PIPING HAND BOOK

INDEX

CODE: - A group of general rules or systematic procedures for design, fabrication, installation and inspection prepared in such a manner that it can be adopted by legal jurisdiction and made into law.

STANDARD: - Documents prepared by a professional group or committee who are believed to be good and proper engineering practice and which contain mandatory requirements. The users are responsible for the correct application of the same. Compliance with a standard does not itself confer immunity from legal obligation.

American institute standards:
API – American Petroleum Institute.
AISