatures exist.
5. Points at which high temperature and low temperature hydrogen attack may occur.
6. Dead ends subject to turbulence or where liquid to vapour interface or condensation occurs.
7. Valve bodies and trim, fittings, ring grooves and rings, flange faces, and unexposed threads.
8. Welded areas subject to preferential attack.
9. Catalyst, flue gas, and slurry piping.
10. Steam systems subject to "Wire-Cutting" or Graphitization or where condensation occurs.
11. Ferrous and non ferrous piping subject to stress corrosion cracking.
12. Alkali lines subject to caustic embrittlement with resultant cracking at weld joints and HAZ.
13. Areas near flanges or welded attachments, which act as cooling fins, thereby causing local corrosion because of slight temperature differences.
14. Locations where impingement or fluid velocity changes can cause local accelerated corrosion and/or erosion.
15. Chrome nickel and chrome molybdenum lines in high temperature service near points of increased stress such as bends and anchor points.
16. Austenitic stainless steel and lines where possibility of polythionic acid formation exists or where chlorides are present, are prone to stress corrosion cracking.

17. Area of steam or electric tracing that contracts pipe handling materials, such as caustic soda, where concentrated heat can cause corrosion.
18. Area immediately downstream of chemical injection points where localized corrosion might occur in the reaction zone.
19. Dissimilar metal in contact which may lead to galvanic corrosion.
20. Rubber lined and glass lined pipes may get damaged near the flanges and due to cracks and deteriorations in the linings.
21. Stagnant portion of pipelines in crude service containing high sulphur are prone to corrosion due to sulfur reducing bacteria.
22. Terminal pipelines, which have a chance of carrying sea/ ballast water.
23. Areas having low pH, high chloride ions.



# Inspection Stages & Procedures



## **10.0 INSPECTION STAGES & PROCEDURES**

### **10.1 ONSTREAM INSPECTION (PIPELINES UNDER OPERATION)**

Most of the piping can be inspected when these are in service. Onstream inspection of critical pipes and in corrosive service of the process units can be done to increase the unit run and to reduce premature failures. The piping in the offsite areas can be inspected onstream and a regular inspection programme can be drawn up. Piping having high temperature is difficult to inspect on stream. Proper inspection of these lines is done when these are under shutdown. The following factors should be taken into consideration during Onstream inspection of the piping.

#### **10.1.1 Visual Inspection**

##### **i Leaks:**

Frequent visual inspection should be made for leaks. Particulars attention should be given to pipe connections, the packing glands of valves and expansion joints.

##### **ii Misalignment:**

The piping should be inspected for misalignment. The following are some observations which may indicate misalignment.

- a) Pipe dislodged from its support so that the weight of the pipe is distributed unevenly on the hangers or the saddles.
- b) Deformation of the wall of the vessel in the vicinity of the pipe attachment.
- c) Pipe supports forced out of plumb by expansion or contraction of the piping.
- d) Shifting of base plate or shearing of the foundation bolts of mechanical equipment to which the piping is attached.
- e) Cracks in the connecting flanges or pump casings and turbines to which the piping is attached.

##### **iii Supports:**

Pipe supports should be visually inspected for the following:

- a) Condition of protective coatings or fire proofing, if any. If fire proofing is found defective, sufficient fire proofing should be removed to determine extent of corrosion.

- b) Evidence of corrosion.
- c) Distortion.
- d) General Physical damage.
- e) Movement or deterioration of concrete footings.
- f) Condition of foundation bolts.
- g) Free operation of pipe rollers.
- h) Secure attachment of brackets and beams to the supports.
- i) Secure attachment and proper adjustment of pipe hangers, if used, spring hangers loading should be checked both cold and hot and the readings obtained should be checked against the original cold and hot readings. The movement of spring supports should be monitored.
- j) Broken or otherwise defective pipe anchors.
- k) Cold pull wherever required, as per design document, should be provided in presence of inspector and proper recording should be maintained.
- l) Free operation of pulleys or pivot points of counter balanced piping systems.

**iv Vibrations:**

- a) If vibration or swaying is observed, inspection should be made for cracks in welds, particularly at points of restraint such as where piping is attached to equipment and in the vicinity of anchors. Additional supports should be considered for poorly braced small size piping and valves and for main vibrating line to which they are attached.
- b) In case of severe vibration detailed investigations should be carried out to determine the source of problems and take remedial action.
- c) Vibrations / shaking can be continuous or intermittent and both are harmful depending on the severity.
- d) If hammering sound (due to internal flow) is heard in a line, a crack may be anticipated at restrained locations or the location where hammering severity is more. The cause of hammering should be identified and corrected.

- e) Intermittent wetting due to falling of liquid from leaky valves / flanges or rainwater on bare hot piping (particularly alloy steel) have resulted in cracks, leading to fire & unit interruption. Such cases should be identified and corrective action taken.
- f) Locations of temperature fluctuation (due to mix up of two streams at different temperatures) in SS piping are vulnerable to cracks due to thermal fatigue. Process modifications to reduce temperature difference, changing the design of junction where two components at different temperatures meet, or metallurgy upgradation (like from SS to Duplex SS or Inconel, wherever feasible) would help to solve the problem.

#### **v External Corrosion**

- a) Areas susceptible to external corrosion has already been discussed. (Refer para 8.1).
- b) The grass should not be allowed to touch the piping. If possible all piping should be installed at an elevation above the grass growth height. The minimum height of 0.5M should be maintained above ground level to avoid corrosion of piping.
- c) If under the insulation or concrete lining corrosion is noticed, more areas should be exposed to know the extent of corrosion. For the pitted pipes the depth of pits may be measured by pit gauge.
- d) For assessing corrosion under insulation (CUI) of piping, modern on-line inspection methods like Lixi profiler may also be useful.
- e) For assessing the health of underground or covered areas Lamb wave technique can be used which can cover length of 60 to 80 mtrs. on both side depending on the requirement of level of deterioration.
- f) For assessing the localized crevice corrosion points at support ultrasonic testing like U STRAT can be used. In this method, angle probes are placed at 12 O' clock position of the pipe and the corrosion at 6 O' clock can be assessed by the reflected waves.

Wherever, the localized corrosion is severe, putting PVC type long lasting adhesive coat like Clock O' spring can be used.

#### **vi Bulging, Bowing & Sagging**

Lines should be checked for bulging, bowing and sagging in between the supports.

#### **vii Mechanical Damage from External Forces**

Pipes should be inspected for Dents, Scratches etc. from external sources

#### **viii Failure of Paint & Protective Coating**

Condition of paint and protective coating should be checked.

#### **ix Cracks**

Pipelines should be inspected for cracks. Particular attention should be given to areas near the weld joints.

#### **x Inspection of Insulation**

Damage of insulation should be checked for hot as well as cold lines.

#### **xi Concrete lining**

Externally concrete lined piping should be visually inspected for cracking and dislodging of concrete.

- a) The details of locations of thickness survey of a piping circuit is given in the attached sketch no. 1. These are suggested minimum requirement. Areas can be increased depending upon the thickness readings. The above methodology can be used for insulated lines.

### **10.1.2 Ultrasonic Inspection**

Ultrasonic thickness survey of the pipelines shall be carried out to ascertain the remaining wall thickness. The following guideline is suggested for the above ground pipelines.

- i Minimum 3 readings should be taken on all the bends of the piping network, at the outer curvature. One reading should be at the centre of bend and two readings in the same line on either side of this reading.
- ii Minimum one ultrasonic scan each on the straight pipes on the upstream and downstream of the bend adjacent to welding of the bend and pipe. One ultrasonic scan will consist of 4 readings (3, 6, 9 and 12 O' Clock positions). Pipelines in which there is a possibility of ballast water coming, one ultrasonic scan will consist of 6 readings (3, 5, 6, 7, 9 and 12 O' Clock positions) to scan the bottom portions where corrosion may take place.
- iii One ultrasonic scan on the entire circumference (4 reading) for every 30 meters for straight portions of the pipe and one scan on every piece of pipe.

- iv Minimum one ultrasonic scan (four readings) each on reducer / expander and their downstream on the pipe.
- v Minimum one ultrasonic scan (four readings) each on each piece of pipe.
- vi One ultrasonic scan on the pipe, downstream of valves / orifice etc.
- vii One ultrasonic scan minimum on the straight pipe for every three meters length at lower elevation portion where possibilities of collection and stagnation of carryover water exists.
- viii One ultrasonic scan on branch connections, dead ends etc. The details of locations of thickness survey a piping circuit is given in the attached sketch no.-1. The number of locations can increase depending upon the thickness readings. The above methodology can be used for insulated lines. Insulation on the lines may be removed stage wise.
- ix Thickness survey to be carried out in the piping at road crossing and dyke crossing

**NOTE:**

1. Most of the ultrasonic instruments are not explosion proof and therefore, they must be used in the areas that are free of explosive mixture.
2. On high temperature surfaces while taking the thickness measurements, adequate precautions should be taken so that instrument and transducers are not damaged.

### **10.1.3 Radiography Inspection**

The critical spots may be radiographed during operation to know the wall thickness as well as internal condition like fouling, pitting, scale etc. Radiography is highly useful when line is insulated since insulation need not be removed for doing radiography. The critical spots e.g. welding joints, spots where the nipples / small dia drain lines are welded may be radiographed to know the internal condition.

#### **Corrosion Probes**

One of the methods of measuring internal corrosion rate of piping on stream is installing corrosion probes and measuring corrosion rates.

The corrosion probes should be installed at the critical locations of important pipelines to know the rate of internal corrosion. The readings should be taken weekly and the deterioration rate should be established.

#### **10.1.4 Corrosion Coupons**

Corrosion coupons may be installed in the important and critical pipelines for assessing the internal corrosion rates. The coupons are taken out after a specified period and thoroughly cleaned. The weight loss of coupons over a specified period gives the internal corrosion rate of the pipes.

#### **10.1.5 High Temperature Piping**

Operation of piping at temperatures in the creep range may cause creep damage or deterioration of the pipe. Piping protected against excessive temperature by internal insulation, failure of insulation will result in overheating of the metal wall thereby causing hot spot. The excessive temperature greatly reduces the strength of the metal and may cause bulging, scaling and metal deterioration or complete failure.

Some hot spots can be detected by a red glow particularly if seen in dark. Portable thermometers, pyrometers, or temperature indicating crayons may be used to know the skin temperature.

Temperature Survey (using Thermography) of insulated and hot piping should be done to detect hot spots and measure the temperature. This method is very fast and inspection can be done from a distance.

#### **10.1.6 Underground Piping**

##### **Cathodically Protected Piping**

Wherever cathodic protection by impressed current is provided for underground piping, the pipe to soil potential readings should be checked using Cu-CuSO<sub>4</sub> half cell once in a month. The potential readings should be compared with original readings. A voltage of – 850m V with respect to Cu-CuSO<sub>4</sub> half-cell is considered adequate to give satisfactory protection. Polarization Potential more than – 1.2 V can cause damage and disbanding of wrapping and coating of the pipelines due to evolution of H<sub>2</sub> and can cause hydrogen embrittlement of the pipelines. To judge the adequacy of cathodic protection system, CPL (Computerized Potential Logging) may be carried out once in four years.

##### **Underground Pipelines without cathodic protection and having only wrapping and coating**

Condition of wrapping and coating should be checked by Pearson Survey. Location of damaged wrapping and coating as indicated by Pearson Survey should be dug out. External visual inspection and thickness survey should be carried out for dugout portions. Besides this, excavation shall be done at vulnerable locations like regions of low velocity, bends reducers, expanders, branch connections, dead ends.

Ultrasonic thickness survey should be carried out at these locations to know the wall thickness. For straight portion one location for every 100 M should be exposed for thickness survey. If st. portion between two bends is less than 100M, then one location in between these two bends should be exposed for inspection. Internal metal loss and fouling can also be determined by radiography. After inspection, number of locations for digging and thickness survey may be increased or decreased.

Wrapping and coating at the dug out portions shall be examined visually or by using a holiday detector. Properties of coatings e.g. mechanical strength, chemical composition, resistivity etc. should be checked by taking out a sample of coating. The stray current interference of the underground pipe should be checked by Cu-CuSO<sub>4</sub> half-cell. The incidence of stray current interference is very high in the underground portion of cathodically protected and non cathodically protected pipelines which are separated by insulating flanges / couplings. This interference current causes severe damage in the unprotected line at the point of discharge, if the wrapping and coating is damaged. As such, this location should be inspected by exposing them once in a year.

All lines should be inspected at and just below the point where these enter the earth and concrete slab because serious corrosion occurs at these locations due to differential aeration.

### **Marine and Terminal Pipelines**

Marine and terminal piping which have a chance of carrying seawater ballast should be visually inspected and thickness surveyed. These lines are most prone to corrosion in the bottom portion of the lines. The corrosion may be in the form of pitting. Underwater marine lines should be thoroughly inspected for external corrosion and deterioration. Potential readings for the cathodically protected marine lines should be checked once in a month with silver-silver chloride half-cell.

For cross country piping during each pigging, analysis of pig run residue may be carried out to know the effectiveness of corrosion inhibitor and to know whether internal corrosion is taking place or not.

Instrumented pig survey (IPS) for the internal as well as external corrosion may be carried out for entire piping network. The frequency of such inspection may be decided based on experience and the data collected. To collect base line data, it is a good practice to do IPS on the newly constructed pipelines.

Internal corrosion monitoring of the lines can be done by exposing corrosion coupons and installing corrosion probes, at vulnerable locations.



## **10.2 INSPECTION DURING SHUTDOWN**

Shutdown inspection of pipelines relates to the inspection of the lines when it is not carrying product. Valves and other fittings in the network can be taken out. During the shutdown inspection, the visual, ultrasonic, radiographic inspections as detailed for on-stream inspection additional inspections like hammer testing, internal inspection, hydrostatic testing which can only be carried out during shutdowns.

Austenitic SS piping where there is a chance of stress corrosion cracking due to formation of polytheonic acid should be kept under inert atmosphere. If at all they are to be opened to atmosphere, passivation of the SS piping should be done, as per NACE standard RP-01-70.

### **10.2.1 Internal Corrosion, Erosion & Fouling**

Piping can be opened at various places by removing valves or flanged locations to permit visual inspection. Thorough visual inspection should be carried out for corrosion, erosion and fouling.

The nature and extent of internal deposit should be noted. Samples may be collected for chemical analysis.

In some of the vulnerable locations like piping in water, phenol, steam services where pitting type of corrosion takes place and ultrasonic thickness survey and radiography does not reveal the true picture of internal condition of pipes, samples should be cut for thorough internal examination. The sample should be split open into two halves and internal surface is inspected for pitting, grooving etc. the internally strip lined bends and pipes should be visually examined for bulging, cracking, weld defects etc. thickness of the strip may be measured to find out thinning of the strips.

### **10.2.2 Cracks**

Welds, heat-affected areas adjoining welds, points of restraint or strain, areas subject to stress corrosion cracking, hydrogen attack and caustic embrittlement should be carefully inspected for cracks. For spot check, dye penetrant and magnetic particle inspection should be used. Alloy and stainless steel pipings need special attention. In-situ metallography at critical spots may also be done. Magnifying glass can be used for cracks detection.

### **10.2.3 Misalignment**

If misalignment of piping was noted during operation, the cause should be determined. Misalignment is usually caused by:

- i Inadequate provision for expansion
- ii Broken or defective anchors
- iii Excessive friction on sliding saddles, indicating lack of lubrication or necessity of rollers
- iv Broken rollers or inability of rollers to turn because of corrosion or lack of lubrication.
- v Broken or improperly adjusted hangers
- vi Hangers which are too short and thus limit movement of the piping can cause lifting of the piping

The causes of misalignment which could not be corrected during on-stream should be attended during the shutdown.

#### **10.2.4 Inspection on Gasket Faces of Flanges**

The gasket faces of flange joints which have been opened should be inspected visually for corrosion for defects (such as scratches, cut and gouges) which might cause leakage. Grooves and rings of ring gasket joints should be checked for defects like dents, cut, pitting and grooving.

#### **10.2.5 Flange Fasteners**

Ensuring the proper positioning of fasteners and use of correct length of fasteners for engagement and protrusion is also of utmost importance to ensure proper tightening of the flange joints. Some of the precautions are given below:

- a. Short bolting in length as well as dia. should be checked – minimum of one thread should be out of nut surface in both ends.
- b. Precautions for embedded flanges should be taken – length of studs going inside the threaded hole of integral flange should be monitored.
- c. For RTJ flanges, ring material, hardness & ring face should be checked.
- d. Use of tightening tools like torque wrench, bolt tensioner etc as specified / required should be mentioned.

#### **10.2.6 Hot Spots**

Where hot spots on internally insulated pipe were noted during operation, the internal insulation should be inspected visually for failure, the pipe wall at the hot spot should be inspected visually for oxidation and scaling. The scale should be removed to sound metal and area should be checked for cracks. The thickness should be measured to assure that sufficient thickness is left for the service. The

outside diameter of piping in high temperature service should be measured to check for creep. Deformations.

### **10.2.7 Thickness Measurements**

Thickness of inaccessible pipe in high temperature service which could not be measured by radiographic or ultrasonic instruments during operation can be measured during shutdown.

### **10.2.8 Hammer Testing**

Hammer testing may also be carried out to supplement visual and ultrasonic inspection. The health of the lines can be determined by the sound produced by the hammer strike and the size of indentation. However, while doing hammer testing the following points should be considered:

- i Hammer testing of pipe, valves and fittings of cast iron and stress relieved lines in caustic and corrosive service should not be carried out.
- ii Care should be taken not to hammer hard enough to damage otherwise sound piping.
- iii Hammer testing should not be performed on glass-lined pipes.
- iv Only inspection hammer (2 lb weight) should be used.
- v Hammer testing should not be done on the charged lines and lines under pressure.
- vi Hammer testing of some alloys can cause stress corrosion cracking.

### **10.2.9 Hydrostatic Testing**

The underground piping may be hydrostatically pressure tested once in five years to ascertain their condition. Excessive pressure drop during hydrostatic test may indicate presence of leak in the underground piping. The hydrostatic testing may be done section wise isolating the section by valves. Adequate arrangements should be made to dispose the water after the testing. Necessary precautions should be taken while hydrostatically testing the pipelines. For details of hydrostatic testing para 10.8 may be referred.

## **10.3 STATUTORY INSPECTION**

Piping replacement and modifications being carried out in steam lines falling under the purview of IBR authorities need to be executed & certified by IBR authorized Agencies & Inspector. The material used for

the above job shall also conform to IBR requirements. For new Projects, the approval for the steam piping drawings needs to be obtained from IBR authorities at the beginning of the Project. Execution and certification will be same as above.

# Quality Assurance Plan for New Constructions



# QUALITY ASSURANCE PLAN FOR NEW CONSTRUCTIONS

Quality assurance plan of new facilities needs attention right from the design stage, P&ID review, checks during detail engineering, construction quality control. Selection of the commissioning team and the leader is also vital to ensure quality of the final facility. The major areas to be looked into during these stages are suggested as under.

## 11.1 QUALITY ASSURANCE DURING DESIGN STAGE

The finalization of design basis has to be done with meticulous care. The specification and Front End Engineering Design (FEED), procurement, construction and commissioning stages need adequate involvement of project team.

The PFD and P&ID reviews and layout checks are also need to be reviewed critically. The Isometrics and General Arrangement Drawings (GADs) developed by the detailed engineering contractor also needs thorough review.

Quality Assurance Plan (QAP) should be developed in advance to ensure reliability of the new facility. The stages of QAP should include systematic review of the following depending on the criticality:

- Purchase order, drawings and specifications.
- Approval of QAP.
- Manufacturing process.
- Heat treatment.
- Chemical composition.
- Product analysis.
- Tensile strength.
- Hydrostatic test.
- Transverse tension test.
- Dimensions.
- Workmanship, finish and appearance.
- Marks and abrasion.
- End finish.
- Product marking.
- Packing.
- Documentation.
- Release note.

The QAP should clearly define the role and responsibility of the Manufacturer, Third Party Inspector, PMC and Owner.

Some specific points have been listed below based on the recent experiences of commissioning of new facilities. These aspects should

also be taken care of during the design stage to ensure reliability of the new facilities.

- (1) All small bore pipings and tracer lines, size  $\frac{3}{4}$ " and below should be welded by TIG process for all types of joints, e.g. butt, socket, tee, etc. to ensure proper quality of welding. Use of half coupling may be considered to increase reliability of small-bore connections.
- (2) Minimum thickness of pipe for sizes upto 1½" should be Sch.80 for CS and AS.
- (3) Reinforcement pad shall be provided at support location.
- (4) Steam drain points should be routed to a drain header and taken out of the unit area.
- (5) As far as possible long trunion types of supports more than 500mm long are to be avoided. In case of long trunion supports are unavoidable in straight length of pipe, it is to be provided with reinforcement pad on the pipe.
- (6) Stiffener should be provided in small bore bleeder/ drain point connection welded to immediate upstream or downstream of safety valves.
- (7) Fire fighting points are to be provided at higher elevation in case of tall columns, structures.
- (8) As far as possible, stub-in type branch connection are to be provided when branch size is less than one size than the main pipe.
- (9) All the reinforcement pad telltale holes should be drilled and tapped properly. Gas cut holes should not be accepted.
- (10) Wherever two phase flow in piping is expected, piping design including its support system should be checked w.r.t. most adverse conditions/ ratio of both the phases (slug flow) to avoid line vibration during operation.
- (11) In the Heaters having steam air decoking provision, the main lines and decoking lines should be supported in such a fashion so that either of the lines should not remain unsupported in the hanging position when remaining disconnected.
- (12) The supports welded on insert plates in the RCC columns should be checked for their adequacy to bear the required loads and movements of the system. The insert plates should be fixed with anchor fasteners grouted in RCC column.

- (13) Insulation windows for inspection and thickness survey are to be provided in insulating piping of more than 6" diameter at all approachable location with provision of caps to avoid ingress of water.
- (14) Wherever insulation is to be provided on piping for human safety, it should be replaced by a cage of 1" GI wire mesh wrapped around the piping with the help of spacers tack welded on the wire mesh.
- (15) All the fittings like valves, flanges etc. in high temperature service ( $> = 300\text{ }^{\circ}\text{C}$ ) should also be fully insulated if they are in open area or the localized cooling can cause operational problems like coking etc.
- (16) All SS piping should have chloride free insulation or preferably should have SS foil wrapped between pipe and insulation.
- (17) Branch connections for fire hydrants along the roads should be totally above grounds. Hydrant connections also should remain above ground.
- (18) Firewater and cooling water lines emerging from underground should be wrapped coated beyond the ground level upto a length of 500mm.
- (19) No cast iron valves should be used in firewater or any other service.
- (20) Hard surfacing with a proper slope towards open drain system is to be provided beneath the offsite pipe rack area with a clear space of 500mm from bottom of the pipe.
- (21) Interspacing between the offsite piping on the support pedestal should be such that the lines should not touch each other even after insulation (at least 3" gap after insulation).
- (22) Identification marks for location/ visibility of drain points of offsite piping should be provided. All drain points should be approachable and clearly visible.
- (23) Long lengths of vent and drain piping should be properly supported w.r.t. main pipe. Instrument piping connected to orifice flange should be directly supported with the pipe so that during expansion / contraction, the whole assembly moves with the pipe.
- (24) Piping insulation ends should be properly sealed to avoid water ingress.
- (25) Hard surfacing under the piping bay in offsite areas should be done with proper slope & drainage facility.



- (26) Proper slope and gap should be provided in piping culverts to avoid water logging.
- (27) In fire water lines, the hydrant tapping should not be taken from the bottom side of pipe. Tapping should be taken from the top or from side.
- (28) Removal of temporary supports and left over construction material should be removed before Hydrostatic test of the line.

## **11.2 QUALITY ASSURANCE DURING CONSTRUCTION STAGE**

In spite of best efforts in the design stage, the quality of new facilities can't be assured without proper involvement of Inspection & Project team of the Owner. The selection of the Project team and commissioning team is the most vital aspect for the successful commissioning of the new facility and unfortunately is the most neglected in our case.

The Owner supervision during construction can't be diluted inspite of having PMC, EPC or LSTK contractors.

The Third Party Inspection Agencies, wherever employed, should be different from the executing agency.

Although, the involvement of Owner's representative can't be spelt out however, to mention few one must take care of the followings:

- (1) Spring type supports should be unlocked and cold set prior to commissioning of the system by the contractor as per the instructions of spring support manufacturer in presence of PMC/ Owner's representative.

A complete list of all the spring supports in a particular units is to be compiled alongwith relevant documents & details and submitted to XXX Inspection & Maintenance Department prior to Mechanical completion of the Project.

Movement of the spring supports to be closely observed during startup and recorded till system attains its maximum operating temperature.

- (2) The structural layout and erection should take care of adequate gap for piping, considering insulation and expansion movement of piping.
- (3) All the mating flanges connecting to equipment like – Columns, Vessels, Heat Exchangers, Pumps, Compressors etc. are to be welded after proper alignment and leveling of terminal equipment to avoid the misalignment and tension at nozzle flanges.

- (4) Piping passing through technology structure (RCC floors) or passing near the concrete column etc. should have adequate annular space to avoid restriction of line movement during thermal expansion. The gap should be taken care for hot lines alongwith insulation thickness.
- (5) All the RTJ ring gaskets should have proper identification marking with metallurgical certificate available.
- (6) Positive Material Identification (PMI) should be carried out for all the components of Alloy Steel, Stainless Steel and other higher metallurgy piping and checked on three-tier basis to ensure correct metallurgy. First at supplier's shop, second at our stores and third after fabrication & erection at site. The properly identified material should be given a distinct colour by supplier before dispatch to avoid any mixing with other material. Third Party Inspector should also certify PMI.

Part of the weld joints should also be carried out for Alloy Steel/ Stainless Steel circuits in-situ. This should be incorporated in the contract.

- (7) Electrical resistance coils should be used for pre heating/ post heating of all the alloy steel welding of dia. 2" and above. Pre heating/ post heating should be made mandatory for all the alloy steels irrespective of fillet/ butt weld sizes.
- (8) Temperature recorders used in stress relieving should be calibrated and the related certificate should be available at site for verification.
- (9) Contractor, who is awarded the work involving use of low hydrogen electrodes, must have a furnace suitable for baking of electrodes at 300 °C.
- (10) Welding of alloy steel butt weld joints should not be left incomplete for long hours. Earlier in few cases, only root run was done on a day and remaining welding was planned next day. Next day the partially welded joints were found cracked.
- (11) Cold pull if provided should be specifically certified by Engineer-in-charge/ Inspector.
- (12) All critical service gate/ globe/ check valves should be site tested prior to installation.
- (13) All the supports of a piping system should be checked for their correctness and adequacy after complete installation by the Designer to avoid any problem during operation.

(14) Flushing should be done properly after dropping the safety valves and control valves etc. to avoid any ingress of foreign material. Proper flushing to the satisfaction of Production Department should be part of main contract.

(15) All piping system should be drained and air flushed after hydrotesting.

**(16)** A list of all expansion bellows installed area wise alongwith spares supplied should be handed over to XXX Inspection & Maintenance Department by consultant/ contractor.

Bellows should be checked for proper supporting.

Bellows shall be unlocked prior to commissioning in presence of PMC/ Owner's representatives.

(17) Distinct colour code to be used for different materials (including IBR materials) for piping and fitting. On the pipes, the colour strips shall cover the full length of pipe and bends. This colour marking shall be part of purchase order for compliance at the supplier's end.

(18) Piping circuits falling under the purview of statutory inspection like IBR should be executed & certified by IBR authorized Agencies & Inspectors.

## Inspection of Piping during Fabrication



## **12.0 INSPECTION OF PIPING DURING FABRICATION**

During erection of piping, it is very essential to inspect the condition of the pipes before use. Detail inspection of material, size, dent, external corrosion, quality must be carried out during fabrication. The various checks to be carried out during erection are given in the following chapters:

### **12.1 INSPECTION OF PIPES BEFORE USE**

#### **New Pipes**

- i Check from the documents as well as site to ensure that right material is being used as per the requirements. Some piping systems such as those used in steam generation may be subjected to other regulatory requirements.
- ii Check for pipe size (mainly diameter) and wall thickness. The variations should be within the permissible limits as given in the appropriate code & specification.
- iii It is desirable to use half coupling (socket welded or screwed) of 3000 class alongwith schedule-80 nipples for instruments tapings.

#### **Old Pipes**

In case old pipes are to be installed in a pipe lines system:

- i The pipe must be of a known specification.
- ii There must not be any buckling.
- iii There must not be any cracks, grooves, dents or other surface defects that exceed the maximum permissible limits as per various codes.
- iv The old pipes should be checked for hardness.

### **12.2 INJURIOUS DEFECTS**

Pipe shall be inspected before assembly into the mainline or manifold. Distortion, buckling, denting, flattening, gouging, grooves or notches and all harmful defects of this nature shall be prevented, repaired or eliminated as per the specifications. However, as a guideline "clause for injurious defects" in ANSI 31.4 is reproduced below:

1. Injurious gouges, grooves, or notches shall be removed. These injurious defects may be repaired by use of welding procedures prescribed in API 5L or 5LX, or removed by grinding, provided the

resulting wall thickness is not less than that permitted by the material specification.

2. When conditions outlined above cannot be met, the damaged portion shall be removed as a cylinder. Insert patching is not permitted. Weld on patching, other than complete encirclement, is not permitted in pipelines intended to operate specified minimum yield strength of the pipe.
3. Notches or laminations on pipe ends shall not be repaired. The damaged end shall be removed as a cylinder and the pipe end properly rebevelled.
4. Distorted or flattened lengths shall be discarded.
5. A dent (as opposed to a scratch, gouge, or groove) may be defined as a gross disturbance in the curvature of the pipe wall. A dent containing a stress concentrator, such as a scratch, gouge, groove or arc burn shall be removed by cutting out the damaged portion of the pipe as a cylinder.
6. All dents which affect the curvature of the pipe at the seem or at any girth weld shall be removed. All dents which exceed a maximum depth of  $\frac{1}{4}$  inch (6 mm) in pipe NPS 12 and smaller or two percent of the nominal pipe diameter in sizes greater than NPS 12, shall not be permitted in pipelines intended to operate at a hoop stress of more than 20 percent of the specified minimum yield strength of the pipe. Insert-patching, overlay, or pounding out of dents shall not be permitted in pipelines intended to operate a hoop stress of more than 20 percent of the specified minimum yield strength of the pipe.
7. Buckled pipe shall be replaced as a cylinder.

### **12.3 FORMING OF PIPES**

1. Bends shall be made from a pipe in such a manner as to preserve the cross-sectional shape of the pipe and shall be free from buckling, cracks or other evidence of mechanical damage.
2. If a pipe containing a longitudinal weld, the longitudinal weld must be as near as practicable to the evidence of mechanical damage.
3. Pipe bends designed as creased or corrugated shall not be used under severe cyclic conditions.
4. Mitre Bends

Care should be taken in making mitred joints to provide proper spacing and alignment and full penetration weld joints.

5. Flattening of the bends should be avoided and limits should be as per the specifications of pipes.
6. Dimensions and tolerances of fabricated and forged bends should be checked as per the given specifications. However, these should be checked for quality, wrinkles, cracks etc. thickness at the outer curvature should be measured to determine the reduction of thickness during forming operation. Make sure that the proper type of bend is being used in the piping system as per the drawing.

## **12.4 WELDING**

For joint fit-up, welder's qualifications, welding procedure qualification and inspection prior to welding and during welding, preheat and post-weld heat treatment, IOC "Welding Manual" may be referred.

## **12.5 INSPECTION AFTER WELDING**

- i After welding, all the weld joints and HAZ should be visually checked preferably after removing the ripples for cracks and defects. If required dye penetrant test may be carried out.
- ii Radiography
  - A) Radiography of the weld joints should be carried out as per the specifications.
  - B) 100% of girth welds shall be inspected by radiographic or other accepted NDT methods in the following cases:
    - i With populated areas such as residential subdivisions, shopping centers, and designated commercial and industrial areas.
    - ii River, lake and stream crossings within the area subject to frequent inundation, and river, lake and stream crossings on bridges
    - iii Railroad or public highway rights of way, including tunnels, bridges, and overhead railroad and road crossings
    - iv Offshore and inland coastal waters
    - v Old girth welds in used pipe
  - C) Radiography examination shall be carried out after final heat treatment where the later is done. However, it is a good practice to carryout radiography or other NDT methods of welds before and after the post weld heat treatment.

- iii The welding may be checked ultrasonically in lieu of radiography. The only limitation of ultrasonic examination is that no permanent records are available. Acceptability of welds in radiographic and ultrasonic examinations should be found out as per the relevant codes.
- iv All radiographs of welds shall be preserved for a minimum period of 5 years prior to disposal.

## **12.6 SUPPORTS**

Check for proper supports as per engineering drawings. The following information is given for general guidance.

- i Supports should be placed as near as practicable to changes in direction (lateral or vertical).
- ii Supports should be provided for piping sections which require frequent dismantling for maintenance such as installation of blanks etc.
- iii Piping that discharge to the atmosphere should be firmly anchored to counteract the reaction force of discharging fluid.
- iv The clear space around bends, loops and pipe terminal ends should be sufficient to allow free movement of these portions on thermal expansion.
- v Preferably, supports should not be welded directly to pipe except anchor supports.
- vi While checking the supports, the shoe of pipelines and their positioning with respect to support should also be checked in both hot as well as cold conditions.
- vii The shoe on the pipelines should be fully welded to the pipe. Otherwise corrosion may take place in space between pipe and the shoe.
- viii All the lines in the coastal refineries should be provided with fully welded 120° circumference pads at all the pipe supports locations to protect the lines from external crevice corrosion.

## **12.7 PRESSURE TESTS**

The piping system should be pressure tested after all the welding jobs on the line have completed. After pressure testing, if is not advisable to do any welding jobs on the tested pipe. In the event of repairs or



additions are made following the tests, the affected piping shall be retested.

### **12.7.1 Test Fluid**

The Test shall be hydrostatic using water, except for the following:

- a) If there is a possibility of damage due to freezing or if the operating fluid or piping material would be adversely affected by water, any other suitable liquid may be used. If a flammable liquid is used its flash point shall not be less than 50°C, and consideration shall be given to the test environment.
- b) If hydrostatic testing is not considered practicable, a pneumatic test may be substituted using air or another non-flammable gas.

### **12.7.2 Test Preparation**

- a) All joints including welds are to be left uninsulated and exposed for examination during the test.
- b) Piping designed for vapour or gas shall be provided with additional temporary support, if necessary, to support the weight of test liquid.
- c) Expansion joints shall be provided with temporary restraint if required for the additional load under test or shall be isolated from the test.
- d) Equipment which is not to be included in the test shall be either disconnected from the piping or isolated by blinds or other means during the test. Valves may be used provided the valve (including the closure mechanism) is suitable for proposed test pressure.
- e) Relief valves and rupture discs should not be subjected to the pressure test.
- f) If a pressure test is to be maintained for a period of time and test liquid is subjected to thermal expansion, precautions shall be taken to avoid excessive pressure.
- g) All pressure gages, flow meter etc. and other pressure parts of connected instruments shall also be tested at the pressure at least equal to that of line.
- h) Pressure Gages
  - i) A minimum number of two pressure gages should be used for pressure tests one to be installed at the pressurising point and the other at the farthest / highest point.

- ii The range of each pressure gage should be such so that the required pressure reading falls in the area of one-third to two third of the range of dial.
- iii Correctness of pressure gages should be ensured. Only properly calibrated / tested pressure gauges should be used.
- i) During liquid pressure testing all air should be expelled from the piping through vents provided at all high points.
- j) The increase of pressure should be gradual to avoid any shock and resultant failure.
- k) There should not be any leakage in the pressurizing system.

### 12.7.3 Test Pressure

#### Hydrostatic Testing of Internally Pressured Piping

- i Completed piping shall be pressure tested as per the code and regulatory laws using potable water as test fluid. DM water or passivating solution should be used for stainless steel piping.
- ii Unless otherwise specified in the engineering design, the hydrostatic test pressure shall be 1 ½ times the design pressure.
- iii For a design temperature above the test temperature by the following formula:

$$P_T = \frac{1.5 P S_T}{S}$$

Where

- $P_T$  = Minimum hydrostatic test pressure (gage)
  - $P$  = Internal design gage pressure
  - $S_T$  = Allowable stress of pipe material at test temperature
  - $S$  = Allowable stress of pipe material at temperature
- When  $S_T/S$  is greater than 6.5, 6.5 shall be used for the value of  $S_T/S$  for the calculation purposes.

- iv Where design pressure is not known the minimum hydrotest pressure shall be 1 ½ times of the pump shutoff pressure or maximum operating pressure of the pipeline whichever is higher.
- v All reinforcing pads on pressure openings should be tested with air at 25 psig. The test openings should not be plugged following the test.
- vi Hydrotesting of ferritic and Martensitic steels should be avoided when atmospheric temperature is below 10 °C. This is due to

possibility of brittle fracture caused by ductile to brittle transition below 10 °C.

### **Hydrostatic Testing of Piping with Vessels as a System**

- i Where the test pressure of piping attached to a vessel is same as or less than the test pressure for the vessel, the piping may be tested with the vessel at the test pressure of the piping.
- ii 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, then the piping and the vessel may be tested together at the test pressure of the vessel, and provided the vessel test pressure is not less than 115% of the piping design pressure adjusted for temperature.

### **Hydrostatic Testing of Externally Pressured Piping**

- i Lines in external pressure service shall be subjected to an internal test pressure of 1 ½ times the external differential design pressure but not less than a gage pressure of 15 psi.
- ii In jacketed lines, the internal line shall be pressure tested on the basis of the internal or external design pressure, whichever is critical, this test must be performed before completion of the jacket if necessary to provide visual access to the joints of the internal line.
- iii In jacketed lines the jacket shall be pressure tested on the basis of jacket design pressure unless other wise limited by the engineering design.

### **Pneumatic Testing**

If the piping is tested pneumatically the test pressure shall be 110% of the design pressure. Pneumatic testing involves the hazard due to possible release of energy stored and compressed gas. Therefore particular care must be taken to minimize the chances of the brittle failure during the testing. The test temperature is important in this regard and must be considered when the choice of material is made in the original design. Any pneumatic test shall include the preliminary check at not more than 25psi gage pressure. The pressure shall be increased gradually in steps providing sufficient time to allow the piping equalizes strains during the test to check for leaks.

#### **Note:**

- i The pressure shall be maintained for a sufficient time not less than 10 minutes to determine if there are any leaks.

- ii Zero pressure drop are shown by pressure gages is not sure criterion for deciding the success of hydro-test. Minor seepage may not be reflected in the pressure gage. All the joints and exposed surfaces should be inspected and thoroughly checked.
- iii Systems (such as underground lines) that cannot be inspected visually for leaks should be tested by applying the desired pressure and then removing the source of pressure. The pressure drop, observed for an extended period, will be an indication of system tightness. However, lengthy test periods may require temperature corrections, when employing this method, pressure recorders are used to furnish a permanent record of test.
- iv After Hydrotesting, the water should be completely drained. The rate of depressurizing should be slow.
- v Warning: Hammer testing of equipment undergoing pressure test may cause failure resulting in possible injury to those performing the test.

#### **12.7.4 Pressure Testing of Liquid Petroleum Transportation Piping System**

##### **Hydrostatic Testing of Internal Pressure Piping**

- a) Portions of piping systems to be operated at a hoop stress of more than 20 percent of the specified minimum yield strength of the pipe shall be subjected at any point to a hydrostatic proof test equivalent to not less than 1.25 times the internal design pressure at that point for not less than four hours. When lines are tested at pressures which develop a hoop stress, based on nominal wall thickness, in excess of 90% of specified minimum yield strength of the pipe, special care shall be used to prevent overstrain of the pipe.
  - 1 Those portions of the piping systems where all of the pressured components are visually inspected during the proof test to determine that there is no leakage require no further test. This can include lengths of pipe, which are pretested for use as replacement sections.
  - 2 On those portions of piping system not visually inspected while under test, the proof test shall be followed by a reduced pressure leak the internal design pressure for not less than four hours.
- b) API RP-1110 may be used for guidance for the hydrostatic test.
- c) The hydrostatic test shall be conducted with water except liquid petroleum that does not vapourize rapidly may be used, provided;

- 1 The pipeline section under test is not offshore and is outside cities and other populated areas and each building within 300 feet (90 meters) of the test section is unoccupied while the test pressure is equal to or greater than a pressure which produces a hoop stress of 50 per cent of the specific minimum yield strength of the pipe.
  - 2 The test section is kept under surveillance by regular patrols during test; and
  - 3 Communication is maintained along test section.
- d) If the testing medium in the system will be subject to thermal expansion during the test, provisions shall be made for relief of excess pressure. Effects of temperature changes shall be taken into account when interpretations are made of recorded test pressure.
- e) After completion of hydrostatic test, it is important in cold weather, that the lines, valves and fittings be drained completely of any water to avoid damage due to freezing.

### **Leak Testing**

One-hour hydrostatic or pneumatic leak test may be used for piping systems to be operated at a hoop stress of 20 percent or less of the specified minimum yields strength of the pipe. The hydrostatic test pressure shall be not less than 1.25 times the internal design pressure. The pneumatic test gage pressure shall be 100 psi (7 bars) or that pressure which would produce a nominal hoop stress of 25 percent of the specified minimum yield strength of the pipe, whichever is less.

## **12.8 PAINTING**

After successful hydrostatic testing, the pipelines are externally painted to provide protection against external corrosion. While painting, the following points may be kept in mind:

- i Proper surface preparation

The surface should be free of moisture, dust, soil, rust, oil grease etc. sand blasting/shot blasting method should be preferred wherever practicable. After sand blasting, the surface should not be left unprimed for more than 4 hrs.

- ii Dry Film Thickness

This should be checked in accordance with the technical specification for primer as well as total dry film thickness.

- iii The primer should be applied as soon as possible after the surface preparation.
- iv The relative humidity of surrounding during painting should be preferably in the range of 65% to 85%.
- v Each coat of paint must be thoroughly dry before the next is applied unless a special wet-on-wet process is used. If the thumb is pressed against the film with a slight twisting movement and no damage to paint occurs, the film is hard enough for the next coat to be applied. For curing time for each coat, manufacturer recommendation may be followed.
- vi The normal dry film thickness of paints should be as per manufacturer's recommendations. Paint thickness gauge can be used for measuring the dry film thickness of paints.
- vii Austenitic SS pipes should not be painted with any paints containing Zn, Al and chlorides etc.

A Common Paint Colour Code System for Piping & Equipment have been developed and approved in line with ANSI Colour Code System with minor changes to suit Refinery application. This will help in having common colour identification for each service across all the Refineries, easily identifiable colour for various groups of services. The new Colour Code shall be followed in Refineries for all the new Projects and additional facilities Projects. As regards, existing Plants the new Colour Code System will be adopted in a manner, which coincides with the repainting schedule of the Piping to optimize expenditure on this account. The Common Paint Colour Code System for Refineries is enclosed as [Annexure –V](#) for ready reference.

## **12.9 EXTERNAL CORROSION CONTROL FOR BURIED OR SUBMERGED PIPELINES**

Control of external corrosion of buried or submerged pipe and components in new installations shall be accomplished by the application of an effective protective coating and if necessary supplemented by cathodic protection. For piping systems offshore special attention shall be given to control external corrosion of the pipeline risers in the 'splash' zone.

### **12.9.1 Protective Coating**

- a) Protective coatings used on buried or submerged pipe and components shall have the following characteristics.
  1. Mitigate corrosion
  2. Have sufficient adhesion to the metal surface to effectively resist under film migration of moisture.

3. Be ductile enough to resist cracking
  4. Have strength sufficient to resist damage due to handling and soil stress.
  5. Have properties compatible with any supplemental cathodic protection.
- b) Welds shall be inspected for irregularities that could protrude through the pipe coating, and any such irregularities shall be removed.
- c) Pipe coating shall be inspected both visually and by an electric holiday detector. Any holiday or other damage to the coating detrimental to effective corrosion control shall be repaired and re-inspected.
- d) Insulating type coating, if used, shall have low moisture absorption characteristics and provide high electrical resistance.
- e) The backfill operation shall be inspected for quality composition and placement of material to prevent damage to pipe coating.
- f) Where a connection is made to a coated pipe, all damaged coating shall be removed and new coating applied on the attachments as well as on the pipe.

### **12.9.2 Cathodic Protection System**

- a) A cathodic protection system provided by a galvanic anode or impressed current anode system shall be installed that will mitigate corrosion and contain a method of determining the degree of cathodic protection achieved on the buried or submerged piping system.
- b) Cathodic protection shall be controlled so as not to damage the protective coating, pipe or components.
- c) Pipe to soil voltage of (–) 0.85 volts with respect to Cu-CuSO<sub>4</sub> half-cell has been found to give adequate protection to the cathodically protected pipelines. The excessive voltage may damage the wrapping and coating of the pipe. A voltage (–) 1.2 volts may adversely affect the wrapping and coating.
- d) Buried or submerged coated piping systems shall be electrically isolated at all interconnections with foreign system.

For other details regarding cathodic protection systems, standards like NACE, RP-01-69 or NACE-RP-06-75 and others may be referred.

## **12.10 INSULATION**

Check for proper insulation. Inspection windows with covers should be provided at suitable locations for thickness survey in further. This insulating type coating must have low moisture absorption and provide high electrical resistance. The insulating material for stainless steel piping must contain low chlorides to prevent stress corrosion cracking. For high temperature SS piping Al-shielding on the insulation should be avoided. Check for clearance for piping with the ground. Piping should not be in contact with grass, soil, water etc.



## RETIRING LIMITS

- A) ANSI B 31.3 – Chemical plant and Petroleum Refinery Piping code, a section of the American Standard code for Pressure Piping, contains formulas and data for determining the wall thickness required for piping. It relates the thickness, diameter and allowable stress to the maximum safe working pressure. ANSI B 31.3 contains a rather elaborate formula for determining the required thickness but permits for use of the Barlow formula without reservation for determining the required thickness. The Barlow formula is as follows:

$$T = \frac{PD}{2SE}$$

- Where t = The required thickness of the pipe wall in inches  
 P = Pressure within the pipe, in pounds per square inch  
 D = Outside diameter of the pipe, in inches  
 S = Allowable unit stress, in pounds per square inch, at the maximum operating temperature  
 E = Longitudinal joint efficiency

The above formula is generally used for calculating the thickness of the pipe wall except at high pressure where thick-walled tubing is required or at high temperatures where the creep properties of the pipe metal become important in determining the ultimate service strength.

At low pressures and low temperatures the thickness required by the formula may be so small that the pipe would have insufficient structural strength. For this reason an absolute minimum thickness should be determined for each size of pipe, below which thickness the pipe wall would not be permitted to deteriorate regardless of the results obtained by the formula.

As a guideline, minimum thickness for carbon steel piping are given in the following table.

Nominal pipe size inches	Min. thickness	
	Inch	M. M
2 and smaller	0.06	1.5
2 ½ - 3	0.07	1.7
4	0.09	2.2
6	0.11	2.7
8	0.12	3.0
10 – 24	0.13	3.3

- B) For liquid petroleum transportation piping system extracts from ANSI B 31.4/1979 has been given in Appendix – I for pipeline repairs.

## **PIPELINE REPAIRS AND INSPECTION**

The portion of piping, which has reached the retiring limit or will reach retiring limit before the scheduled next inspection should be replaced. While replacing the pipes the following points should be considered:

1. The metallurgy and dimensions of the new pipe should match with the existing pipe. The new pipe should be inspected (Refer para 10.1 for details)
2. Repairs should be made carefully by qualified welder using approved welding procedures
3. When ERW pipes are used, the weld seam should be kept staggered and ERW or welded seams of the pipe should not appear at 6 O'clock position.
4. Some piping systems, which are covered under other statutory requirements must be checked for conformation with appropriate and specifications.
5. Inspection of joint fit up, etc. should be done as per the inspection requirements originally specified.
6. Weld joints/repared welds should be subjected to same pre-weld and post-weld heat treatment.
7. Bake out of hydrogen service piping should be carried out for approximately 2 to 4 hrs. at a temperature range of 650 to 800 °F before taking up any repair job. It is preferred to go for coil heating for better control in heating, soaking and cooling.
8. Hydrostatic Testing: The repaired portion of the pipelines may be hydrostatically tested. The test pressure should be 1.5 times the maximum operating pressure. For other requirements on pressure testing para 10.8 be referred.
9. Painting, insulation, wrapping and coating should be done as per the original requirements.

### **14.1 INSPECTION OF VALVES IN SERVICE**

Valves should be dismantled at specified intervals to permit examination of all internal parts. Body thickness measurements should be made at locations, which were inaccessible before dismantling, particularly at locations showing evidence of erosion. Bodies of valves operating in severe cyclic temperature service should be checked internally for cracks.

Gate valves, which have been used for throttling, should be measured for thickness at the bottom between the seats, as serious deterioration may have occurred because of turbulence. This is a particularly weak point because of the wedging action of the disc when the valve is closed. The seating surface should be inspected visually for defect, which might cause leaking. The wedging guides should be inspected for corrosion and erosion. The connection between the stem and disc should be inspected to assure that the disc will not become detached from the stem during operation. Swing check valves can be inspected by removing the cover or cap. The clapper or disc should be checked for freedom of rotation and the nut holding it to the arm should be checked for security and the presence of a locking pin, lock washer, or tack weld. The arm should be free to swing and the anchor pin should be inspected for wear. Also the seating surface on both the disc and valve body can be checked for deterioration by feeling them with the fingers. After the valves has been reassembled, it should be hydrostatically and/or pneumatically tested for tightness. If tested pneumatically a soap solution should be applied to the edges of the seating surface and observed for any evidence of leakage.

## DOCUMENTATION

Isometrics of each piping circuit as per actual site conditions should be prepared. The records should be maintained to give the information like:

- i Identification of particular piping system in terms of location, total length, material specification, general process flow, service condition and location of corrosion probes, if any.
- ii The location of thickness measurements points, the replacements carried out, corrosion rate etc. The history and thickness records of pipelines are kept in history card (form no. 2) and data record cards (form no. 9) respectively. A sample of Isometric of Pipeline Circuit & Data Record Cards are given in [Annexure-VII](#).

A review of the records of previous inspection and present inspection should be made. On the basis of findings, a work schedule should be prepared for future inspection by on-stream techniques as well as during next shutdown.

# Annexures



## 16.0 ANNEXURES

### Annexure – I

#### **EXTRACTS FROM ANSI/ASME B 31.4.1979 – ON LIQUID PETROLEUM TRANSPORTATION PIPING SYSTEMS**

451.6.2 Permanent Repairs for pipelines operating at a hoop stress of more than 20 percent of the specified minimum yield strength of the pipe.

##### a) Limits and Dispositions of Imperfections

1. Gouges and grooves having a depth greater than 12 ½ percent of the nominal wall thickness shall be removed or repaired.
2. Dents meeting any of the following conditions shall be removed or repaired
  - i Dents which affect the pipe curvature at the pipe seam or at any girth weld;
  - ii Dents containing a scratch, gauge or groove; or
  - iii Dents exceeding a depth of ¼ inch (6 mm) in pipe NPS 12 and smaller or two percent of the nominal pipe diameter in sizes greater than NPS 12.
3. All arc burns shall be removed or repaired
4. All cracks shall be removed or repaired.
5. All welds found to have imperfections not meeting the standards of acceptability of 434.8.5 (b), for field welds or the acceptance limits in the appropriate specifications for the grade any type of pipe shall be removed or repaired.
6. General Corrosion: Pipe shall be replaced or repaired if the area is small, or operated at a reduced pressure (see 451.7) if general corrosion has reduced the wall thickness to less than the design thickness calculated in accordance with 404.1.2 decreased by an amount equal to the manufacturing tolerance applicable to the pipe or component.

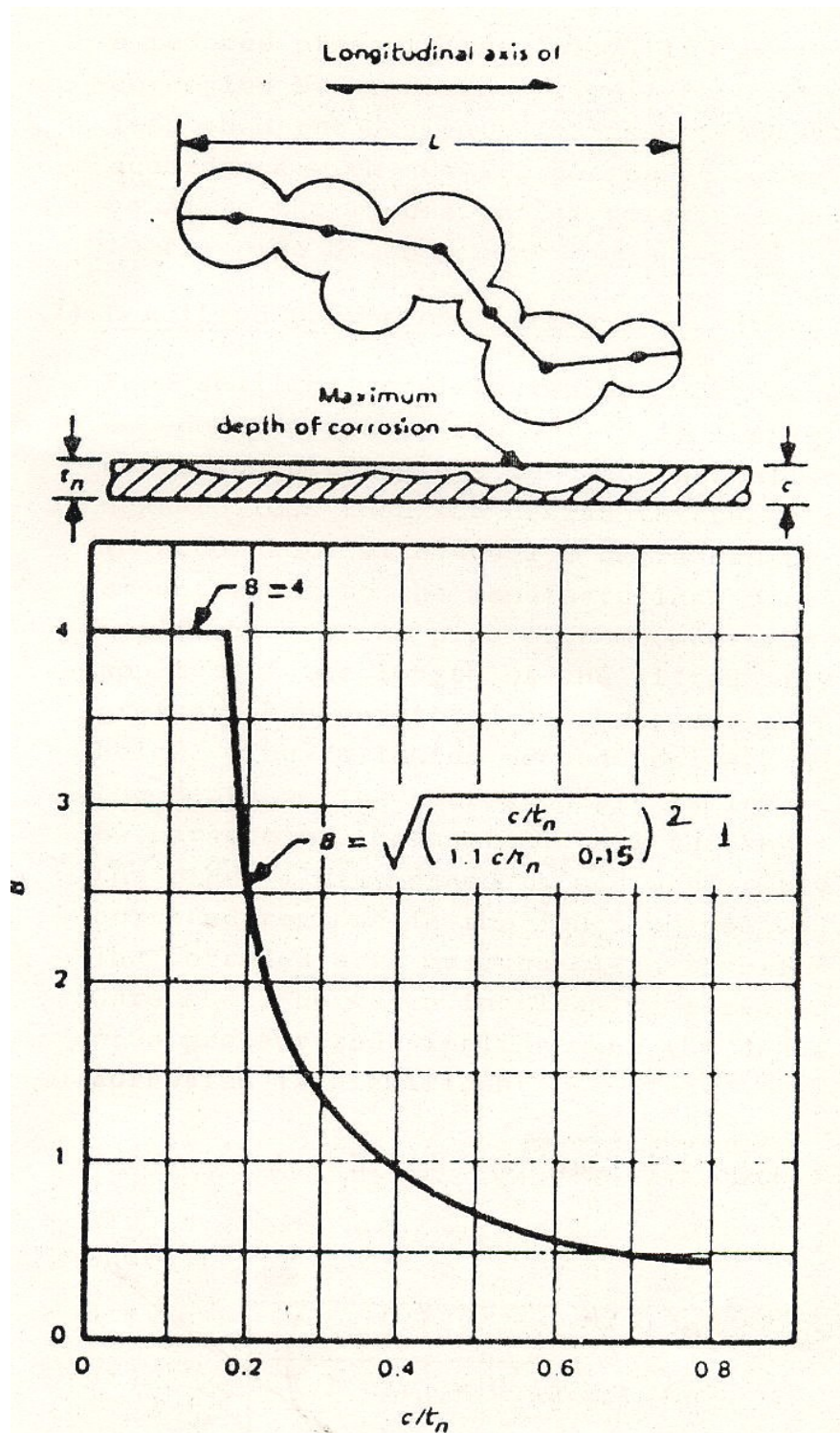


FIG. 451.6.2(a) (7) PARAMETERS USED IN ANALYSIS OF THE STRENGTH OF CORRODED AREAS

51

Parameters used in analysis of the strength of corroded areas

## 7. Localized Corrosion Pitting

Pipe shall be repaired, replaced or operated a reduced pressure (see 451.7) if localized corrosion pitting has reduced the wall thickness to less than the design thickness calculated in accordance with 404.1.2 decreased by an amount equal to the manufacturing tolerance applicable to the pipe or component. This applies if the length of the pitted area is greater than permitted by the equation shown below. The following method applies only when the depth of the corrosion pit is less than 80 percent of the nominal wall thickness of the pipe. This method is not applicable to corroded regions in the longitudinal weld area. The corroded area must be clean to bare metal. Care shall be taken in cleaning corroded areas of a pressurized pipeline when the degree of the corrosion is significant. √

$$L = 1.12 B \sqrt{Dt_n}$$

$$B = \sqrt{-\left(\frac{c/t_n}{1.1 c/t_n - 0.15}\right)^2 - 1}$$

- L = Maximum allowable longitudinal extent of the corroded area as shown in Fig. 451.6.2 (a) (7) inch (mm)
- B = A value not to exceed 4.0 which may be determined from the above equation of Fig 451.6.2 (a) (7)
- D = Nominal outside diameter of the pipe, inch (mm)
- t<sub>n</sub> = Nominal wall thickness of the pipe, inch (mm)
- C = Maximum depth of the corroded area, inch (mm)

8. Areas where grinding has reduced the remaining' wall thickness to less than the design thickness calculated in accordance with 404.1.2 decreased by an amount equal to the manufacturing tolerance applicable to the pipe or component may be analyzed the same as localised corrosion pitting (see 451.6.2 (7) to determine if ground area need to be replaced, repaired, or the operating pressure reduced (see 451.7).
9. All pipe containing leaks shall be removed or repaired.

### 451.7 De-rating a pipeline to a lower operating pressure

Pipe containing localized corrosion pitting or areas repaired by grinding where the remaining material in the pipe does not meet the depth and length limits in 451.6.2 (a) (7) may be de-rated to a lower operating pressure in lieu of a replacement or repair.

- a) Lower operating pressure may be based on 404.1.2 and the actual remaining wall thickness of the pipe, or
- b) Lower operating pressure may be determined by the following equations



$$P_d = 1.1P_i \left[ \frac{1 - 0.67 \left( \frac{C}{t_n} \right)}{1 - \frac{0.67 C}{\sqrt{G^2 + 1} t_n}} \right]$$

Where

$$G = 0.893 \left( \sqrt{\frac{L}{Dt_n}} \right)$$

G = A value not to exceed 4.0 in the above analysis and which may be determined from the above equation

P<sub>d</sub> = Derated internal design gage pressure, psi (bar)

P<sub>i</sub> = Original internal design gage pressure, based on specified nominal wall thickness of the pipe (see 404.1) psi (bar).

L = Longitudinal extent of the corroded area as shown in fig. 451.6.2 (a) (7) in inches (mm).

For T<sub>n</sub>, C and D, see 451.6.2 (a) (7)

For values of G greater than 4.0

$$P_d = 1.1P_i \left[ 1 - \frac{C}{t_n} \right]$$

Except P<sub>d</sub> shall not exceed P<sub>i</sub>

## PRESERVATION OF NEW PIPES IN WARE HOUSE

Moisture, oxygen and acidic environment are the main contributing factors causing deterioration on the internal or external surface of pipes. These may cause rusting, pitting of surfaces and other forms of deterioration. Hence new pipe should be preserved properly in the pipe-stacking yard. Following points should be considered while stacking new pipes in store yards.

- i All the pipes (C. S. and low alloy steel pipes) should be stacked properly in horizontal position over the steel racks or wooden rafters or sleepers.
- ii All the tubes/pipes should be preferably stacked under the shed to protect from rainwater.
- iii All the pipes/tubes end should be plugged with suitable wooden plug or plastic caps.
- iv Before placing the plug/ caps the inside surface of pipes or tubes should be flushed with dry air to ensure absence of any corrosive materials.
- v For pipes with threaded connection extra care should be taken in protecting the threads by putting plastic caps or wrapping with jute cloth (Hessian cloth).
- vi Pipes or tubes should not touch the ground or should not be allowed to get submerged in ground or pool of water.
- vii Pipes or tubes should be stacked away from acidic/corrosive environment and also away from cooling tower as far as possible.
- viii The pipes external surface should be cleaned manually and painted with a coat of bituminous paint or any lubricating oil of viscosity of SAE 30 compounded with inhibitor and wetting agent (spent oil). Any used lubricating oil can be used. It can be applied by brushing, splashing or spraying. Anti corrosive compound, SERVO-RP-102 or equivalent can be used as oil preservatives.
- ix Water proof wrapping paper are also used for storing new pipes. Paper coated with volatile corrosion inhibitor (V. C. I. paper) have long life and easily available.
- x A separate area should be earmarked for items covered under I. B. R. pipes should have separate codification with same preservation procedure.
- xi Different types of pipes should be stacked separately.
- xii In cases where it is decided to paint the entire piping, the colour and sizes of legend letters stenciled on the piping for easy identification of materials near the both ends of pipe.

## **SAMPLE PRESERVATION SCHEME FOR SULFUR RECOVERY UNIT**

Preservation scheme of idle piping in idle units has to be developed by proper study of the process units and finalizing the flushing schemes of each circuit. Subsequently, the circuit may have to be bottled up or filled with inert medium depending on the period for which the circuit has to be preserved. A sample idle time preservation scheme of SRU and ARU is enclosed, which will help the practicing engineers to develop the preservation scheme for the desired circuits.

Before taking shutdown for idle time preservation, liquid/solid materials from all the lines, vessels, exchangers and any other metallic equipment shall be drained, thereafter, all the lines, vessels and equipments shall be cleaned thoroughly by steam flushing and water/solvent flushing. This is required to avoid choking of lines and equipments by sulphur and sulphur compounds, as any leftover sulphur and sulphur compounds, upon cooling from incrustation, which cannot be removed easily.

### **STATIC EQUIPMENT**

Acid Gas Knock Out (K.O) Drum (Carbon Steel), Hydrogen Rich Gas K.O.Drum, Fuel Gas K.O.Drum: SWS Gas K.O.Drum, Ammonia Rich Gas KOD. Acid Gas condensate collection drum, SWS / NH<sub>3</sub> Rich Gas condensate Drums. Atmospheric Flush Drum

- Remove all the condensate inside the K.O. Drum
- Clean the internal surfaces of K.O. Drum by manual cleaning and solvent cleaning by Naphtha. The surface shall be free of all debris clean with potable water if required before cleaning with naphtha.
- Check for condition of internal coating, if any
- If the internal coating is in good condition, no painting is required.
- If the internal coating is found to be peeling off, clean the surface by manual and hand tool as per SSPC-SP-2.
- Apply one coat of two component self priming epoxy cured with Polyamine hardener @100 microns DFT (Dry film thickness/coat) by spray/brush
- Dry with instrument air
- Seal all the openings of K.O. Drum to prevent ingress of moisture into K.O. Drum.

### **Blow down drum (carbon steel)**

- Remove all water and liquids inside the Blow down drum. Clean the inside drums manually. Wash with potable water if required and dry with air.
- Blind all the inlet and outlet nozzles and ensure all the openings are sealed and leak free excepting one inlet and one outlet.

- Purge with nitrogen and maintain a positive pressure of 5-10 psig.

### **Chemical injection pot (Carbon steel) & Chemical Preparation Tank (Carbon steel)**

Remove all the chemicals from the chemical injection pot and store separately in plastic carboys. Wash inside surface of the pot and connected piping by potable water and drain out after washing.

### **Waste heat recovery boiler (Carbon steel)**

Tube side: Process gas

- Blind all the inlet and outlet nozzles and ensure all the openings are sealed and leak free excepting one inlet and outlet.
- Purge with Nitrogen and maintain a positive pressure of 5-10 psig.
- Shell side: Boiler feed water / Medium Pressure steam:
- Flush with D.M. water and then fill with D.M. water containing 200ppm of Hydrazine. The system shall be completely filled.

### **Sulphur condensers (CS)**

Tube side: Process gas:

- Blind all the inlet and outlet nozzles and ensure all the openings are sealed and leak free excepting one inlet and outlet.
- Purge with Nitrogen and maintain a positive pressure of 5-10 psig.

Shell side: LP Steam / Water

Flush with D.M. water and then fill with D.M. water containing 200ppm of Hydrazine.

### **Reheaters: (Carbon steel)**

Tube side: Process gas

- Blind all the inlet and outlet nozzles and ensure all the openings are sealed and leak free excepting one inlet and outlet.
- Purge with Nitrogen and maintain a positive pressure of 5-10 psig.

Shell side: High Pressure Steam / Condensate

Flush with D.M. water and then fill with D.M. water containing 200ppm of Hydrazine.

### **Pit heating coil and sump heating coil**

- If heating coils are made of carbon steel with steam as heating medium

- D.M. water wash / D.M. Water with 200 ppm Hydrazine.
- Otherwise remove all the liquids inside and dry. Then purge with Nitrogen after ensuring all openings are sealed and leak free excepting one inlet and outlet.

Maintain a positive pressure of 5-10 psig.

### **Sulphur pit made of Concrete**

- Clean inside of the pit manually and close the pit of all openings to avoid any ingress of water and debris.
- Heating coils (Low Pressure steam)
- Flush with potable water and fill with D.M. water containing 200 ppm of Hydrazine.

### **Pit ejector (Steam ejector)**

Same as heating coils in 1.1.8 above

### **Catalytic converters associated components**

Service ( $H_2S$ ,  $SO_2$ , Sn,  $N_2$ ,  $CS_2$ ,  $H_2O$ ) Wash with potable water/solvent to remove all chemicals completely and finally flush with D.M. water, dry with instrument air and keep closed.

### **Catalytic incinerators / Burners**

Main Burner, Line Burner

- Remove all the nozzles and oil gun and keep it in safe custody.
- Cover the burner from inside by a plastic sheet to avoid falling of debris.

Grease and/or oil all moving parts associated with burners, Seal burner openings.

### **Sulphur yard (concrete)**

Keep the yard clean and prevent accumulation of dirt and debris. Keep the sulphur bags covered.

## **ROTATING EQUIPMENT**

### **Combustion Air Blowers**

Apply Industrial grease and petroleum based oil in the exposed areas of shaft and manually rotates the shaft once in a fortnight.

### **Sulphur pumps; Boiler feed water pumps and chemical injection pumps**

- Drain all the vents and drains on both ends of the pump
- Drain the casing and the bearings house
- Flush with D.M. water to clean and dry with air.
- Fill the pump casing with a petroleum based oil of approximately SAE20 to 30 viscosity. Rotate the pump shaft to ensure complete coverage.
- Rotate the pump shaft manually once in a week
- Spray the exposed portion of the pump shaft with petroleum based oil. Repeat if necessary.
- Fill the shaft couplings with rust preventive industrial grease with corrosion inhibitor.
- Spray the gland with the petroleum based oil of approximately SAE 20 to 30 viscosity.
- Change of lubricants as per manufacturer's instructions.

### **Motors**

- Erect a shelter over outdoor motors
- Continuously energize heating or arrange auxiliary heating
- Drain Oil-Lubricated bearings and fill with petroleum-based oil of approximately SAE 20 to 30 Viscosity Rotate the shaft once in a fortnight.
- Fill grease type bearing with normal operating grease and rotate the shaft once in a fortnight.
- Uncouple motor and operate for 2 hrs once in a month. Clean coolers of motor by air blowing once in a fortnight.
- Coat exposed shaft with petroleum oil of approximately SEA 20 to 30 viscosity and wrap with plastic tape.

### **TREATED COOLING WATER SYSTEM**

#### **For idle time upto 3 months**

The cooling water system shall not be shutdown, Cooling water shall be circulated through coolers, condensers and piping as per design flow rate.

#### **For idle time of more than 3 months: Cooling water lines**

Fill and keep pressurized with potable water containing 500mg/l of REMIDOL 4000, manufactured by chemtreat India Ltd. Navi Mumbai or VISCO 3900, supplied by NALCO Chemicals, Calcutta.

Process side of Shell and Tube Heat Exchangers: Seal all openings purge with nitrogen and keep under positive pressure of 5-10 psig.

### **INSTRUMENTATION**

- Pressure instruments
- Temperature instruments
- Level instruments
- Analyzers

- Flow Instruments  
All the above instruments shall be protected from weather by covering with plastic sheet.

### **Carbon Steel Piping**

- Chemical injection piping
- Fuel Gas piping to unit / K. O. Drum
- Acid gas piping to K. O. Drum
- Acid gas to Burner piping
- Process gas piping
- TSP solution piping
- MP Steam/ LP Steam piping
- Liquid sulphur piping
- TAIL gas piping
- Steam & air + H<sub>2</sub>S gas piping
- Inert gas piping
- Purge with Nitrogen after ensuring all the openings including blinding of flanges are sealed and leak free excepting one inlet and outlet and maintain a positive pressure of 5-10 psig
- Instrument Air piping
- Service air piping
- Process air piping
- Seal all opening piping and ensure leak free excepting one inlet and one outlet Purge with dry instrument air and maintain a positive pressure of 5-10 psig flanges.

### **All flange joints, Nuts and Bolts**

Spray petroleum based oil of approximately SAE 20 to 30-viscosity or Rust preventive oil and wrap and flange joints with plastic tape.

### **Valves**

Lubricate and cover exposed valve stem with Industrial grease. Spray petroleum oil in between flanges, if any, operate the valves once in a fortnight.

### **Switch Gear System**

- Place bags of silica Gel in the cabinet of switchgear and motor controls located in the buildings and maintain heat in the buildings.
- Ensure environment is dust free by keeping the door closed.
- Energize the heaters of the equipments once in a fortnight.
- Protect outdoor controls by covering with plastic sheet if plastic film is placed on the cabinets, a 2" gap may be left around the bottom.

### **Other Electrical Items**

Solenoid controls, Connectors, Capacitors, Fuse boards etc.  
A preservative chemical 8070, Electricals 88 from M/s Stanvac Chemicals Ltd., New Delhi (manufactured in USA) shall be used as per manufacturer's instructions and procedure for preservation of above items.



## **IDLE TIME PRESERVATION SCHEME FOR AMINE TREATING UNIT**

Before taking shutdown for idle time preservation, the Amine Treating Unit shall be operated without feed process gas to remove acid gases from amine solution as much as possible. Required level of corrosion inhibitor shall also be maintained in the circulating amine before idle time shutdown. This is required to avoid corrosion of carbon steel surfaces by the leftover amine solution after the shutdown.

### **STATIC EQUIPMENT**

- LPG Absorber with Amine
- Fuel gas Absorber with Amine
- Flash column
- Amine Regenerator
- Sour Fuel Gas filter/separators
- Amine Storage Tank
- Skim off vessel
- Amine Regenerator Reflux Drum

Purge individual equipment with Nitrogen and ensure that all openings are sealed and leak free. Maintain under a positive pressure of 5-10 psig.

Amine Sump, corrosion Inhibitor drum, Amine Settler vessel, Amine Regenerator Re-boiler condensate pot, Antifoam Agent Drum

- Clean with potable water and dry by compressed air and keep closed.

1st stage and 2nd stage caustic wash vessel. Clean and flush with potable water. Keep covered.

### **Sour Gas Cooler**

Gas side: Purge with Nitrogen and seal all the openings and maintain positive pressure of 5-10 psig with Nitrogen.

Cooling watersides: Drain cooling water and purge with Nitrogen and keep under positive of 5-10 psig N<sub>2</sub>.

### **Rich Lean Amine Exchanger:**

- a) For shell & tube Exchanger  
Drain amine and flush with D.M. water and air-drying. Keep closed.
- b) Heat Exchanger  
For plate Heat Exchanger:

- Perform normal washing, chemical cleaning or mechanical cleaning prior to protection
- Disassemble plates to ensure complete cleaning and drying.
- For storage periods over twelve months, coat rubber sealing rings with a suitable compound to promote ease of removal.
- Reassemble plates. Leave drain valves open. Reprime frame materials as necessary, coat bolts and nuts with Rust preventive oil.

Amine Regenerator Condenser: Amine Side: Purge with Nitrogen and seal all the openings and maintain positive pressure of 5-10 psig. with Nitrogen

Cooling waterside: Drain, purge with N2 and keep under positive pressure of 5-10 psig.

Amine Regenerator Reboiler Steam Side Keep filled with D.M. water containing 200ppm Hydrazine

Lean amine cooler Amine side: Purge with Nitrogen and seal all the openings maintain positive pressure of 5-10 psig.

Cooling waterside: Drain, purge with nitrogen and keep under nitrogen pressure of 5-10 psig.

## **ROTATING EQUIPMENT**

- Rich amine transfer pumps
- Amine Sump pumps
- Antifoam agent injection pumps
- Weak caustic circulation pumps
- Strong caustic circulation pumps
- Fresh caustic injection pumps
- Flashed Rich amine pumps
- Regenerator Reflux pumps
- Lean Amine pumps
- Corrosion Inhibitor Pump
- Drain all the vents and drains on the both ends of the pump.
- Drain the casing and bearing house.
- Flush to clean and dry with air.
- Fill the pump casing with a petroleum based oil of approximately SAE 20 to 30 viscosity. Rotate the pump shaft to ensure complete coverage.
- Rotate the pump shaft manually once in a week.
- Spray the exposed portion of the pump shaft and gland with petroleum based oil Repeat if necessary.
- Fill the shaft couplings with rust preventive Industrial grease with corrosion Inhibitor.
- Refresh lubricants as per manufacturer's instructions.

## **Filters**

Charcoal Filters

Cartridge Filters

Drain, backwash with potable water and keep filter media/cartridge under

Potable water

## **INSTRUMENTS**

- Pressure instrument
- Temperature instruments
- Level instruments
- Flow instruments

All the above instruments shall be protected from weather by covering with plastic sheet.

## **PIPING**

- Lean amine liquid piping
- Rich amine liquid piping
- LPG/lean amine piping
- Fuel gas vapor piping
- LPG piping
- Sweet LPG piping

Purge with Nitrogen and seal all the openings without any leaks and maintain positive pressure of 5-10 psig.

Antifoam agent liquid piping. Flush with potable water and dry by air.

Weak caustic liquid piping

Strong caustic liquid piping

Fresh caustic piping

Flush with D.M. water and dry by air

## **Valves**

Lubricate and cover exposed valve stem with Industrial grease. Spray petroleum oil in between flanges, if any operate the valves once in a fortnight.

## **Flanges, Joints, Nuts and Bolts**

Spray petroleum based oil of approximately SAE 20 to 30 viscosity of Rust preventive oil and wrap the flange joints with plastic tape

## **MOTORS**

- Erect a shelter over outdoor motors to protect from rain and high humidity.
- Continuously energize heaters or arrange auxiliary heating
- Drain Oil-Lubricated bearings and fill with petroleum-based oil of approximately SAE 20 to 30 Viscosity Rotate the shaft once in a month.
- Fill grease type bearing with normal operating grease and rotate the shaft once a month
- Coat exposed shaft with petroleum oil and wrap with plastic tape.

## PROCEDURE FOR PASSIVATION OF AUSTENITIC STAINLESS STEEL EQUIPMENT

### INTRODUCTION

Neutralization of Austenitic SS is necessary to avoid stress corrosion cracking due to polythionic acid attack of the SS equipment and piping. This is formed if the system is opened to the atmosphere without due safeguard. XXX, Mathura has developed a draft procedure for passivation, which has been reviewed by EIL (SMMS) and a detailed guideline prepared. This is given for Refineries to develop specific passivation scheme for desired equipment.

### NEUTRALIZATION SOLUTION

- Wt% Soda ash solution as envisaged by Mathura Refinery will provide adequate level of residual alkalinity on the metal surfaces (after the solution is drained from the equipment) that will neutralize any polythionic acid formation. Other parameters like addition of 0.4 wt% sodium nitrate, pH of solution at minimum of and chloride level at maximum of 100 ppm is in order.
- Samples of solution should be taken from suitable points and concentration should be adjusted, if needed.
- Chloride content should be checked before pumping the solution to the system.
- Use neutralizing tank by adding low chloride 250 Kgs. Soda ash and 50 Kgs. Of Sodium nitrate for each batch. Alternative combination and batches may also be used as may be suitable.

### PREPARATION AND BLINDING

- Scheme for 2 (two) circuits may be made. One for tube side of exchanger alongwith other equipment that can easily be taken on line e.g. Reactor, vessels etc.
- Another circuit may be made for covering shell side of the exchanger and some other equipment in this circuit.
- Column should be treated separately, so also the heaters.
- Isolation and positive blinding of Heater should be ensured.
- Blinds in heater exchangers and column should be installed under nitrogen positive pressure with due precautions. A typical neutralization and

blinding scheme with solution entry and exit points is enclosed for reference.

Two blinds on heater outlet (H1), line No. 04 to V-10-01.

- Tube side inlet to E-05, line No. 01.
  - Line No. 02, inlet to E-01C shell and FRC by pass.
  - Provide spacer alongwith a blind on line 03 (E01A) shell outlet.
- Suitable scheme may be developed as above depending on actual layout of equipment and piping site.
  - Before taking the Reactor into the circuit for neutralization, approval of licenser should be taken. If no work is involved in Reactor, the same may be maintained under Nitrogen positive pressure with inlet and outlet positively blinded.

## **COLUMN**

Circulation of solution in the column is not feasible. Hence swabbing or spraying will have to be resorted to. Opening of minimum number of manholes should be ensured as more the opening more possibilities of ingress of air into the system. Manholes closer to SS portion should only be opened. As suggested in procedure by Mathura Refinery, maximum manpower should be developed to ensure completion of work as early as possible. Gas free atmosphere should, however, be ensured before man entry. Spraying is preferable than swabbing for uniformity.

## **FURNACE/ HEATER**

### **External**

External surface should be sprayed with suitable sprayer (long nose nozzle). Swabbing may not give uniformity and will not be possible to cover the entire lengths and breadths of tubes. Entire operation should be done at the earliest possible time. Minimum number of manhole/pinholes should be opened.

### **Internal**

Can either be kept under nitrogen positive pressure if feasible or filled with neutralizing solution by pumping and ensuring that the heater is completely filled with solution through suitable inlet and outlet joints.

### **Procedure**

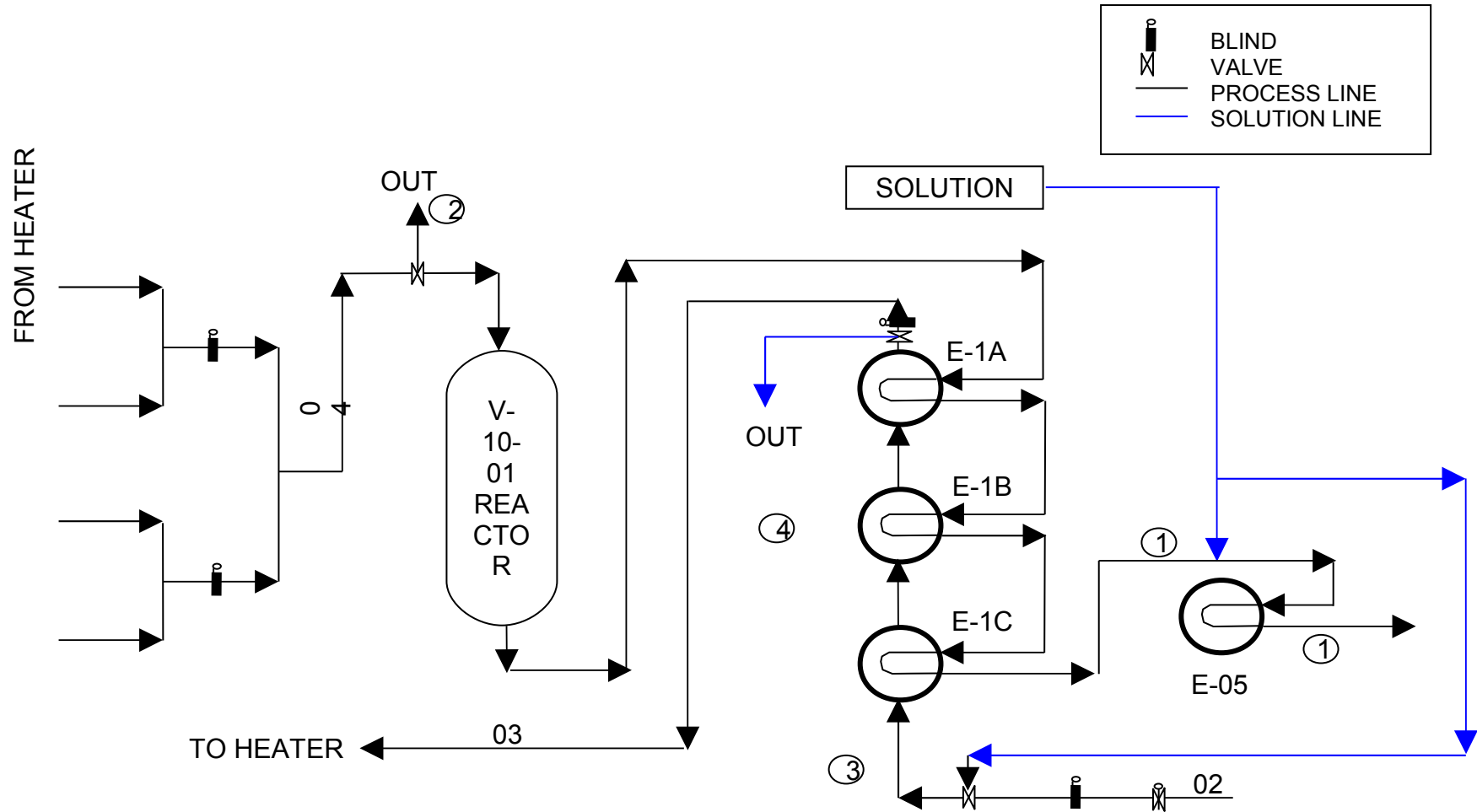
- Fill the tube side and Reactor from the filling point No. 1 (see attached drawing) with the solution backward to Exchangers E01 C/B/A tube side.

- Fill Exchangers E01 A/B/C shell side from point 3 with the solution.
- Continue filling the system until Soda Ash solution can be collected from points 2 and 4 (on the drawing) and make sure that the system is completely filled up with the solution.

Take samples from points 2 and 4 and check the concentration of the solution, prepare additional batches and continue re-filling if the solution concentration is less than 1%.

### **Soaking Time**

Soak the system for 8 hours minimum before dumping the catalyst, if Reactor is involved.



TYPICAL PROCESS EQUIPMENT NEUTRALIZATION SCHEME



## **NACE RP-0170 ON PROTECTION OF AUSTENITIC STAINLESS STEEL EQUIPMENT**

### **Protection of Austenitic Stainless Steel and Other Austenitic Alloys from Polythionic Acid Stress Corrosion Cracking during Shutdown of Refinery Equipment**

#### **1.0 General**

1.1 If sulfide corrosion products are present on the surfaces of austenitic stainless steel and other austenitic alloy process equipment, there is a definite risk of polythionic acid stress corrosion cracking (SCC) when oxygen (air) and water are admitted during an outage. Tensile stresses, both residual and applied, are usually present in “cold” equipment. In the presence of polythionic acids, SCC may occur in stressed austenitic stainless steels and other austenitic alloys that are in a sensitized condition.

1.1.1 Polythionic acid SCC normally occurs with the standard (0.08% carbon max.) and high carbon (0.10% max.) grades that have become sensitized either by weld fabrication or by operation in the sensitizing range of 370<sup>o</sup> to 815<sup>o</sup>C (700<sup>o</sup> to 1500<sup>o</sup>F).

1.1.2 Low-carbon (0.03% max) and chemically stabilized grades (e.g., alloys with titanium or columbium alloying additions) may also become sensitized by prolonged exposure in the sensitizing temperature range. Sensitization will be more rapid in the presence of carbon (coke).

1.1.3 The resistance of chemically stabilized stainless steels and other austenitic alloys to polythionic acid SCC may be significantly improved by thermal stabilization treatment.

1.2 The degree of sensitization and stress levels are generally not known. Therefore, austenitic stainless steel and other austenitic alloy process equipment on which sulfide corrosion products may be present should be protected using one or more of the following methods.

1.2.1 Exclusion of oxygen (air) and water by using a dry nitrogen purge.

Alkaline washing of all surfaces to neutralize any polythionic acids that may form. (Field experience has demonstrated that austenitic stainless

1.2.2 steels and other austenitic alloys are effectively protected with properly applied alkaline solutions.)

1.2.3 Exclusion of water by using a dry air purge with a dew point lower than -15<sup>o</sup>C (5<sup>o</sup>F).

- 1.3 If process equipment remains unopened and “hot” (above the water dew point of the gas in the equipment), additional protection is unnecessary.
- 1.4 The internal surface of austenitic stainless steel and other austenitic alloy furnace tubes maybe susceptible to polythionic acid SCC whether or not they have been thermally decoked and should be protected. If thermally decoked, protection should be performed after decoking.
- 1.5 Protection of the external surfaces of austenitic stainless steel and other austenitic alloy furnace tubes should be considered when sulfur containing fuels have been used for furnace firing.

## **2.0 Nitrogen Purging**

- 2.1 Process equipment may be protected by keeping it tightly closed and purging with dry nitrogen to exclude oxygen (air). Use of dry nitrogen is an effective means of lowering the water dew point temperature to less than ambient. Nitrogen purging provides optimum protection for catalyts.
- 2.2 If reactors to be opened but furnaces are not, the furnaces may be purged with nitrogen and blinded off. A small positive nitrogen pressure should be maintained.
  - 2.2.1 Nitrogen should be dry and free of oxygen. (The user is cautioned that oxygen levels as high as 1000 ppm have been found in commercial nitrogen).
- 2.3 At the user’s discretion, 5000 ppm ammonia may be added to the nitrogen.

The addition of ammonia is generally unnecessary when purging with dry nitrogen, but may be advantageous where water and/ or oxygen may be present.

Ammonia is toxic, and fresh air breathing equipment must be worn during installation and removal of blinds.

Copper based alloys must be isolated from ammoniated nitrogen.

It should be determined that ammonia will not have an adverse effect on catalyst.

- 2.4 Nitrogen purging is preferable for protection of vertical tube heaters if alkaline wash solutions cannot be drained fully.
- 2.5 If steam is being used for purging or steam air decoking, steam injection should be stopped before the metal temperature cools to 56°C

(100°F) above the water dew point. When de-pressured, but before cooling lower than 56°C (100°F) above the water dew point, the system should be purged with dry nitrogen. Some purge flow should be maintained until blinds are installed. A positive nitrogen purge pressure should be maintained on the system after blinding.

- 2.6 The user is cautioned that wearing fresh-air breathing equipment in nitrogen-purged equipment requires special precautions, in accordance with local plant safety procedures.

### **3.0 Alkaline Wash Solutions**

- 3.1 Sodium carbonate (soda ash) solutions are used to protect austenitic stainless steels and other austenitic alloys from polythionic acid SCC. Solution pH should be greater than 9. These solutions may also contain an alkaline surfactant and corrosion inhibitor.

- 3.2 The recommended wash solution is 2 wt% soda ash (industry practice varies from 1 to 5 wt%, with a majority using 2 wt% solutions). A 1.4 to 2 wt% soda ash solution will provide a sufficient level of residual alkalinity on metal surfaces after the solution drain from the equipment. Additionally, this low concentration will facilitate solution preparation.

- 3.2.1 The use of caustic soda is not recommended.

- 3.2.2 Experience with potassium carbonate is limited. No cracking has been reported by those who have substituted it for soda ash.

- 3.3 Because of successful past experience with solutions containing small amounts of chloride, it is not always necessary to provide chloride-free solutions.

- 3.3.1 Chloride concentration in the freshly mixed wash solution should be limited to 150 ppm. This nominal chloride limit is attainable with commercially available chemicals.

- 3.4 In special cases, flushing with ammoniated condensate may be necessary. The solution should have a pH above 9 and a chloride content of less than 5 ppm.

- 3.5 The addition of an alkaline surfactant to the wash solution at 0.2 wt% concentration is recommended to promote penetration of coke, scale, or oil films. Heating of the wash solution to 49°C (120°F) may accelerate the penetration of oily films and residues.

- 3.6 Corrosion inhibitors have been used to decrease the possibility of chloride SCC by these alkaline solutions.

- 3.6.1 At the user's option, 0.4 wt% sodium nitrate maybe added. (In laboratory tests, low concentrations of sodium nitrate have been found

to be effective in suppressing SCC of austenitic stainless steel in boiling magnesium chloride solutions). Caution: Excess  $\text{NaNO}_3$  can cause SCC of carbon steel.

#### **4.0 Alkaline Washing**

- 4.1 Austenitic stainless steel and other austenitic alloy equipment to be opened to the air is best protected with a soda ash solution (defined in section-3). Soda ash solutions neutralize acids and, after draining, leave a thin alkaline film on the surface that can neutralize any additional acid formation. It is vital that this film not be washed off and that it remains in place as the equipment goes back on-stream.
  - 4.1.1 The equipment must be alkaline washed before any exposure to air. It is very important to contact 100% of the equipment's internal surfaces.
  - 4.1.2 The equipment should be soaked for a minimum of two hours. If deposits or sludges are present, the solution should be circulated vigorously (two hours minimum). Longer times are not detrimental in either case.
  - 4.1.3 The circulating solution should be analyzed at appropriate intervals to ensure that pH and chloride limits are maintained.
  - 4.1.4 It is essential that the alkaline wash not be followed by a water wash.
  - 4.1.5 Each system must be evaluated individually and precautions taken to ensure that unvented gas pockets or cascading through down-flow sections do not prevent complete surface contact.
  - 4.1.6 If washing the outside of furnace tubes is necessary to remove deposits, a soda ash solution should be used because these surfaces may be subject to polythionic acid SCC.
- 4.2 Hydro jetting of equipment should be conducted using a soda ash solution.
  - 4.2.1 After hydro jetting, equipment should be kept dry and out of the weather. If this is not possible, the soda ash wash should be repeated as required to maintain a residual film of soda ash. Equipment shall be reinstalled with soda ash residual film left on surfaces.
- 4.3 Hydrostatic testing of equipment should be conducted using a soda ash solution. Ammoniated condensate may be used if the equipment is not reopened or exposed to oxygen (air).
- 4.4 If sodium chloride ions cannot be tolerated in the process system, the equipment can be washed with ammoniated condensate after being closed. If the unit is not started up immediately, the solution can be left

in place or displaced with nitrogen or dry hydrocarbon. The unit must not be exposed to oxygen (air) after this procedure. Ammonia solutions do not leave a residual alkaline film after being drained.

- 4.5 On completion of alkaline washing, all remaining alkaline solution must be drained from all low points in the system prior to returning equipment to service. Failure to do so can result in concentration of carbonate and chloride salts by evaporation, which can also lead to SCC in austenitic stainless steels.

## **5.0 Protection of Reactors**

- 5.1 Reactors containing catalyst require special consideration. Personnel safety and protection of the catalyst may dictate the use of procedures that are less than optimum in terms of protection from polythionic acid SCC.

- 5.1.1 Non-regenerated catalysts frequently are pyrophoric. This may require that such catalysts either be kept wet or out of contact with oxygen (air) by the use of nitrogen purging.

- 5.2 Industry experience suggests that austenitic low-carbon and stabilized grade weld overlays and stabilized grade wrought internals in reactors are very resistant to polythionic acid SCC for reactor operating temperatures below 450°C (850°F).

- 5.3 Recommended procedures for protection of reactors that will be opened for entry and have a history of successful use in the field are as follows:

- 5.3.1 Catalyst unloading and loading can be conducted under nitrogen-blanketing conditions by personnel using appropriate fresh-air breathing equipment. Following unloading, the reactor is purged with dry air and this purge is maintained while the reactor is open. Purge air dew point temperatures from -15° to -46°C (5° to -50°F) have been used.

- 5.3.2 If the catalyst is to be discarded, the reactor can be filled with soda ash solution to wet both catalyst and reactor parts. The solution strength should be increased to 5 wt% to compensate for the acidity of deposits held by the catalyst. Unloading can then be conducted in air while keeping the catalyst wetted with soda ash solution to prevent pyrophoric ignition. The reactor should then be washed down with soda ash solution and dried prior to repairs or catalyst loading.

- 5.3.3 If the user wishes to eliminate the use of soda ash solutions and fresh air breathing equipment while unloading the catalyst, the catalyst may be dumped, following wetting with good quality fresh water (less than 50 ppm chloride), without nitrogen purging. This should be preceded by a careful investigation to determine that:

- (1) Only stabilized grades have been used where austenitic stainless steel materials have been specified.
- (2) These alloy materials have not become sensitized as a result of either vessel fabrication procedures or the reactors thermal history during operation.

This procedure involves some risk of polythionic acid SCC through either accidental use of unstabilized grades or misinterpretation of the thermal history of the reactor.

**IDLE TIME PRESERVATION OF STATIC & ROTARY  
EQUIPMENT – OISD-171**

<b>S. No.</b>	<b>CONTENTS</b>
1.0	General
1.1.	Introduction
1.2	Scope
1.3	Definition
1.4	Consideration for Selection of Protective System
2.0	Preservation of Idle Static Equipment
2.1	Preservation of Heat Exchangers
2.2	Preservation of Columns & Vessels
2.3	Preservation of Fired Heaters, Ducts and Stacks
2.4	Preservation of Equipment in Cooling Towers
2.5	Preservation of Atmospheric Storage Tanks
2.6	Preservation of Idle Boilers
2.7	Preservation of Pipelines
3.0	Preservation of Idle Rotary Equipment
3.1	Preservation of Idle Pumps
3.2	Preservation of Idle Compressors
3.3	Preservation of Steam Turbines
3.4	Preservation of Gas Turbine
3.5	Preservation of Diesel Engines
3.6	Preservation of Fans & Blowers
4.0	Preservation of Materials in Stores
4.1	Preservation of Heater Component
4.2	Preservation of Pipes, Pipe Fittings and Valves
4.3	Preservation of Heat Exchangers/ Condensers/ Coolers
4.4	Preservation of Plates

- 4.5 Preservation of Structural Steel
- 4.6 Preservation of Column Trays & Fittings
- 4.7 Preservation of Vessel & Exchanger Shell
- 4.8 Preservation of Refractory
- 4.9 Preservation of Spare Parts of Pumps and Reciprocating Compressors
- 4.10 Preservation of Anti-Friction Bearings
- 4.11 Preservation/ represervation of components of centrifugal Compressor/  
Steam Turbine/ Gas Turbine/ Diesel Engine
- 4.12 Preservation Procedure for Equipment not Installed/ kept at Store
- 5.0 References

## **Annexure I**

### Commonly Used Preservative



**OISD-STD-171**  
**PRESERVATION OF IDLE STATIC & ROTARY MECHANICAL**  
**EQUIPMENT**

## 1.0 GENERAL

### 1.1. INTRODUCTION

Preservation of idle equipment installed in the plant involves safeguarding unattended and inactive equipment from deterioration during their down period, generally above one month arising out due to the reasons like feed problems, haulage problem, major repairs, revamps, modifications, retrofitting, etc. Deterioration of equipment during periods of idling is usually caused by conditions entirely different from those that exist during operation. Many deposits formed during operations turn usually corrosive under shutdown conditions. Moisture, oxygen, dirt, dust, ultraviolet rays, extreme pressure and temperature, corrosive environment of coastal areas and closeness to other chemical plants, are the some of the factors causing deterioration.

Preservation of static and rotary equipment and their spare parts, which are required to be kept in store for prolonged periods, needs to be carried out to prevent their deterioration, and as such preservation procedures for the equipment/ spares kept in store should be adopted. New equipment received at plant/project site should be preserved considering manufacturer's recommendations.

### 1.2 SCOPE: -

This standard lays down the preservation procedures to be followed in oil and gas installations for various static and rotary idle mechanical equipment installed at plant and for the equipment/spares kept in stores. The scope does not include the electrical equipment, instruments and chemicals.

### 1.3 DEFINITIONS

#### a) Preservation:

Preservation is safeguarding of unattended and inactive equipment from deterioration during their down period.

#### b) Coating :

Coating means an application of a coat of preservative media like paint, Oil or grease etc.,

#### c) Surface Preparation:

Surface Preparation includes cleaning of the parent metal surface for removing foreign particles like rust, scale, liquid etc., by mechanical or chemical cleaning techniques.

### 1.4 CONSIDERATION FOR SELECTION OF PROTECTIVE SYSTEM:-

A careful study should be undertaken before finalizing a protection system. This should consider the type of

equipment, its cost and ease of repair/replacement, period of protection, rate of deterioration expected and allowable deterioration etc. Equipment, which can be shifted easily, should preferably be moved to warehouse.

Before going for protective measures, following should be considered:

- a) Period of shutdown
- b) Allowable deterioration and rate of deterioration
- c) Probability of reuse
- d) Expenditure for repair/replacement
- e) Time for repair/replacement after the shutdown
- f) Type of protection systems( various alternatives)
- g) Condition of the equipment
- h) Criticality of the service
- i) Type of environment in which equipment/spares are to be stored.

Equipment/spares will need no preservation if

- a) It has become obsolete and will not be put to service again.

- b) It has deteriorated beyond economical repair and required to be condemned.

- c) The estimated value of the equipment is not worth the expenditure to be made for preservation, if it is not in critical service.

## **2.0 PRESERVATION OF IDLE STATIC EQUIPMENT**

This section covers the Preservation of following idle equipment.

- a) Heat Exchangers
- b) Columns & Vessels
- c) Fired Heaters, Ducts & Stacks
- d) Cooling Towers
- e) Storage Tanks
- f) Boilers
- g) Pipelines

## **2.1 PRESERVATION OF HEAT EXCHANGERS**

Exchangers need to be carefully protected when idle. Exchangers may deteriorate due to conditions, which are different from those that exist during operation. The deterioration may be primarily due to water, sludge or other corrosive elements in the entrapped process fluids and environmental conditions. Some fluids may have a

tendency to congeal after a long time of retention. Preservation technique should be based on the duration of idleness, type of equipment, its service and environment. Exchangers in non-corrosive service should be preserved in case idle period is more than six months. For exchangers in corrosive services, preservation should be done based on corrosiveness of the fluid. The following procedures for preservation should be adopted:

- a) Open the exchangers, remove the bundle, disassemble all components.
- b) Clean all the parts thoroughly by hydro blasting / hydro jetting or chemical cleaning. No deposits should be left on inside or outside surface of the equipment/bundle.
- c) Thoroughly coat with preservative oil/grease on the required surfaces including bolting flange and gasket faces, etc.
- d) Reassemble all components, blank off all nozzles and close all vents and drains.
- e) All the exposed bolts and flanges to be coated with grease.
- f) Austenitic stainless steel component should be suitably passivated before exposure to atmosphere in line with the procedure as

laid down in NACE Standard RP-01-70.

g) Depending on the environmental conditions, coating to be applied on the external surfaces. If the weather is very humid, completely remove the insulation and apply the paint.

h) For finned air cooler, clean the tubes internally, circulate preservative oil through the tubes and seal off all the header boxes.

i) When the tube bundle is to be stored separately, bolt wooden flanges to both the tube sheets and cover with waterproof tarpaulin, if necessary.

## **2.2 PRESERVATION OF COLUMNS & VESSELS**

In columns/vessels when idle, corrosion can take place either due to condensation of retained vapours or from the moisture in the atmosphere. Corrosive products may also form due to the chemical reaction of water with scales/deposits. Following procedures for preservation should be adopted:

- a) Flush/clean the equipment, carry out neutralization wherever applicable and drain.
- b) Purge with nitrogen after ensuring that all the openings are sealed and leak free. Maintain a positive pressure of 100

mm of water column. Alternatively spraying oil on the inner surfaces or filling and draining oil or placing desiccants like bags of lime or silica gel may be considered.

c) Remove the safety valves (bolted only) and close all the openings. Safety valves shall be stored indoors.

d) Coat all the exposed bolts anchor bolts, gaskets, flange faces with grease/preservative oil.

e) Austenitic stainless steel components shall be suitably passivated before exposure to atmosphere in line with the procedure as laid down in NACE Standard RP-01-70.

### **2.3 PRESERVATION OF FIRED HEATERS, DUCTS AND STACKS**

In heaters when idle, corrosion may take place either due to condensation or chemical reaction of atmospheric moisture with scale/deposits on the tubes. Following procedures for preservation should be adopted.

a) Tubes should be completely cleaned from outside and inside surface. After cleaning the header, boxes should be sealed. For vertical heater drying with nitrogen/ air should be considered. If the complete cleaning is not possible, suitable neutralizing agent

should be flushed through the tubes to avoid any damage that may occur during idle period.

b) All the hinges on access doors, peep holes, drains and dampers, etc. should be coated with grease to ensure smooth operation after shutdown.

c) When the external surface of the furnace/ducts/stack reveals paint failure, it is advisable to touch up and maintain the paint on a regular schedule. Sulphur deposits if found, should be removed.

d) Refractory should be kept dry at all the times to prevent any cracking due to water ingress. The ingress of atmospheric moisture should be avoided by proper capping of stack and duct opening and by sealing all those locations from where water or moist air can seep in. Supplementary heat or a desiccant can also be considered.

### **2.4 PRESERVATION OF EQUIPMENT IN COOLING TOWERS**

The cooling tower consists of concrete basin, main structure of red wood, fan and fan motor. The conditions are more severe when the cooling tower is in operation than it is idle. Following preservation procedures should be adopted while cooling tower is idle.

a) Drain and flush all the pipe lines.

b) Drain all water from the basin, remove all debris, muck, etc. and clean the basin thoroughly.

c) Replace all unsatisfactory structural members. Replace warped and missing slats.

d) Carryout repairs to the concrete walls and floors of the basin for cracks, loose concrete, slope of the floor, etc.

e) Remove fan motor and protect it as per OISD-146 (Preservation of idle electrical equipment).

f) Drain the oil from gear box and refill it with a high grade mineral oil. Clean the exterior surfaces of the gear reducer housing and paint them. Wrap all exposed shaft with Plastic tape. Store the reducer in a warm and dry area.

g) Clean the fan with appropriate cleaner and apply suitable paint, if required.

h) Cover the fan drive gear with a light grease and water proof paper.

i) Secure the fan blades to prevent rotation and to provide supports.

In areas where it is undesirable or unnecessary to remove the

fan drive components, the fan should be operated every 3-4 weeks and routine preventive maintenance be carried out.

The dry wood of an idle cooling tower is a serious fire hazard. Therefore, for idle periods of about two months, a perforated hose should be laid around the tower and spray water periodically to keep wood in wet condition all the time. For extended shutdowns, the plenum and fill should be sprayed with a fire retarding chemical and a biocide.

## **2.5 PRESERVATION OF ATMOSPHERIC STORAGE TANKS**

Tank interiors can be corroded by the water present in the product or by condensation of the vapours in fixed type of roofs. Floating roof is subjected to exterior corrosion due to stagnant water on the roof. Following procedures for preservation should be adopted.

a) The tank shall be made free of gas and any residue. Extra precautions shall be taken when pyrophoric iron sulfide or residue of leaded gasoline are present.

b) All the loose scales on the internal surface of the tank should be removed.

c) The internal surface should be coated with preservative oil by spraying. Brushing can be used in the case of structural members.

d) All the manholes should be closed.

e) The external surface should be cleaned and protected by suitable repainting as necessary.

f) Tanks located in areas subjected to windstorms of high velocity shall be filled with an inhibited water.

g) If the tank is with steam coils, the condensate should be drained off and the steam coil should be positively blinded.

h) The tanks isolated from service shall be externally inspected annually.

i) In case of floating roof tanks, the floating roofs should preferably be kept afloat by filling with inhibited water and roof drains be kept open. Water accumulated on the roof tops due to rain etc, if any, shall be cleaned periodically.

## **2.6 PRESERVATION OF IDLE BOILERS**

Unless proper storage procedures are followed, severe corrosion may occur in idle boilers. The method to protect idle boilers depend primarily on length of downtime. Cold storage of boilers include dry or wet storage. Dry storage is preferred when the boilers will be out of service for a period

of 45 days or more while wet storage may be suitable for a shorter duration.

### **Cold storage**

#### **a) Dry Storage**

The boiler should be drained, thoroughly cleaned and dried completely by means of hot air. Close attention should be given to complete elimination of moisture from nondrainable super heater tubes. A suitable absorbing material in a water tight container should be placed in the boiler drums or on top of the flues in a fire tube boiler. The most commonly used moisture absorbents are quick lime and silica gel. Silica gel is more efficient in absorbing moisture and can be regenerated by heating so that it can be used over again and again. Since it is not a caustic substance, can be used more easily and safely, it is generally preferred.

After placing the quick lime or silica gel in the boiler as per manufacturer's recommendation, all openings should be tightly closed. The unit should be checked at an interval of every two or three months, as experience dictates, for renewal of the lime or regeneration of silica gel.

#### **b) Wet Storage**

The boiler should be cleaned and inspected and then filled to the normal water level. If deaerated water is not

available, dissolved gases should be expelled by boiling water for a short time with boiler vented to atmosphere. The boiler water alkalinity should be adjusted with caustic soda to a minimum of 400 PPM. Sufficient Sodium sulfite should also be added to produce a minimum sulfite residual of 100 PPM. After the boiler is cooled and before a vacuum is created, the unit should be filled completely with water and all connections closed.

Test should be conducted on weekly basis and additions to the treatment chemicals should be made necessary to maintain the minimum recommended concentrations. When treatment additions are required, the boiler water should be circulated by means of an external pump or by lowering the water to operating levels and steaming the boiler for a short time. The boiler should then be completely flooded as outlined previously. The temperature of boiler should be maintained as low as possible since the corrosion rate increases at higher temperatures.

When the boiler is returned to service, a high rate of blowdown should be maintained initially so that alkalinity and sulfite be reduced to normal operating levels rapidly.

In some small installations or where weekly testing is not practicable, Chromate salts

can be employed to protect idle boilers against corrosion. The concentration maintained should be 2000-2500 PPM as sodium chromate. The boiler should be completely filled and closed tightly. To assure good mixing, circulation of the water with a pump is recommended. Boilers stored in this manner should be blown down heavily to dissipate the chromate colour, before being returned to service.

Nitrogen or other inert gas may also be used for storage purpose. A slight positive pressure of the gas is maintained after the boiler has been filled to operating level with deaerated feed water.

### c) Super heater Storage

In some boilers it is not possible to separate the super heater section from rest of the boiler. Accordingly, it is necessary to follow the same storage procedure for the super heater section as for the other portions of the boiler. Wet storage of drainable super heaters is relatively simple while wet storage of nondrainable super heaters is more complicated. In dry storage, care must be taken to remove all the moisture from the nondrainable super heaters by reheating the super heaters sufficiently to evaporate all the water. This may be accomplished by means of a small fire in the boiler furnace. In some cases it may be possible to dry the nondrainable super heaters



with hot air diverted from the air heaters of one of the operating boiler. Depending on the actual design, there may be a choice as to whether the dry air is directed over the external surfaces or internally.

Since a residue will be left in nondrainable super heater tubes after boiling out, if the superheater has been flooded with water containing boiler water salts, it is desirable to employ a method of wet storage which does not involve the use of solid chemicals.

Volatile chemicals or inert gases can be used in superheater section. The volatile chemicals recommended are hydrazine and ammonia or neutralizing amine. If high purity is not available to fill the entire boiler, the superheater tubes can be filled with condensate or demineralised water from the outlet end. The recommended treatment concentrations are approximately 100 PPM of hydrazine and sufficient ammonia or neutralizing amine to elevate the PH to approximately 9.0-10.0.

simple modification. The modification required is a 2" steam line from main steam header to be connected to the blowdown line upstream of blowdown valves with 2 nos. of 2" NRV. Through this accumulator steam line, steam from the main steam header enter into MUD DRUM and get condensed and hence the boiler will be under pressure without keeping the burners in service. About 3 to 5 Tonnes per hour of steam may be consumed in this way to keep the boiler as Accumulator- depending upon the insulation of the boiler.

To keep the boiler as accumulator

- a) Stop the burner/s
- b) Stop the FD fan
- c) Close the main stop valve
- d) Open both accumulator steam line block valves slowly avoiding water hammering

To put back the boiler in service

- a) Open the start up vent line
- b) Open the SH drain
- c) Start FD fan
- d) Take the burner/s into service

## Hot storage

Instead of keeping standby boilers in banked condition or operating all the boilers in lower capacity, standby boilers can be kept under pressure as "Accumulator" with a

- e) After about 5 minutes of venting of steam, open the main stop valve and close the start up vent and SH drain valve

To operate blowdown valves during accumulator condition (drum level may rise during accumulator condition due to the condensation of the accumulator steam in the MUD DRUM) to lower the drum level.

- a) Close the accumulator steam 2" gate valve near the MUD DRUM

- b) Operate the blow down valves

- c) After blow down - close the blow down valves and open the Accumulator Steam 2" gate valve

### 3.0 PRESERVATION OF PIPELINES

The following procedures should be adopted

- a) Flush the lines clean
- b) Open the flange joints and valves at low points to ensure complete draining.
- c) Dry the lines or circulate an inhibited or uninhibited oil through them
- d) Inspect insulated and wrapped lines, uncovering

the piping where leaks are suspected.

- e) Repair all damaged insulation and wrapping. Bare pipe should be wire brushed and painted.

- f) Lubricate all valves.

- g) Spray all external surfaces of the valves with oil and cover valve stem with grease. Relief valve should be rotated or separated from their discharge piping. Their discharge side should be sprayed with oil and covered with water proof paper or plastic.

- h) Tighten all flanges. Spray mating flanges joints with oil, and wrap them with suitable wrapper to prevent crevice corrosion between mating flanges.

On idle units, process and utility lines (except fire water lines) should be blinded off near the battery limit.

### 4.0 PRESERVATION OF IDLE ROTARY EQUIPMENT

This section covers preservation of the following Rotary Equipment while they are idle.

- a) Pumps
- b) Compressors
- c) Steam Turbines
- d) Gas Turbine

- e) Diesel Engine
- f) Fans & Blowers

#### **4.1 PRESERVATION OF IDLE PUMPS**

The following procedure should be adopted for preserving an idle pump

##### **4.1.1 Preservation of idle centrifugal Pumps**

- a) Close the suction and discharge valves and blind the same. Isolate the pump from all other connected auxiliary lines. In case the pump is to be removed and kept in storage, disconnect all pipe connections and blind the suction and discharge flanges.
- b) Open all vents and drains in the pump casing and bearing housing. Flush the casing and housing with a suitable solvent or cleaning agent.
- c) For pumps with gland packing, remove the packing, coat the interior of the stuffing box with light grease, repack with a few rings of ordinary non-metallic packing to avoid ingress of water into the stuffing box and then retighten the gland.
- d) For pumps with single mechanical seal, loosen the seal gland, pack the seal with a light grease

and tighten the seal gland lightly.

e) For pumps with double mechanical seal, drain the stuffing box and flush it with a cleaning agent, plug the lower stuffing box drain and fill it with lightweight grease or lubricating oil.

f) Plug the bearing housing drains and fill the bearing housing completely with lubricating oil.

g) Close all drains and fill the entire pump casing with a lubricating oil. Rotate the pump shaft slowly to ensure complete coating of the inner surfaces.

h) Rotate the pump shaft every three to four weeks, leaving it in a different position each time.

i) Clean the exposed pump shaft and protect with grease.

j) Protect the shaft couplings by filling them with grease or coating them with a rust preventive.

##### **4.1.2 Preservation of Reciprocating Pumps.**

- l) Preservation of idle steam/air driven Reciprocating Pumps**

a) Open all vents and drains on both the liquid end and steam/air end of the pump.

b) Disconnect all pipe connections, blind the suction, discharge and steam flanges/ air connections.

c) Remove the packing from the stuffing box and coat the stuffing box and rods inside the box with light grease. Repack the stuffing box with a non-metallic packing and re-tighten the gland.

d) Remove the valve cover plate from liquid end of the pump and slide valve cover from steam/air end. Remove a valve from each end of each cylinder on the liquid end. Flush the cylinders with a cleaning agent. Fill all cylinders with suitable preservative oil. Fill the steam/ air cylinders with a suitable preservative oil through slide valve opening at the steam/air end. Slowly bar each piston back and forth.

e) Apply a suitable rust preventive to all valves and valve covers and install them back.

f) Drain the excess preservative oil from the cylinders and close all vents and drains.

g) Clean and cover exposed rods with grease.

h) Fill all lubricators with oil.

## II) **Preservation of idle motor driven Injection/Metering Pumps**

a) Open all vents and drains.

b) Remove the pump, clean, fill the liquid chamber with lubricating oil and fix back the pump.

c) Blind the suction and discharge valves

d) In case of diaphragm type pump drain the hydraulic oil from the hydraulic chamber, flush and fill the hydraulic chamber with a lubricating oil.

e) Drain the gear box oil; flush and fill the gear box with a lubricating oil.

f) Close all vents and drains in the pump and gear box.

g) For pumps with gland packing, remove the packing, coat the interior of the stuffing box with light grease, repack with a few rings of ordinary non-metallic packing to avoid ingress of water into the stuffing box and then retighten the gland.

### 3.2 PRESERVATION OF IDLE COMPRESSORS.

The following procedure should be adopted for preserving idle compressors.

#### 3.2.1 Preservation of idle centrifugal Compressors

Whenever the centrifugal compressor is required to be at stand still for a prolonged shutdown of more than 3 months the following method may be used for preserving the compressor components.

a) The compressor casing may be charged with a low positive pressure of dry nitrogen 50 to 70 mm WG during the whole time of shutdown at stand still condition for all the compressors which are not provided with oil seals. For the type of compressors, which are provided with oil seals nitrogen supply, may be given after putting into operation the seal oil system. However, if the nitrogen pressure can be maintained around 70 mm WG even without seal oil system in service, nitrogen supply can be given without operating seal oil system

b) The lube oil and seal systems should be operated for half an hour once a week to

protect the system against corrosion.

c) The compressor rotor shall be rotated by turning gear or by hand by the following procedures:

- It should be rotated by 180 degree from the standstill condition after three months

- It should be rotated by 90 degree after 3 months.

- It should be again rotated by 180 degree after 3 months.

- It should be rotated by 90 degree position after 3 months.

- This procedure shall be continued subsequently.

For compressors, which are idle for a period over 6 months, the following preservation methods may be used.

a) Blind off all process, oil supply and oil drain openings

b) Remove the rotor and associated parts, such as bearing and seals and diaphragms.

c) Preserve the removed parts with a protective material as detailed in Para 4.9

d) Fill the compressor system with oil through a drain opening and displace all air from the case by venting and close all drain and vent connections.

e) Fill the oil seal system with oil.

f) The water-cooling system shall be drained, flushed and filled with clean fresh water dozed with anticorrosive chemical.

g) Change water every six months.

### **3.2.2. Preservation of idle Reciprocating Compressor.**

The following procedures should be adopted for preserving an idle reciprocating compressor.

a) Close and seal all frame openings to prevent contamination of frame interior.

b) When the compressor (lubricated as well as dry lubricated) compressor is kept idle for a period less than six months, run the motor driven/hand driven crank mechanism lube oil pump for 10-15 minutes once in every week.

While the crank mechanism lube oil pump in operation, rotate the shaft by a few revolutions at least once in every two weeks. The shaft needs not to be stopped at previous locations.

c) When the compressor (lubricated as well as dry lubricated) is kept idle for more than six months fill up the crankcase with enough suitable preservative oil to bring the oil level to the mark on the oil level gauge window. Close all holes/ opening of the crankcase and purge the air inside the crankcase with dry nitrogen and keep a nitrogen pressure of about 100 mm WG. Run the lube oil pump for 10-15 minutes and at the same time rotate the shaft, by a few revolutions, manually or by a barring jack. Avoid that the shaft stops in previous position. Repeat the operation once in two weeks. In case dry nitrogen is not available, introduce in the crankcase a suitable quantity of dehydrating agent at such a location that it does not get soaked with oil during the running of lube oil pump. Check the effectiveness of the dehydrating agent periodically.

d) Apply suitable grease on the shaft end outside the crankcase and all other exposed surfaces.

e) For lubricated compressors keep the compressor valves immersed in suitable rust preventive oil. As an alternative apply rust

preventive oil on the compressor valves and keep them in plastic bags with dehydrator. For dry lubricated compressors remove the valves from cylinder, put sufficient quantity of dehydrating agent in the valve chambers and assemble the valve covers. Clean the valves and keep them in plastic bags with dehydrator

f) When lubricated compressors are kept idle for less than 6 months, wet the cylinder and packing with sufficient quantity of lube oil and also have 10-15 piston strokes at the same time. Repeat the operation once in every two weeks.

g) When dry lubricated compressors are kept idle for less than 6 months, Seal all holes of the cylinder, purge with dry nitrogen and maintain a pressure of about 100 mm WG. If nitrogen is not available, keep sufficient quantity of dehydrating agent such as silica gel and close tightly. Check periodically effectiveness of the dehydrating agent.

h) When lubricated compressors and dry-lubricated compressors (for process that allow traces of grease), are kept idle for more than 6 months, take out the

pistons out of the cylinders. Remove the piston rings and rider rings. For metallic piston rings, apply grease on the entire surface and keep them in sealed polythene bags with dehydrator. Non-metallic piston rings do not require any special protection. Clean thoroughly and apply suitable grease inside the cylinder and the housing for valves and packing. Seal all holes of the cylinder, purge with dry nitrogen and maintain a pressure of about 100 mm WG. If dry nitrogen is not available, keep sufficient quantity of dehydrating agent such as silica gel inside the cylinder and check the effectiveness of the dehydrating agent periodically. Fill lubricators with lubricating oil. For dry-lubricated compressor all traces of rust preventive grease shall be removed before putting into service.

i) When dry-lubricated compressors for process that do not allow traces of grease, are kept idle for more than 6 months, the pistons, piston rings, valves and packing shall be degreased with thinners and kept in sealed polythene bags with dehydrator. Seal all holes of the cylinder, purge with dry nitrogen

and maintain a pressure of about 100 mm WG. If dry nitrogen is not available, keep sufficient quantity of dehydrating agent such as silica gel inside the cylinder and check the effectiveness of the dehydrating agent periodically.

j) Drain cooling water from cylinder jackets, inter coolers and after coolers wherever applicable.

k) Purge the piping with dry nitrogen. Close all openings and maintain a nitrogen pressure of 100 mm of WG. As an alternative, close all openings tightly and keep inside the piping sufficient quantity of dehydrating agent such as silica gel, in accordance with their dimensions and shape. Check the dehydrating agent periodically.

### **3.2.3 Preservation of idle oil free screw type Air Compressor.**

The following procedure should be adopted when the compressor kept idle for a period up to two months the compressor should be run on no load once a week for approx. 10-15 minutes

When the compressor kept idle for more than two months, the following steps should be adopted

a) With the compressor running on LOADED condition open the manual condensate drains of inter cooler and after cooler and ensure all drain pipes are free. Close the drains and reopen them only after the unit has stopped.

b) Remove the moisture trap flange of the inter cooler and place sufficient quantity of moisture absorbing agent inside the moisture trap.

c) Close the flange hole of moisture trap airtight. Keep the flange separate in dry condition.

d) Close the manual drains.

e) Rotate the compressor drive shaft a few turns by hand once a week.

f) Drain off the lubricating oil and refill the oil sump with a suitable preservative oil

g) Run the compressor on no load after first two months for at least half an hour to ensure that the normal working temperatures have been reached. Before running the compressor, remove and discard the moisture absorbing agent and refit the moisture trap flange.

h) Proceed further as described under steps



(a) to (e) above using a new moisture-absorbing agent.

i) When the unit is standing idle for an extended period the above-mentioned procedure should be repeated every six months.

j) Drain the cooling water, close the inlet and outlet valves and fill the line with fresh water.

### **3.2.4 Preservation of idle oil flooded screw Compressor**

When the compressor is going to be idle for more than six months

- a) Blind off suction and discharge valves
- b) Drain the oil in the casing of the screw elements.
- c) Flush and fill the casing of the screw elements with a suitable preservative oil.
- d) Close all drains and vents
- e) Drain the cooling water, close the inlet and outlet valves and fill the line with fresh water dozed with anticorrosive chemical.
- f) Rotate the compressor drive shaft a few turns by hand once a week.
- g) Change the preservative oil every six months/one year as per schedule.

h) Change water every six months.

### **3.3 PRESERVATION OF STEAM TURBINES**

a) The lube oil system and governing oil system shall be either kept in service on a weekly basis or filled with a low positive pressure of dry nitrogen.

b) Dry nitrogen may be admitted into the turbine including all steam spaces and gland sealing through one of the pressure tapping points in the turbine exhaust hood of turbine case. This shall be done during a period of minimum humidity and air inside the turbine is to be purged out completely.

c) Maintain a positive pressure of about 50 to 75 mm WG during the idle time and monitor the same.

#### **The turbine rotor shall be rotated by turning gear or by hand by the following procedures:**

- It should be rotated by 180 degree from the standstill condition after three months
- It should be rotated by 90 degree after 3 months.

- It should be again rotated by 180 degree after 3 months.
- It should be rotated by 90 degree position after 3 months.
- This procedure shall be continued subsequently.

### 3.4 PRESERVATION OF GAS TURBINE

The following procedure should be adopted for preserving idle gas turbine

Machine already erected at site and the final commissioning of the machine is expected to be longer than one month.

- a) For a single shaft turbine, cranking has to be done for half an hour once in a week keeping the lube oil system under operation. Apart from cranking of HP shaft, Low pressure (LP) shaft of two-shaft turbine has to be rotated manually for a few complete revolutions every week with help of suitable fixtures fitted with coupling hub in the direction of rotation keeping the lube oil under operation.
- b) The lube oil has to be internally circulated through a centrifuge every day for 8 hours or whatever time required to

drive out the moisture/ dirt/ dust from the lubricating oil when the Gas Turbine is lying in idle condition.

c) If the cranking is not possible by motor not being provided with electrical connections, in such case rotation of the machine to be done manually using suitable fixtures keeping the lube oil under operation.

d) The rotor in no case shall be rotated without lube oil circulation.

Machine already commissioned and the idle period is longer than one month

a) The unit should be operated on NO LOAD for at least 30 minutes in every month to dry out any moisture inside the ducting and other components and to recirculate the lubricating oil to recoat the moving parts to prevent rust and corrosion.

b) The lube oil has to be internally circulated through a centrifuge every day for 8 hours or whatever time required to drive out the moisture/ dirt/ dust from the lubricating oil when the Gas Turbine is lying in idle condition.

c) If the cranking is not possible by motor not

being provided with electrical connections, in such case rotation of the machine to be done manually using suitable fixtures keeping the lube oil under operation.

d) The rotor in no case shall be rotated without lube oil circulation.

### **3.5 PRESERVATION OF DIESEL ENGINES**

The following procedure should be adopted for preserving an idle diesel engine when the diesel engine is kept idle for a period less than 6 months, run the engine on load for 10-15 minutes once in a week. If the engine cannot be run on load, idle run the engine till the temperatures of cooling water and lubricating oil reach the normal operating range.

When the engine is kept idle for a period more than six months the following steps should be adopted.

a) Start the engine, increase the speed gradually up to 1200 rpm or a fast idle, operate the engine with no load until the engine is thoroughly warm and then stop the engine.

b) Drain all lubricating oil from the oil sump and refill the oil sump with suitable preservative oil.

c) Drain coolant from cooling system and thoroughly flush with clean water and suitable radiator cleaner. Refill the cooling system with mixture of water and suitable radiator protector in the ratio recommended by the manufacturer.

d) Fill two portable containers one with diesel and other with the preservative oil mentioned in (b) above

e) Start the engine with engine pulling fuel from the container with diesel through the filter and the injector drain line flowing into the container with diesel. Once the engine is running smooth at idle, switch the fuel line to the container with preservative oil. Run the engine 5-10 minutes on NO LOAD till it is observed that the preservative oil is coming out from injector return line. Stop the engine.

f) Drain the oil sump, fuel filter and fix back the drain plugs.

g) Turn fuel pump manual shut off valve to 'OFF' position so that the engine will not start.

h) When the engine has become cool, disconnect the inlet and exhaust manifolds, spray suitable preservative oil into air

intake and exhaust outlets, engine being turned by hand during spray operation. Cover all intake manifold opening with tape to prevent entry of dirt and moisture. Cover all engine openings of cylinder block, oil breather and crank case including coolant inlets and outlets. All vents, dynamo, starter motor, magneto if any and air cleaners to be carefully sealed with water proof paper and water proof adhesive tape.

i) Loosen V belt tension. Remove rock lever covers and spray preservative oil over rocker levers, valve springs & stems, guides, cross head and push tubes. Replace cover.

j) Do not rotate the crank shaft after the above operations.

k) Tag the Engine with date of treatment to indicate it has been treated with preservatives and should not be turned over.

l) Periodically inspect engines for rust or corrosion and take corrective action if necessary.

m) Repeat the engine preservative treatment as mentioned above once in every six months.

n) Before taking into service, the engine shall be preserved as per the procedure given below

i) Clean off all accumulated dirt and rust preventive using suitable solvent from exterior of engine.

ii) Remove all paper cover, tape and wrappings and reinstall the dismantled components. Carry out precommissioning checks.

iii) Flush cooling system.

iv) Refill the oil sump with clean lubricating oil

v) Adjust the injectors, valve and belts and check cylinder head cap screws, filters, air filter and screens.

vi) Pressurize the lubricating system about 1 Kg/ cm<sup>2</sup> including turbo charger or supercharger prior to starting the engine.

vii) Run the engine with diesel on NO LOAD LOW IDLE for 5 minutes to flush the entire fuel system out of any preservative oil

viii) Remove any foreign matter, which may collect on screens and strainers, before regular operation of the engine.

When the diesel engine is kept in store as a spare complete set and likely to be unused for more than six months

- a) Keep the engine on a suitable pedestal
- b) Just after six months from the date of dispatch, the preservative oil should be drained off from the engine. After flushing the internal parts with a suitable solvent, wipe and clean the parts with the solvents. Clean the parts with dry felt cloth.
- c) After drying suitable rust preventive should be again sprayed and dried on the parts
- d) The crank case should be filled with suitable rust preventive and should be filled up to the high oil level mark of crank ease
- e) Connect a electrical motor driven lube oil priming pump with suction of the pump connected to the crank case drain point and discharge connected to the inlet of the lube oil filters
- f) All the openings to be covered or blinded to make the engine air tight

- g) Run the lube oil pump once in week to achieve the operating pressure inside the engine and then stop the pump. By this method all bearings, pistons connecting rod, rocker arms, valves, etc. will be lubricated
- h) After six months repeat the above procedure as per steps (b) to (g) mentioned above
- i) Replace the preservative oil as per schedule.

### **3.5 PRESERVATION OF FANS & BLOWERS**

The following procedure should be adopted for preserving idle fans and blowers

- a) Coat the interior of the casing and the impeller of the fan/blower with a suitable rust preventive.
- b) Blind the suction and discharge end of the fans/blowers.
- c) Close all openings in the casings.
- d) Clean and coat the exposed shaft with grease.
- e) In case of grease lubricated bearings remove the grease, clean the bearing and bearing housing and fill the bearing housing fully with fresh grease. Close all openings of the bearing housing.

f) In case of oil lubricated bearings drain the oil. Flush and fill the housing fully with suitable grade of fresh lubricating oil. Close all openings of the bearing housing

g) Coat all the exterior surface of the casing/bearing housing with suitable rust preventive.

h) Drain the oil from gear box and refill it with a high grade mineral oil. Clean the exterior surfaces of the gear box and paint them. Wrap all exposed shaft with Plastic tape. Store the reducer in a warm and dry. The gear box rotor shall be rotated by the following procedures:

- It should be rotated by 180 degree from the standstill condition after three months
- It should be rotated by 90 degree after 3 months.
- It should be again rotated by 180 degree after 3 months.
- It should be rotated by 90 degree position after 3 months.
- This procedures shall be continued

#### **4.0 PRESERVATION OF MATERIALS IN STORES**

Moisture, oxygen and atmospheric conditions are the main contributing factors causing deterioration. These may cause rusting, pitting of surfaces and other forms of deterioration. Proper identification system should be used for material stored in the warehouse to avoid mixing. Procedure for preservation of stored material should be adopted as follows.

#### **4.1 PRESERVATION OF HEATER COMPONENT:**

##### **4.1.1 HEATER TUBES:**

Both CS and low alloy steel heater tubes can be stored outdoor on a sloped concrete surface. These tubes shall be kept either on steel racks or wooden rafter. Tubes shall not be allowed to get submerged in the ground or in contact with water. Both the ends of tubes shall be suitably capped or plugged. CS heater tubes shall be given a coat of oil preservative externally before stacking the tubes. 300 mm length at each end of tube shall be coated with grease and water proof wrapping paper where rolling operation is performed. To avoid chloride attack, it is preferable to store Stainless steel heater tubes indoors on wooden rafter with both the ends plugged.

#### 4.1.2 Return Bends:

CS/ Low alloy steel cast plug type return bends should be stored in a covered shed. Grease preservative shall be applied on all the machined and threaded surfaces. However other type of return bend can be stored outdoors after applying necessary protective coatings as given to heater tubes in downward position to avoid any accumulation of water inside the bend.

#### 4.1.3 Heater Tube Support or Hangers, etc. :

These shall be stored indoor. No preservative is needed for these components.

### 4.2 PRESERVATION OF PIPES, PIPE FITTINGS AND VALVES

#### 4.2.1 Preservation of Pipes:

Both CS and low alloy steel pipes can be stored outdoor in a self draining position on a concrete surface either on steel racks or woody rafter placed in such a position that rain water does not accumulate and affect pipes. Pipes shall not be allowed to get submerged in ground or pool of water.

Pipes/ pipefittings shall be protected with an external coat of black bituminous paint. Pipes shall also be painted internally at the

ends, upto a length of 12" or as practicable.

Stainless steel pipes shall be stored indoor on wooden rafters/ concrete, separate from CS, with ends opened or plugged. The ink used for marking, if any shall be free from chloride, sulphur and lead.

For pipes with threaded connection, extra care shall be taken in protecting the threads by putting plastic caps or wrapping with jute cloth.

#### 4.2.2 Preservation of Flanges:

Flanges with anticorrosive painting shall be stacked on stands /concrete or wooden sleepers with their gasket seating surfaces at the bottom and covered with tarpaulin. All the flange gasket-seating surface must have a protective coating & extreme care must be taken during handling to avoid damage.

All SS flanges should be stored indoors.

#### 4.2.3 Preservation of Pipe Fittings:

Forged fittings can be stored outdoor on sloped concrete surface or wooden platform. All fittings shall be preferably given a coat of anticorrosive paint and shall be stored in such a location that rain water does not accumulate in it.

Stainless steel fittings should be stored indoors.

#### **4.2.4 Preservation of Fasteners:**

Fasteners shall be kept indoors. Carbon steel and alloy steel fasteners shall be stored in separate bays after oil preservation spray. Stainless steel fasteners do not require any protection.

#### **4.2.4 Preservation of Valves:**

End cover of all the valves shall be plugged by wooden/ rubber/ PVC blanks.

Valves shall be stacked on a concrete surface on wooden rafters, with wooden planks on flanges.

Grease shall be applied on valve steel spindle and flange faces of CS & AS valves. Valves shall be kept in upright with spindle upward and gate in closed position.

All SS valves shall be stored indoor without any preservative.

### **4.3 PRESERVATION OF HEAT EXCHANGERS/ CONDENSERS/ COOLERS:**

#### **4.3.1 Bundles:**

CS & AS tube bundles shall be stored suitably covered on wooden rafters. Oil preservation spray on tube extended surface shall be done once in a year. Tube

sheets shall be greased properly and covered with wooden boards.

CS & AS tube bundles can also be stored in wooden boxes with tarpaulin cover on top.

Tube bundles of brass/ stainless steel and high alloy steel shall be stored on wooden rafters with proper covers. Special care needs to be taken for SS bundle to avoid chloride attack. No preservative is needed for these bundles.

#### **4.3.2 Tubes:**

All the exchanger/ condenser tubes shall be stored indoor on steel racks. CS and alloy steel tubes shall be coated with oil preservative or black bituminous paint whereas brass/ stainless steel tubes do not require any preservative. Tubes may be provided with tightly fitted HDPE/ PVC end caps.

#### **4.3.3 Tube Sheets:**

CS and alloy steel tube sheets shall be stored indoor on wooden rafters with grease applied on it. Brass/ SS tube sheets shall be stored indoor without any preservative.

### **4.4 PRESERVATION OF PLATES:**

CS plates can be stored in a sloping fashion on wooden rafters in bunches keeping



sufficient clearance from the ground. Top, bottom and side surface of the bunch (of same size) coming in contact with atmosphere should be coated with preservative oil/grease/paint.

Alloy Steel/ Stainless steel plates may be stored indoor. No preservative is required for these plates.

#### **4.5 PRESERVATION OF STRUCTURAL STEEL:**

Structural steel shall be positioned in a way to allow self-draining. Structural steel should not be in contact with soil during preservation.

#### **4.6 PRESERVATION OF COLUMN TRAYS & FITTINGS:**

These shall be stored indoor. CS/AS fittings shall be kept after a spray of oil preservatives. Stainless steel parts shall be kept as it is.

#### **4.7 PRESERVATION OF VESSEL & EXCHANGER SHELL:**

Closed vessel shall be kept on their steel supports. In absence of steel support, wooden saddles shall be used. Vessel shall be painted externally with Zinc Oxide primer. Preservative oil spray shall be done on internal surface. Flanged faces shall be greased and covered with wooden boards. All the nozzles shall

be suitably covered so that rainwater will not ingress.

#### **4.8 PRESERVATION OF REFRACTORY**

##### **4.8.1 Refractory Bricks:**

Refractory bricks shall be stored indoors in a dry shed. The storage shed shall be at a well-drained location. In stacking, the bricks shall be stacked on edge with laths in horizontal joints.

##### **4.8.2 Refractory Castables:**

Castables shall be kept in dry storage and protected from rains and moisture. The stacking of castables shall start approximately 15 cms above the concrete floor which itself shall be sufficiently above ground level. If the floor is not dry ensure storage of bags above the damp floor by providing timber boards on bricks, planks or any other suitable device.

Bags of castables shall be stacked at least 30 cm away from the walls to ensure that they shall not come in contact with walls, which may be damp. In very large sheds, bags shall be covered with plastic sheets.

#### **4.9 PRESERVATION OF SPARE PARTS OF PUMPS AND RECIPROCATING COMPRESSORS:**

Preservation should be carried out in accordance to Para 4.4 of OISD-STD-126

#### **4.10 PRESERVATION OF ANTI-FRICTION BEARINGS:**

Preservation should be carried out in accordance to Para 4.5 of OISD-STD-126

#### **4.11 PRESERVATION/ REPRESERVATION OF COMPONENTS OF CENTRIFUGAL COMPRESSOR / STEAM TURBINE / GAS TURBINE / DIESEL ENGINE**

##### **4.11.1 Rotor: -**

Preservation/ Re-preservation of rotor should be carried out in accordance to Para 4.3 of OISD-STD-126.

##### **4.11.2 Casing:-**

Casing surface to be sprayed with suitable rust preventive oil. To the extent possible the parting planes of the casing shall be kept on top. If this is not possible and if the casing is required to be kept in the inverted position, the parting planes shall be kept on dry wooden beams. To avoid rusting of the contact area between the casing parting plane and the wooden beams, rubber pads or grease/ oil immersed felt shall be kept.

##### **4.11.3 Journal Bearings, Thrust Bearings, Oil Seals And Couplings:**

These small spare parts which are to under go forced lubrication, should be

protected by coating with suitable grease and wrapped in water proof plastic paper/ VCI paper.

4.11.4 Crank case/Connecting rods/ pistons/liners and other components to be stored in a covered shed preferably with a coating of anticorrosive paint. All shaft connecting rods shall be provided with proper wooden supports.

#### **4.12 PRESERVATION PROCEDURE FOR EQUIPMENT NOT INSTALLED/ KEPT AT STORE.**

When the Reciprocating Compressor is not installed at site and likely to be kept idle more than six months.

- a) Inspect the Crank case cover to check the condition of crank shaft, connecting rod and other components. After cleaning them thoroughly flush and drain the Crankcase by filling suitable preservative oil and then fill the same oil upto the Crank Case oil level.
- b) Open the inspection cover to check the condition of piston rod, rod nut, cross head, etc and after cleaning these are to be coated with rust protective layers. Close the crank case cover to prevent the entry of dirt/ dust and moisture.
- c) Suction and Discharge valves, piston rod pressure packing rings should be taken out and cleaned thoroughly by some solvent and then coat them with

some rust preventive oil and wrap then in polythene pack and should be kept separately.

- d) All piping connections and openings should be carefully plugged, blinded.
- e) Lubricated cylinders should be lubricated by manually turning the force feed lubricator, which should be kept filled up with suitable preservative oil. Wherever the force feed lubricators are not available apply suitable preservative oil inside the cylinder surfaces.
- f) For non-lubricated cylinders, keep sufficient dehydrating agents such as silica gel inside the cylinder and close all the openings tightly. Check the effectiveness of the dehydrating agent periodically.
- g) The barring of the compressor to be done at least once in three months.

When the oil free screw air compressor is not commissioned and kept idle for more than five months.

- a) Renew the drying agent such as silica gel placed in the inter cooler moisture trap immediately upon receipt of the compressor at site
- b) Renew the drying agent such as silica gel kept in the inter cooler moisture trap once in every 3 months
- c) Store the compressor units indoors in a dry space

- d) Ensure that there is absolutely no water in the crate, on any plastic cover, or any where along the canopy or the base frame of the unit
- e) Install a motor driven special lube oil pump of small capacity capable of developing the maximum operating pressure of the main oil pump of the compressor with suction of the pump connected to the oil sump drain point and the discharge of the pump connected to the upstream of the lube oil filter.
- f) Fill the lubricating circuit with a rust inhibiting oil.
- g) Run the special oil pump for 15 minutes. While the oil circulates, turn the compressor coupling by hand. The silica gel kept in the inter cooler moisture trap is to be removed before starting the lube oil pump. After lubrication insert new silica gel.
- h) Repeat the procedure mentioned in (g) above once in six months

## 5.0 REFERENCES

- (i) *API Guide for Inspection of Refinery Equipment - Chapter XVIII – Protection of Idle Equipment.*
- (ii) *NACE Standard – RP - 01 – 70 - Protection of Austenitic Stainless Steel in Refineries against Stress Corrosion Cracking by Use of Neutralizing Solutions During Shut Down.*

- (iii) *ASME Boiler & Pressure Vessel Code, Sec VII – Recommended Rules for care of Power Boilers.*
  
- (iv) *The Preservation of Equipment and Piping Standing Idle – DEP – 70.10.70.11 – GEN of Shell Group.*
  
- (v) *OISD-STD-126 – Specific Maintenance Practices for Rotating Equipment.*
  
- (vi) *OISD-STD-146 – Preservation of Idle Electrical Equipment.*

## ANNEXURE I

### COMMONLY USED PRESERVATIVES

- I. OIL PRESERVATIVES:** Generally, it is a lubricating oil of viscosity SAE 30, compounded with inhibitor and wetting agent. It may be applied by brushing, splashing or spraying. In absence of any oil preservatives, spent lubricating oil can also be used in exigency.
- II. GREASE PRESERVATIVE:** It is an asphaltic/ petroleum type base cutback with solvent. It leaves a greasy film that can be easily removed by a petroleum solvent. It may be applied by brushing or dipping.
- III. PAINTS:** Bituminous anti corrosive paints manufactured by various reputed manufacturers can be used. It is applied by brushing or spraying.
- IV. WRAPPING:** Water proof wrapping papers may also be used. Papers coated with volatile corrosion inhibitor (VCI paper) are available and have got longer life.

## DIMENSIONS OF SEAMLESS AND WELDED STEEL PIPE AS PER ANSI B36.10 and B38.19

Measurement in	Nominal pipe size	Out side dia	Sche d5s*	Sch 105*	Sch 10	Sch 20	Sch 30	Stand and t (40.S)	Sch 40	Sch 60	Extra strong	Sch 80	Sch 100	Sch 120	Sch. 140	Sch. 160	XX strong
Inch	1/8"	0.405	-	0.049	-	-	-	0.068	0.068	-	0.095	0.095	-	-	-	-	-
mm	3	10.287	-	1.245	-	-	-	1.727	1.727	-	2.413	2.413	-	-	-	-	-
Inch	1/4"	0.540	-	0.065	-	-	-	0.088	0.088	-	0.119	0.119	-	-	-	-	-
mm	6	13.716	-	1.651	-	-	-	2.235	2.235	-	3.023	3.023	-	-	-	-	-
Inch	3/8"	0.675	-	0.065	-	-	-	0.091	0.091	-	0.126	0.126	-	-	-	-	-
mm	10	17.145	-	1.651	-	-	-	2.311	2.311	-	3.200	3.200	-	-	-	-	-
Inch	1/2"	0.840	0.065	0.083	-	-	-	0.109	0.109	-	0.141	0.147	-	-	-	0.188	0.294
mm	15	21.336	1.651	2.108	-	-	-	2.769	2.769	-	3.734	3.734	-	-	-	4.775	7.468
Inch	3/4"	1.050	0.065	0.083	-	-	-	0.113	0.113	-	0.154	0.154	-	-	-	0.219	0.308
mm	20	26.670	1.651	2.108	-	-	-	2.870	2.870	-	3.912	3.912	-	-	-	5.563	9.093
Inch	1"	1.315	0.065	0.109	-	-	-	0.140	0.140	-	0.191	0.191	-	-	-	0.250	0.358
mm	25	33.401	1.651	2.769	-	-	-	3.556	3.556	-	4.851	4.851	-	-	-	6.350	9.093
Inch	1- 1/4"	1.660	0.065	0.109	-	-	-	0.140	0.140	-	0.191	0.191	-	-	-	0.250	0.382
mm	32	42.164	1.651	2.769	-	-	-	3.556	3.556	-	4.851	4.851	-	-	-	6.350	9.703
Inch	1-1/2"	1.900	0.065	0.109	-	-	-	0.145	0.145	-	0.200	0.200	-	-	-	0.281	0.400
Mm	40	48.260	1.651	2.769	-	-	-	3.683	3.683	-	5.080	5.080	-	-	-	7.137	10.160
Inch	2"	3.375	0.065	0.109	-	-	-	0.154	0.154	-	0.218	0.218	-	-	-	0.344	0.436
Mm	50	60.325	1.651	2.769	-	-	-	3.912	3.912	-	5.537	5.537	-	-	-	8.738	11.074
Inch	2-1/2"	2.875	0.083	0.120	-	-	-	0.203	0.203	-	0.276	0.276	-	-	-	0.375	0.552
Mm	65	73.025	2.108	3.048	-	-	-	5.156	5.156	-	7.010	7.010	-	-	-	9.525	14.021
Inch	3"	3.500	0.083	0.120	-	-	-	0.216	0.216	-	0.300	0.300	-	-	-	0.438	0.600
mm	80	88.900	2.108	3.048	-	-	-	5.486	5.486	-	7.620	7.620	-	-	-	11.125	15.240
Inch	3-1/2"	4.000	0.083	0.120	-	-	-	0.226	0.226	-	0.318	0.318	-	-	-	-	-
mm	90	101.600	2.108	3.048	-	-	-	5.740	5.740	-	8.077	8.077	-	-	-	-	-
Inch	4"	4.500	0.083	0.120	-	-	-	0.237	0.237	-	0.337	0.337	-	0.438	-	0.531	0.674
mm	100	114.300	2.108	3.048	-	-	-	6.020	6.020	-	8.560	8.560	-	11.125	-	13.487	17.120
Inch	5"	5.563	0.109	0.134	-	-	-	0.258	0.258	-	0.375	0.375	-	0.500	-	0.625	0.750
mm	125	141.300	2.769	3.404	-	-	-	6.553	6.553	-	9.525	9.525	-	12.700	-	15.875	19.050
Inch	6"	6.625	0.109	0.133	-	-	-	0.280	0.280	-	0.432	0.432	-	0.562	-	0.719	0.864
mm	150	168.275	2.769	3.404	-	-	-	7.112	7.112	-	10.973	10.973	-	14.275	-	18.263	21.946
Inch	8"	8.625	0.109	0.148	-	0.250	0.277	0.322	0.322	0.406	0.500	0.500	0.594	0.719	0.812	0.906	0.875
mm	200	219.075	2.769	3.759	-	6.350	7.036	8.179	8.179	10.312	12.700	12.700	15.088	18.263	20.625	23.012	22.225
Inch	10"	10.750	0.134	0.165	-	0.250	0.307	0.365	0.365	0.500	0.500	0.594	0.719	0.844	1.000	1.125	1.000

Measurement in	Nominal pipe size	Out side dia	Sche d5s*	Sch 105*	Sch 10	Sch 20	Sch 30	Stand and t (40.S)	Sch 40	Sch 60	Extra strong	Sch 80	Sch 100	Sch 120	Sch. 140	Sch. 160	XX strong
mm	250	273.050	3.404	4.191	-	6.350	7.798	9.271	9.271	12.700	12.700	15.088	18.263	21.438	25.400	28.575	25.400
nch	12"	12.750	0.156	0.180	-	0.250	0.330	0.375	0.406	0.562	0.500	0.688	0.844	1.000	1.125	1.312	1.000
mm	300	323.850	3.962	4.572	-	6.350	8.382	9.525	10.312	14.275	12.700	17.475	21.438	25.400	28.575	33.325	25.403
Inch	14"	14.000	0.156	0.188	0.250	0.312	0.375	0.375	0.438	0.594	0.500	0.750	0.938	1.094	1.250	1.406	-
mm	350	355.600	3.962	4.775	6.350	7.925	9.525	9.525	11.125	15.088	12.700	19.050	23.825	27.788	31.750	35.712	-
Inch	16"	16.000	0.165	0.188	0.250	0.312	0.375	0.375	0.500	0.656	0.500	0.844	1.031	1.219	1.438	1.594	-
mm	400	406.400	4.191	4.775	6.350	7.925	9.525	9.525	12.700	16.662	12.700	21.438	26.187	30.963	36.525	40.488	-
Inch	18"	18.000	0.165	0.188	0.250	0.312	0.438	0.375	0.562	0.750	0.500	0.938	1.156	1.375	1.562	1.781	-
mm	450	457.200	4.191	4.775	6.350	7.925	11.125	9.525	14.275	19.050	12.700	23.825	29.362	34.925	39.675	45.237	-
Inch	20"	20.000	0.188	0.218	0.250	0.375	0.500	0.375	0.594	0.812	0.500	1.031	1.281	1.500	1.750	1.969	-
mm	500	508.800	4.775	5.537	6.350	9.525	12.700	9.525	15.088	20.625	12.700	26.187	32.537	38.100	44.450	50.013	-
Inch	22"	22.000	0.188	0.218	0.250	0.375	0.500	0.375	-	0.875	0.500	1.125	1.375	1.625	1.875	2.125	-
mm	550	528.800	4.775	5.537	6.350	9.525	12.700	9.525	-	22.225	12.700	28.575	34.925	41.275	47.625	53.975	-
Inch	24"	24.000	0.218	0.250	0.250	0.375	0.562	0.375	0.688	0.969	0.500	1.219	1.531	1.812	2.062	2.344	-
mm	600	609.600	5.537	6.350	6.350	9.525	14.275	9.525	17.475	24.613	12.700	30.963	38.885	46.025	52.375	59.538	-
Inch	26"	26.000	-	-	0.312	0.500	-	0.375	-	-	0.500	-	-	-	-	-	-
mm	650	660.400	-	-	7.925	12.700	-	9.525	-	-	12.700	-	-	-	-	-	-
Inch	28"	28.000	-	-	0.312	0.500	0.625	0.375	-	-	0.500	-	-	-	-	-	-
mm	700	711.200	-	-	7.925	12.700	15.875	9.525	-	-	12.700	-	-	-	-	-	-
Inch	30"	30.000	0.250	0.312	0.312	0.500	0.625	0.375	-	-	0.500	-	-	-	-	-	-
mm	750	762.000	6.350	7.925	7.925	12.700	15.875	9.525	-	-	12.700	-	-	-	-	-	-
Inch	32"	32.000	-	-	0.312	0.500	0.625	0.375	-	-	0.500	-	-	-	-	-	-
mm	800	812.800	-	-	7.925	12.700	15.875	9.525	-	-	12.700	-	-	-	-	-	-
Inch	34"	34.000	-	-	0.312	0.500	0.625	0.375	-	-	0.500	-	-	-	-	-	-
mm	850	863.600	-	-	7.925	12.700	15.875	9.525	-	-	12.700	-	-	-	-	-	-
Inch	36"	36.000	-	-	0.312	0.500	0.625	0.375	0.750	-	0.500	-	-	-	-	-	-
mm	900	914.400	-	-	7.925	12.700	15.875	9.525	19.050	-	12.700	-	-	-	-	-	-

## EQUIVALENTS SPECIFICATIONS OF ASTM TO BRITISH, FRENCH, GERMAN, ITALIAN AND SWEDISH STANDARDS

1	2	3	4	5	6	7	8
MATERIAL	U.S. SPECIFICATIONS	BRITISH	FRENCH	GERMAN	ITALIAN	SWEDISH	NOTES
Carbon steel line pipe	API 5L Seamless Grade A Grade B	BS. 3601	GAPAVE 411	DIN 1629	Aq 35 UNI 663C	SIS 1233-05	1,2
		HFS 22 or CDS 22	A 37C	St 35	Aq 45 UNI 663C	Sis 1434-05	3,4
		HFS 27 or CDS 27	A 42 C	St 45			
	Electric resistance welded Grade A Grade B	Bs 3601 ERW 22 ERW 27	.... .... ....	DIN 1625 Blatt 3st 34-2/Electric Blatt 4st 37-2/ resistance welded	.... .... ....	SIS 1233-06 SIS 1434-06	45
	Electric fusion welded Grade A Grade B	BS 3601 (Double welded) EFW 22 EFW 27	.... .... ....	DIN 1626 Blatt 3st 34-2/ Fusion Blatt 4 st 37-2/ welded	.... .... ....	.... .... ....	2,4 5
	Furnace butt Welded	BS 3601 BW 22	.... ....	DIN 1626 Blatt 3 st 34-2 Furnace butt welded	.... ....	.... ....	
	Carbon steel pipe	ASTM A 53 Seamless Grade A Grade B	BS, 3601	Gapave 411	Din 1629	Aq35 Uni 663C SIS	1233-05
HFS 22 or CDS 22			A 37 C	St 35	Aq45 Uni 663C SIS	1434-05	3,4
HFS 22 or CDS 22			A 42 C	St 45			
Electric resistance welded Grade A Grade B		BS 3601 ERW 22 ERW 27	.... .... ....	Din 1626 Blatt 3 St 34-2 Electric St 37-2 Resistance welded	.... .... ....	.... .... ....	4
Furnace butt Welded		BS 3601 BS 22	.... ....	Din 1626 Blatt 3 St 34-2 Furnace butt welded	.... ....	.... ....	
Carbon steel boiler tube, seamless	ASTM A83	BS 3059/1 or 2	Gapave 211 A 37 C	Din 1629 St 35	.... ....	.... ....	4
Silicon-killed carbon steel pipe for high temperature Service	ASTM A 106 Grade A Grade B Grade C	BS 3602	Capave 421	Din 1717			
		HFS 23	A 37 C	St 35.8	Aq35 Uni 663C SIS	1234-05	2,3
		HFS 27	A 42 C	St 45.8	Aq45 Uni 663C SIS	1435-05	4,6
		HFS 35	A 48 C	.....	....	....	Contd.



1	2	3	4	5	6	7	8
MATERIAL	U.S. SPECIFICATIONS	BRITISH	FRENCH	GERMAN	ITALIAN	SWEDISH	NOTES
Electric fusion welded steel pipe	ASTM A 134	BS 3601 EFW	....	Din 1626 Blatt 2 Electric fusion welded	....	....	2,4
Electric resistance welded steel pipe	ASTM A 135 Grade A	BS 3601 ERW 22	....	Din 1626 Blatt 3	....	SIS 1233-06	4
	Grade B	ERW 27	....	Din 34-2 Electric resistance welded	....	SIS 1434-06	
Electric fusion welded steel pipe	ASTM A 139 Grade A	BS 3601 EFW 22	....	Din 1626 Blatt 2	....	....	2,4
	Grade B	EFW 27	....	St 37	....	....	
Electric fusion welded pipe for high temperature service	ASTM A 155 Class 2	....	....	Din 1626 Blatt 3 mit Abnahmezeugnis C	....	....	
	C 45	....	....	St 34-2	....	....	
	C 50	....	....	St 37-2	....	....	
	C 55	BS. 3602 EFW 28	....	St 42-2	....	....	
	KC 55	....	....	St 42-2 Si-killed	....	....	2,4
	KC 60	BS. 3602 EFW 28S	....	St 42-2 Si-killed	....	....	7,8
	KC 65	....	....	St 52-3	....	....	
	KC 70	....	....	St 52-3	....	....	
Austenitic stainless steel pipe	ASTM A 312 TP 304 TP 304H TP 304L TP 310 TP 316 TP 316H TP 316L TP 317 TP 321 TP 321H TP 347 TP 347H	BS 3605	....	WSN 4301	Designation	....	....
		Grade 801	....	....	X5CrNi189	X 8CN1910	SIS 2333-02
		Grade 811	....	4306	....	....	....
		Grade 801L	....	4841	X2 CrNi189	X3CN1911	SIS 2352-02
		Grade 805	....	4401.4436	X15CrNiSi2520	25CN 2520	SIS 2361-02
		Grade 845	....	....	X5CrNiMo1810	X8CND1712	SIS 2343-02
		Grade 855	....	4404	....	....	....
		Grade 845L	....	....	X2CrNiMo 1810	....	SIS 2353-02
		Grade 846	....	4541	....	....	....
		Grade 822 Ti	....	....	X10CrNiTi189	X8CNT1810	SIS 2337-02
		Grade 832 Ti	....	4550	....	....	....
		Grade 822 Nb	....	....	X10CrNiNb18.9	X8CNNb1811	SIS 2338-02
		Grade 822 Nb	....	....	....	....	....
		Pipe for low temperature service	ASTM A333 Grade 1	BS 3603 27 LT 50	....	WSN 0437	Designation SEW680TTSt41
Grade 3	503 LT 100		....	5637	.... 10Ni 14	....	Contd..
....	....		Gapave 222	....	....	....	
	....	....	Afnor 1503	Din 17175 15Mo3	....	SIS 2912-05	

1	2	3	4	5	6	7	8		
MATERIAL	U.S. SPECIFICATIONS	BRITISH	FRENCH	GERMAN	ITALIAN	SWEDISH	NOTES		
Samples ferritic alloy pipe for elevated temperature tube service	ASTM A335	BS 3604	P1	....	WSN5423	16Mo5	....		
			P2	....	Afnor15CD2-05	....	....		
			P12	HF620 or CD 620	....	Din17175	13CrMo44	....	SIS 2216-05
			P11	HF621 or CD 621	Afnor 10CD5-05	....	....	....	....
			P22	HF622 or CD 622	Afnor 10CD9-10	DIN17175	13CrMo44	....	SIS2216-05
			P5	HF625 or CD 625	....	....	....	....	....
Aluminium alloy pipe	ASTM B241	P9	....	Afnor Z10CD9	....	....	SIS2203-05		
		303 h112	....	....	Din 1746 A1 MnF10	....	....		
		5154 H112	BS 1471NT5 or BS 1474NT5	....	....	Din 1746 A1 Mg3F18	....	....	
		6061 T6	BS 1471 HT 20WP	....	....	Din 1746 A1 MgSi 1F32	....	....	

**Notes:**

- For pipe fabricated to ASA B 31.3 steel should be specified to be open hearth, electric furnace or basic oxygen. Alternatively, Thomas steel is acceptable if fully killed or if it meets the following composition requirements:  
S 0.05% max, P 0.05% max, N 0.009% max.
- Ramming steel is not acceptable for seamless or fusion welded pipe.
- Analysis and test certificates are required.
- Above 650°F use mechanical properties quoted in the appropriate national standard as a basis for design in critical applications.
- For British and Swedish standard welded pipe supplied as equivalent to API 5L Grade B specify: "Welded seams to be non-destructively tested in accordance with para. 11.5 and 11.6 of API 5L. Din 1626 Blatt 4 already requires an equivalent degree of testing.
- Specify "Silicon-killed" for Gapave 421, Din 17175 and UNI 663.
- Above 1000°F use mechanical properties accepted by the national code-writing body as a basis for design in critical applications.
- Din 1626 Blatt 4 may be used as equivalent to ASTM A 155 Class 1.
- SEW = Stahl – Eisen Werkstoffblatt.

## Common Paint Colour Code for XXX Refineries

### SCOPE

This specification covers the requirement of colour scheme for the identification of the contents of the pipelines carrying fluids, storage tanks and equipment in XXX refineries and petrochemical installations. The following colour coding system has been made based on international standards like ASME/ ANSI, BS and Indian Standard & XXX's existing standard colour coding.

### IDENTIFICATION

The system of colour coding consists of a ground colour and secondary colour bands superimposed over the ground colour. The ground colour identifies the basic nature of the service and secondary colour band over the ground colour distinguishes the particular service. The ground colour shall be applied over the entire length of the un-insulated pipes. For insulated lines ground colour shall be provided as per specified length and interval to identify the basic nature of service and secondary colour bands to be painted on these specified length to identify the particular service. Above colour code is applicable for both unit and offsite pipelines.

The following ground colour designation for identification of basic classification of various important services shall be followed:

Post Office Red	-	Fire protection materials
Off White/ Aluminium	-	Steam (all pressures)
Canary Yellow	-	Chemicals and dangerous materials
Dark Admiralty Grey	-	Crude oil, lube oil
Orange	-	Volatile petroleum products (motor spirit and lighter)
Oxide red	-	Non-volatile petroleum products (kerosene and heavier, including waxy distillates and diesel, gas oil)
Black	-	Residual oils, still bottoms, slop oils and asphalts, fuel oil
Sky blue	-	Water (all purities and temperatures)
Sea green	-	Air and its components and Freon

Secondary colours: The narrow bands presenting the secondary colour which identifies the specific service, may be applied by painting or preferably by use of adhesive plastic tapes of the specific colour.

## COLOUR BANDS AND IDENTIFICATION LETTERING

The following specifications of colour bands shall be followed for identifying the piping contents, size and location of bands & letters. The bandwidth and size of letters in legends will depend to some extent upon the pipe diameter. Either white or black letters are selected to provide maximum contrast to the band colour. Bands usually are 50 mm wide and regardless of band width, are spaced 25 mm apart when two bands are employed

Table 1.0: Colour bands and size of lettering for piping:

Outside diameter of pipe or covering in mm	Width of colour bands in mm	Size of legend letters in mm
19 to 32	200	13
38 to 51	200	19
64 to 150	300	32
200 to 250	600	64
Over 250	800	89

In addition, ground colour as per specified length should be provided on insulated piping for easy identification of nature of fluid, on which the colour bands should be painted for identification of each service. The length of the ground colour should be 3 times the width of normal band or 2 meters, whichever is suitable depending on the length of the pipe.

Size of letters stenciled/ written for equipment shall be as given below:

Column and vessel : 150 mm (Height)

Pump, compressor and other machinery : 50 mm (Height)

In addition, the contents of the pipe and/or direction of flow may be further indicated by arrows and legend. If a hazard is involved it must be identified clearly by legend.

Colour bands: The location and size of bands, as recommended, when used, shall be applied to the pipe.

- On both sides of the valves, tees and other fittings of importance.
- Where the pipe enters and emerges from walls and where it emerges from road & walkway overpasses, unit battery limits.
- At uniform intervals along long sections of the pipe.
- Adjacent to tanks, vessels, and pumps.

For piping, writing of name of service and direction of flow for all the lines shall be done at following locations:

3.1.1 Offsite Lines: Both sides of culverts, any one side of walkways, near tank dykes, at tank inlet/outlet points and suction/ discharge of pumps/ compressors.

3.1.2 Unit Lines: At the battery limit, suction/ discharge of pumps/ compressors, near vessels, columns, Tanks, Exchangers etc.

The letters will be in black on pipes painted with light shade colours and white on pipes painted with dark shade colours to give good contrast.

Only writing of service name shall be done on stainless steel lines. Precautions should be taken while painting by using low chloride content painting to avoid any damage to the stainless steel pipes. It is preferable to use adhesive plastic tapes to protect stainless steel pipes.

Colour band specification:













- a) Unit Area: Bands at intervals of 6.0 meters.  
Offsite Area: Bands at intervals of 10.0 meters.
- b) Each pipe segment will have minimum one band indication, irrespective of length.
- c) The bands shall also be displayed near walkways, both sides of culverts, tanks dykes, tanks, vessels, suction and discharge of pumps/ compressors, unit battery limit, near valves of line, etc.
















For alloy steel/ stainless steel pipes and fittings in stores/ fabrication yard, color band (Minimum ½" wide) should be applied along the complete length of pipe, bends/ tees, side-curved surface (on thickness) of flanges as well as valves as per the metallurgy.














In case of camouflaging requirements of civil defence or any other locational requirements, the same shall be followed accordingly.

The specification for application of the complete Piping identification colour code, including base and bands colours, are presented in the enclosed table.














### RECOMMENDED PAINT COLOUR CODE












SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
	<b>HYDROCARBON LINES (UNINSULATED)</b>		
1.	CRUDE SOUR	Dark Ad. Grey with 1 orange band	
2.	CRUDE SWEET	Dark Ad. Grey with 1 red band	
3.	LUBE OILS	Dark admiralty grey with 1 green band	
4.	FLARE LINE	Heat resistant Aluminium	
5.	L.P.G.	Orange with 1 oxide red	
6.	PROPYLENE	Orange with 2 oxford blue band	
7.	NAPHTHA	Orange with 1 green band	
8.	M.S.	Orange with 1 dark ad. grey	
9.	AV. GASOLINE (96 RON)	Orange with 1 band each of green, white & red bands	
10.	GASOLINE (regular, leaded)	Orange with 1 black band	
11.	GASOLINE (Premium, leaded)	Orange with 1 blue band	
12.	GASOLINE (White)	Orange with 1 white band	










SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
13.	GASOLINE (Aviation 100/130)	Orange with 1 red band	
14.	GASOLINE (Aviation 115/145)	Orange with 1 purple band	
15.	N-PENTANE	Orange with 2 blue bands	
16.	DIESEL OIL (White)	Oxide red with 1 white band	
17.	DIESEL OIL (Black)	Oxide red with 1 yellow band	
18.	KEROSENE	Oxide red with 1 green band	
19.	HY.KERO	Oxide red with 2 green bands	
20.	DISULFIDE OIL (EX-MEROX)	Oxide red with 1 black band	
21.	M.T.O.	Oxide red with 3 green bands	
22.	DHPPA	Oxide red with 2 white bands	
23.	FLUSHING OIL	Oxide red with 2 black bands	
24.	LAB FS	Oxide red with 2 dark Ad. Grey	
25.	LAB RS	Oxide red with 3 dark Ad. Grey	
26.	LAB (Off. Spec.)	Oxide red with 1 light grey	
27.	N-PARAFFIN	Oxide red with 1 blue band	












SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
28.	HEAVY ALKYLATE	Oxide red with 1 red band	
29.	BLOW DOWN, VAPOUR LINE	Off White / Aluminium with 1-Brown band	
30.	BLOW DOWN	Off White / Aluminium with 2 brown bands	
31.	A.T.F.	Leaf brown with 1 white band	
32.	TOULENE	Leaf brown with 1 yellow band	
33.	BENZENE	Leaf brown with 1 green band	
34.	LAB PRODUCT	Leaf brown with 1 blue band	
35.	FUEL OIL	Black with 1 yellow band	
36.	FUEL OIL (aromatic rich)	Black with 2 yellow bands	
37.	ASPHALT	Black with 1 white band	
38.	SLOP & WASTE OILS	Black with 1 orange band	
39.	SLOP AROMATIC	Black with 2 orange bands	
	<b>CHEMICAL LINES (UNINSULATED)</b>		
40.	TRI-SODIUM PHOSPHATE	Canary yellow with 1 violet band	





















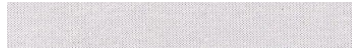








SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
41.	CAUSTIC SODA	Canary yellow with 1 black band	
42.	SODIUM CHLORIDE	Canary yellow with 1 white band	
43.	AMMONIA	Canary yellow with 1 blue band	
44.	CORROSION INHIBITOR	Canary yellow with 1 Aluminium band	
45.	HEXAMETA PHOSPHATE	Canary yellow with 2 black band	
46.	ACID LINES	Golden yellow with 1 red band	
47.	RICH AMINE	Canary yellow with 2 blue bands	
48.	LEAN AMINE	Canary yellow with 3 blue bands	
49.	SOLVENT	Canary yellow with 1 green band	
50.	LCS	Canary yellow with 1 smoke grey	
	<b>WATER LINES (UNINSULATED)</b>		
51.	RAW WATER	Sky blue with 1 black band	
52.	INDUSTRIAL WATER	Sky blue with 2 signal red bands	
53.	TREATED WATER	Sky blue with 1 oxide red band	


SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
54.	DRINKING WATER	Sky blue with 1 green band	
55.	COOLING WATER	Sky blue with 1 light brown band	
56.	SERVICE WATER	Sky blue with 1 signal red band	
57.	TEMPERED WATER	Sky blue with 2 green bands	
58.	DM WATER	Sky blue with 1 Aluminium band	
59.	DM WATER ABOVE 150 °F	Sky blue with 2 black bands	
60.	SOUR WATER	Sky blue with 2 yellow bands	
61.	STRIPPED WATER	Sky blue with 2 blue bands	
62.	ETP TREATED WATER	Sky blue with 2 oxide red bands	
<b>FIRE PROTECTION SYSTEM (ABOVE GROUND)</b>			
63.	FIRE WATER, FOAM & EXTINGUISHERS	Post office red	
<b>AIR &amp; OTHER GAS LINES (UNINSULATED)</b>			
64.	SERVICE AIR	Sea green with 1 signal red band	

SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
65.	INSTRUMENT AIR	Sea green with 1 black band	
66.	NITROGEN	Sea green with 1 orange band	
67.	FREON	Sea green with 1 yellow band	
68.	CHLORINE	Canary yellow with 1 oxide red band	
69.	SO <sub>2</sub>	Canary yellow with 2 white band	
70.	H <sub>2</sub> S	Orange with 2 red oxide bands	
71.	Gas (Fuel)	Orange with 1 Aluminium band	
72.	GAS (Sour)	Orange with 2 Aluminium band	
73.	GAS (Sweet)	Orange with 2 signal red band	
74.	HYDROGEN	Orange with 1 light green band	
<b>STEAM &amp; CONDENSATE LINES (UNINSULATED)</b>			
75.	HP STEAM	Off white / Aluminium with 1 yellow band	
76.	MP STEAM	Off white / Aluminium with 1 red band	
77.	MLP STEAM	Off white / Aluminium with 1 orange band	

SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
78.	LP STEAM	Off white / Aluminium with 1 green band	
79.	CONDENSATE	Sky blue with 1 white band	
80.	CONDENSATE ABOVE 150 °F	Sky blue with 3 oxide red bands	
81.	BFW	Sky blue with 2 gulf red bands	
<p><b>Note:</b> For all insulated steam lines, the colour coding shall be followed as given for uninsulated lines with the specified length of colour bands.</p>			
<b>INSULATED HYDROCARBON PIPING</b>			
82.	IFO SUPPLY	1 black ground colour with 1 yellow band in centre	
83.	IFO RETURN	1 black ground colour with 1 green band in centre	
84.	HPS	1 black ground colour with 1 red band in centre	
85.	BITUMEN	1 black ground colour with 2 red band in centre	
86.	CLO	1 black ground colour with 1 brown band in centre	
87.	VB TAR	1 black ground colour with 2 brown band in centre	
88.	VR AM (BITUMEN / VBU FEED)	1 black ground colour with 1 blue band in centre	

SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
89.	VR BH	1 black ground colour with 2 blue band in centre	
90.	VAC. SLOP	1 black ground colour with 1 white band in centre	
91.	SLOP	1 black ground colour with 1 orange band in centre	
92.	CRUDE SWEET	1 dark admiralty grey ground colour with 1 red band in centre	
93.	CRUDE SOUR	1 dark admiralty grey ground colour with 1 orange band in centre	
94.	VGO / HCU FEED	1 oxide red ground colour with 1 steel grey band in centre	
95.	OHCU BOTTOM / FCCU FEED	1 oxide red ground colour with 2 steel grey band in centre	
<b>UNINSULATED EQUIPMENT, TANKS &amp; STRUCTURES</b>			
96.	HEATER STRUCTURE	Steel grey	
97.	HEATER CASING	Heat resisting Aluminium	
98.	VESSELS & COLUMNS	Aluminium	
99.	HYDROGEN BULLETS	Pink	
100.	LPG VESSELS	Red Oxide	
101.	SO <sub>2</sub> VESSEL	Canary Yellow	

SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
102.	HEAT EXCHANGERS	Heat resisting Aluminium	
103.	FO TANK & HOT TANKS	Black	
104.	ALL OTHER TANKS	Aluminium / off white	
105.	CAUSTIC / AMINE / ACID TANKS	Golden Yellow	
106.	SOUR WATER	Sky Blue	
107.	OUTER SURFACE IN BOILER HOUSE	Heat resisting Aluminium	
108.	COMPRESSORS & BLOWERS	Dark Admiralty Grey	
109.	PUMPS	Navy Blue	
110.	MOTORS & SWITCH GEAR	Bluish Green	
111.	HAND RAILING	Signal Red	
112.	STAIRCASE, LADDER & WALKWAYS	Black	
113.	LOAD LIFTING EQUIPMENT & MONO RAILS ETC.	Leaf Brown	
114.	GENERAL STRUCTURE	Black	
	<b>PIPES &amp; FITTINGS OF ALLOY STEEL &amp; SS MATERIAL IN STORES (REFER ARTICLE 5.0)</b>		
115.	IBR	Signal red	

SI. NO.	SERVICE	RECOMMENDED COLOUR CODE	COLOUR
116.	9Cr - 1Mo	Verdigris green	
117.	5Cr - ½Mo	Satin blue	
118.	2¼ Cr - 1Mo	Aircraft yellow	
119.	1¼Cr - ½Mo	Traffic yellow	
120.	SS-304	Dark blue grey	
121.	SS-316	Dark violet	
122.	SS- 321	Navy blue	
<b>SAFETY COLOUR SCHEMES</b>			
123.	DANGEROUS OBSTRUCTION	Black & alert orange bands	
124.	DANGEROUS OR EXPOSED PARTS OF MACHINERY	Alert orange	

**Painting for Civil Defence requirements:**

- (i) The following items shall be painted for camouflaging, as per specific site requirement of Defence.
  - a) All columns
  - b) All tanks in offsites
  - c) Large vessels
  - d) Spheres
- (ii) Two coats of selected finish paint as per defence requirement shall be applied in a particular pattern as per (iii) and as per the instructions of the Engineer-in-Charge.
- (iii) Method of camouflaging:
  - a) Disruptive painting for camouflaging shall be done in three colours in the ratio of 5:3:2 (all matt finish)

Dark Green	Light Green	Dark Medium Brown
5:	3:	2
  - b) The patches should be asymmetrical and irregular.
  - c) The patches should be inclined at 30° to 60° to the horizontal.
  - d) The patches should be continuous where two surfaces meet at an angle and the patches should be coincide with corners.
  - e) Slits and holes shall be painted in dark shades.
  - f) Width of patches should be 1 to 2 meters.



**STANDARD SPECIFICATION FOR CORROSION PROTECTION OF WRAPPING COATING & TAPE COATING OF UNDER GROUND STEEL PIPELINES**

1.	<p><b>SCOPE</b> This specification covers the requirement for materials, surface preparation, application, inspection, repairs and handling for external corrosion protection tape coating, in situ. of underground steel pipelines with service temperature upto 60°C using. Coal tar based tape coating materials conforming to AWWA C-203 (1991)</p>
2.	<p><b>REFERENCE DOCUMENTS</b> The latest edition of the following standards and documents shall apply 2.1 AWWA C-203 (1991): Coal tar protective coatings and linings for steel water pipelines. 2.2 Doc:MTD 24 (3624) BIS: Draft Indian Standard specification for coal tar based Anticorrosion tape for protection of underground mild steel pipeline. 2.3 SIS05-5900 "Pictorial surface preparation standard for painting steel surface". Or ISO-8501-1988 2.4 SSPC-SP Steel structure painting council surface preparation specifications: SSPC-SPI Solvent cleaning SSPC-SP3 Power tool cleaning SSPC-SP10 Near white metal blast cleaning High voltage test conform to NACE standard RP-02-74</p>
3.	<p><b>GENERAL REQUIREMENTS</b> <b>3.1 Equipments and accessories required for tape coating shall be in good operating conditions at least for completion of the coating job. Adequacy of equipments and accessories shall be approved by the Engineer-in-charge.</b> 3.2 Necessary arrangements for power supply and other utilities shall be made for the completion of the job. 3.3 Necessary testing and inspection facilities as required by this standard shall be developed at site and shall be approved by the Engineer-in-charge.</p>

	<p>3.4 Protective tapes and other materials brought to site shall be as per the specifications of this standard and should be approved by the Engineer-in-Charge. Field and laboratory tests as given in this standard shall be carried out for each batch of primer and tape.</p>
	<p>3.5 All work shall be carried out in accordance with this specification and shall be phase wise approved by the Engineer-in-Charge. Any working procedure computed from this specification shall be approved in advance by the Engineer-in-Charge.</p> <p>3.6 Manufacturers recommended supervisor and skilled applicator shall be engaged by the contractor for application, inspection and quality assurance.</p> <p>3.7 Manufacturers shall possess copy of reference documents and test procedure appearing in this standard.</p>
4.	<p><b><u>DOCUMENTATION</u></b></p> <p>The following documentation is required:</p> <p>4.1 A written quality plan with procedures for qualification trials and for the actual work. The quality plan shall include a time table for the various activities with a description of coating materials to be used, their application qualification of personnel involved in the work, responsibilities and lines of communications, details of equipment and their calibration, proposed hold points for company's inspection and endorsement and the detailed procedures for the testing and inspection.</p> <p>4.2 Daily progress reports with details on weather conditions, particulars of application, e.g. blast cleaning, number of wraps and type of materials applied, anomalies and progress of work versus programme.</p> <p>4.3 Documented evidence that the requirements of this specification have been met, during production trials as well as during the work.</p>

4.	<p><b><u>The documentation shall include</u></b></p> <ul style="list-style-type: none"> <li>• Results of comparison of surface cleanliness, surface profile on blast cleaned surface, Tape coating thickness, holiday detection and adhesion tests.</li> <li>• Particulars of surface preparation, priming and tape application</li> <li>• Details of non-compliance, rejects and repairs</li> <li>• Types of testing equipments and calibration</li> <li>• Code and batch numbers of coating materials used</li> </ul> <p>Field tests on primers and tape coat</p>
5.	<p><b><u>MATERIALS</u></b></p> <p>5.1 General Requirements</p> <p>5.1.1 Manufacturer's test certificates shall be produced and examined by the Engineer-in-charge for all materials, proposed to be used for tape coating as per this standard.</p> <p>5.1.2 All materials brought to site for tape coating shall be suitably marked and identifiable with the following information</p> <ul style="list-style-type: none"> <li>• Manufacturer's name</li> <li>• Type of material and code</li> <li>• Batch number</li> <li>• Date of manufacturing/expiry</li> <li>• Technical data sheet for each type of material</li> <li>• Self life</li> <li>• Manufacturer's Quality Control test certificates with actual results of each batch</li> </ul> <p>5.1.3 Materials without manufacturer's test certificates and identification marks shall not be accepted and used.</p> <p>5.1.4 Test certificate from competent Govt. laboratory on the properties of materials quoted by the manufacturer in the technical data sheet shall also be submitted alongwith the Technical Data Sheet of the products.</p> <p>5.1.5 Each batch of primer and tape shall be tested in the field by the procedure as given in this standard. Engineer-in-charge will review the field test data before use of the materials.</p> <p>5.1.6 All coating materials shall be properly preserved to prevent damage or deterioration.</p>

<p>5.1.7 All coaltar primer containers shall be tightly sealed when not in use and no primer whose date has expired shall be used coating &amp; wrapping purpose. Before expiry of date, this should be brought to the notice of Site Engineer/Engineer Incharge</p> <p>5.1.8 The procured material for coat and wrap shall conform to specification as given below / as specified in the tender. The contractor shall ensure compliance of the technical specification and shall submit the relevant data for the selected make of coat and wrap material in the above format for approval of engineer in charge before procurement.</p>	
<p><b>5.2 Characteristics and Functional Requirements of coating materials</b></p> <p><b>5.2.1 Coal tar tapes:</b> The coating material shall conform to section 8 of AWWA C 203-91 standard “Coal tar protective coatings and linings for steel water pipelines-enamel and tape – Hot applied.” Following are the salient features of coaltar tape coating materials.</p>	
<p><b>5.2.1.1 Primer :</b> The primer shall be type B as specified in AWWA C-203 (1991) section. Following are the main characteristics:</p>	
Type	Fast arying, synthetic chlorinated rubber-synthetic plasticizer-solvent based. Contractor to furnish manufacturers catalogue.
Drying time	5-15 mts. Test method ASTM D 1640-83/89
Flash point	> 23°C ASTM D93-90/D3941-90
Volatile matter (105-110°C) per cent by mass	75 : ASTM D2369-90
Viscosity on FORD UP NO. 44mm nozzle 23°C	35-60 secs. ASTM D1200-88
DFT	25 microns/coat/min.
Coverage (Theoretical)	8-12 M <sup>2</sup> /Lit/Coat
Coverage (Practical) @ 25 microns DFT coat	5-6 M <sup>2</sup> /Lit/Coat ASTM D344-89
Application properties	By power driven machine / brush/Spray should produce an effective bond between metal and subsequent coaltar tape
Adhesion test	The primer shall be tested after applying Tape coating as per AWWAC-203 (1991)

<b>5.2.1.2 Coal Tar Tape:</b> The tape shall be coal-tar component supported on fabric of organic or inorganic Fiber's.			
<b>(a) Raw Coal Tar Pitch:</b> The coal tar (hard pitch) component shall be produced from coal that has a minimum heating value of 13000 BtU/lb (7.223x10 <sup>6</sup> cal/kg) on a moisture and mineral matter free basis (ASTM D 388) and that has been carbonized in a slot-type coke even at a temperature of not less than 900°C. The coal tar (hard pitch) shall have the following salient properties:			
Softening point °C	65 Min.	121 Max.	ASTM D36-86
Specific gravity	1.30 ± 0.05		ASTM D 71-94
Ash content	0.5% Max.		ASTM D 2415-66(1991)
Physical state	Solid at ambient temperature		
<b>(b) Fabric:</b> Type : The fabric shall be a thin, flexible, uniform mat or tissue composed of glass fibers in an open structure bonded with a suitable resinous inert material compatible with coal tar. Weight (min) g/m <sup>2</sup> 40 Thickness (min.) mm        0.3 Note (1) Manufacturer's test data in the laboratory are required for the above properties on the materials supplied.			
<b>(c) Physical properties of coaltar tape:</b>			
Property	Requirement		Test Method
	Min.	Max.	
Service temperature °C	-	60	
Tape thickness mm	2.0	2.5	Section 8.11.3 of AWWA C-203
Weight average	1.25 kg/sq.m/mm		ASTM D146

Breaking strength in longitudinal direction kN/m	0.7	AWWA C-203 10.3.1.2.5	
Adhesion	To pass test as per BIS, DOC, MTD 24(3624) or 8.11.2 of AWWA C-203		
Insoluble content % by wt. In petroleum ether	95% minimum (By SMMS-EIL procedure)		
Width of tape	Contractor to furnish details		
Requirement of surface preparation	As per AWWAC C-203 (1991) & contractor to furnish catalogue		
<b>(d) Physical Properties of Coal Tar Component in finish tape:</b>			
Property	Requirement		Test method
	Min.	Max	
Softening point-°C	65	121	ASTM D 36-86
Penetration at 25C/100g/10 <sup>-1</sup> mm/5 sec	3	20	AWWA C-203 See 8.11.5(OR) ASTM D-5
Filler %	20	30	ASTM D 2415 or AWWA C-203 See 8.11.6
<b>(e) Other requirement</b>			
Type of application (Hot / Cold)	Contractor to specify		
Compound	Plasticised coal tar compound conforming to AWWA C 203 standard.		
Reinforcement	Synthetic Substrate.		
Temperature range for application	Vendor to furnish details		

	Resistance to cathodic disbonding	Shall meet the stipulations of B.S. 4164 – 1987 std. Contractor to furnish the support documents.
6.	<p><b>Surface preparation:</b></p> <ul style="list-style-type: none"> <li>- All oil, grease on the pipe metal surface shall be thoroughly removed by flushing with a suitable solvent (<u>such as xylene or 1.1.1 trichloroethylene</u>) and wiping with clean rags. The solvent cleaning shall be as per SSPC-SP-1. If required detergent cleaning shall be done before or after solvent cleaning.</li> <li>- The degreased pipe metal surface shall be blast cleaned to <u>Sa 2 ½ of SIS-05-5900 OR SSPC-SP-10</u>. With a surface profile of 30-50 microns depth. Blasted surface that rusts before priming shall be cleaned by wire brushing or shall be reblasted. Priming shall be done within 4 hours of completion of blast cleaning. Otherwise total reblasting may be necessary.</li> </ul>	
	<p><b>Surface preparation:</b></p> <ul style="list-style-type: none"> <li>• Blast cleaning equipment for nozzle type, size, safety gauges, working condition, pressure at the tip of the gun</li> <li>• Abrasive type, hardness to provide required profile size and cleanliness</li> <li>• Measurement of surface profile and comparing cleanliness with Visual standards of ISO 8501 – 1988</li> </ul> <p>Measurement of pitting depth area of pitted portion. Inspection of weld filling and grinding and patch plate welding, welding of replaced pipe, if any.</p> <p>Checking of condition of concrete saddles. Rubber padding and end seals wherever required.</p>	

7.	<p><b>Application of primer:</b>  One coat of primer shall be applied immediately on blast-cleaned surface by brush or spray to achieve complete wetting of the surface as recommended by the manufacturer. In case the surface is wet during application of primer the surface should be made dry. The primer shall be allowed to become <u>touch dry prior to tape application</u>. The same manufacturer shall furnish primer and tape.  Primer should not be applied if the humidity is above 80%.</p> <p>- <b>Inspection of primer after application:</b></p> <ul style="list-style-type: none"> <li>• Checking for drying time to be touch dry, tack free drying and hard drying of primer</li> <li>• DFT shall be checked on metal panel separately.</li> <li>• Care must be taken to inspect proper application of primer at weld joints and areas adjacent to fittings.</li> <li>• All primed pipe which have been exposed to whether for more than 48 hours after priming or become "dead" shall be reprimed after cleaning the surface.</li> </ul>
8.	<p><b>Tape coating system and application:</b>  Preparation Of Coal Tar Enamel</p> <p>- Coal tar enamel shall be protected from weather and contamination with water, dirt or other foreign materials. Enamel shall be broken up into small pieces and stacked on a clean platform free from above said materials before being placed into the melting kettle.</p>
	<p>- The enamel pieces shall be heated in the kettle and brought to the application temperature conforming to. <u>AWWAC 203/66/Manufacturer's specification</u>. Accurate thermometers shall be used on the dope kettle and positioned so as to accurately determine the maximum temperature to which the enamel is heated. Kettles shall not be permitted to act as continuous enamel supply source by adding unmelted enamel during the time such kettles are in use, but <u>shall be completely emptied of one charge before the next charge of enamel is added</u>.</p> <p>- Enamel shall be condemned and dumped as unfit for use when in the judgement of Site Engineer, it has become damaged by overheating or by continuous heating.</p> <p>- The application of coating materials on the pipe shall be at temperature recommended by the enamel manufacturer or AWWA C 203/66 specification.</p>



	<ul style="list-style-type: none"> <li>- First, an even coat of the enamel <u>2.5 mm(3/32")</u> thick(Minimum) shall be applied over the surface of the primed pipe. The coating may be done by hot coaltar enamel over the pipe by buckets, gunny rag manipulated back and forth to coat the bottom of the pipe may be used, thus ensuring complete coverage of the surface, followed by a fiber glass wrap, spirally wound tight around the pipe. This shall be carried out by experienced persons only.</li> <li>- A second coat of hot enamel 2.5 mm(3/32") thick will then be applied followed by fiber glass which will be spirally wound around the pipe. No wrinkle on the fiberglass is permitted. The ends of the fiberglass shall be secured to the pipe with hot enamel. <u>A third thin coat</u> of hot enamel, followed by Kraft paper (outer wrap) shall then be applied. Care must be taken to ensure that overlap of wrapping is at least <u>19mm</u> and does not exceed 25 mm.</li> </ul>
	<p><b>Application Method:</b></p> <ul style="list-style-type: none"> <li>- The tape shall be wrap in accordance with the manufacturer recommendation in a manner that shall meet adhesion and holiday detection requirements specified in AWWA C 203-91 standard.</li> <li>- Before application of tape coat (Hot and Cold) it shall be ensured by the contractor that the pipe surface is cleaned by sand blast cleaning to a degree specified by the manufacturer and primed with primer material, which shall ensure and effective bond between substrate and de-coating. The primer shall be allowed to dry to touch prior to tape application.</li> <li>- In hot and cold application of the coal tar tape the inside layer shall be applied on the pipe. The plastic separator shall be removed.</li> <li>- In case Hot application the tape while being enrolled is to be warmed up by a blow lamp or a gas flame. The heating on the surface to wrapped shall be done to a degree as specified in the instruction manual of the manufacturer. In case cold application any pre wrapping coat ,if specified by the manufacturer, is also to be applied.</li> </ul>
9.	<p><b>INSPECTION AND TESTING FOR QUALITY ASSURANCE:</b></p> <ul style="list-style-type: none"> <li>- <u>All coating shall be inspected visually by Site Engineer while being applied.</u> Visual inspection for uniformity without any wrinkles and irregularities and overlapping width as per specifications. Before the piping is buried into the trench the coat and wrap shall be inspected by electrical holiday detector which will detect holidays, pinholes, defects etc. The Contractor shall provide the holiday detector in good working order.</li> <li>- All the coal tar enamel coating shall be tested for Holidays and breaks in the coatings and test Voltages shall conform to NACE Standard RP-02-74 as per latest code specified as under:</li> </ul>

- The maximum testing voltage for a particular coating thickness shall be given here under:

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<b><i>Out side pipe dia (inch)</i></b>	<b><i>Coating thickness Mills</i></b>	<b><i>Test Voltages</i></b>
Less than 1"	16	5000
1	31	7000
2	62	9800
3	84	12100
4	125	14000
5	156	15000
6	188	17100
10"	100	17100
16"	500	28000
18"	625	31000
20"	625	31000
24"	750	35000

- The coated pipes including field joint coating shall be visually inspected for cracks, trapped air, uniformity, damage etc. Any repair arising out of visual inspection will be decided by Engineer-in-charge.

	<ul style="list-style-type: none"> <li>• <b>Measurement of pipe thickness.</b></li> <li>• <b>Adhesion test</b> as per AWWA-C-203 (1991) inclusive of the following steps. <ul style="list-style-type: none"> <li>- Adhesion tests shall be made to determine the proper bond between the tape and the primed pipe. One test per section (of upto 10 meter length) shall be carried out initially afterwards adhesion test is to be done as per the advise of ENGINEER IN CHARGE. Repair required due to adhesion testing shall be decided by the Engineer-in-Charge.</li> <li>- Temperature of the tape and pipe to be tested shall be between 10<sup>0</sup>C and 27<sup>0</sup>C. If required cold water shall be poured over the test area to bring down the temperature to with in the above range.</li> <li>- A test shall be selected where the tape is smooth for 152 mm in the longitudinal direction of the pipe.</li> <li>- Two knife cuts of 152 mm long and 51 mm apart shall be made through the tape.</li> <li>- A flat blade shall be used to pry up 51 mm of the fabric.</li> </ul> </li> </ul>
	<ul style="list-style-type: none"> <li>- The 51 mm flap of fabric shall be grasped firmly in one hand and shall be pulled with a quick motion in the direction of the remaining 102 mm of the 152 mm knife cut.</li> <li>- The adhesion is satisfactory if (I) the tape tears at the point of stripping or (II) the fabric strips from the underlying tape component, leaving no more than 10% or less of the primer or bare metal exposed.</li> <li>- Adhesion between tape to tape can be tested following similar procedure as above. However, this should preferably be done on a test panel.</li> </ul>
	<p><b>MEASUREMENT OF COATING THICKNESS</b></p> <ul style="list-style-type: none"> <li>- Coating thickness of the coated pipes shall be measured at the beginning of coating operation to ensure proper thickness.</li> <li>- Thickness has to be measured with a caliper with caliper surfaces of at least 20 mm diameter, on 5 tape pieces with an edge length of at least 50 mm taken from 5 different coils. The measuring pressure should 0.5N/m<sup>2</sup>. The measuring accuracy should be within 0.1 mm.</li> <li>- All holidays, pinholes, torn wrap, abraded or mutilated spots in the coat and wrap operations shall be immediately repaired. The original coating and wrapping shall be cleaned away and the good edges of the original coating shall be beveled or clipped to ensure satisfactory application. The damaged area shall be thoroughly cleaned before recoating. All the Holiday test should pass stipulations as per Section 8.9 of AWWA C-203 (1991) std. and contractor to furnish support documents.</li> </ul>

**A sample of Isometric of Pipeline Circuit & Data Record Cards**





## 17.0 REFERENCES

1. API -1104 : Welding Pipelines
2. API-1107 : Recommended pipelines maintenance welding practices.
3. API 5L : Line Pipe.
4. ANSI – B – 31.3 : Chemical Plant and Petroleum Refinery Piping.
5. ANSI – B – 31.4 : Liquid Petroleum Transportation Piping System
6. ANSI – B – 36.10 : Welded & Seamless Wrought Steel Pipe
7. ANSI – B – 16.5 : Pipe flanges and flanged fittings, steel metal alloy and other special alloys
8. ANSI – B – 16.9 : Factory made wrought steel butt-welding fittings.
9. ANSI – B – 16.11 : Forged steel fittings socket welding and threaded
10. Piping Hand Book : By Crocker & King
11. ASTM Standards : Section – I Volume 01.01 Steel Piping, Tubing and Fittings,
12. NACE RP – 01 – 69 : Recommended practice. Control of ext, corrosion on underground or submerged metallic piping system
13. BS C. P. – 1021 : Cathodic Protection
14. NACE RP – 01 – 70 : Protection of Austenitic stainless steel from polythionic acid S. C. C. during shutdown of Refinery Equipment
15. Design Engineering Practices on Refinery Piping : Design Engineering Practices on Refinery Piping prepared by CHT
16. Quality Assurance Plan Manual : Prepared by Project, HQ, June '03
17. Project Commissioning Experience : Prepared by Panipat Refinery and M&I
18. Guidelines for Commissioning of New Projects/ Facilities : Prepared by HQ
19. ANSI – B31.1 : Power Piping
20. IBR : Indian Boiler Regulation
21. ANSI B.18.2.1 : Bolts and Nuts
22. ASME/ ANSI B.18.2.2 : Valves/ Flanges
23. Gasket : Chemical Engineering Hand Book  
: Perry's Piping hand book-king & crocker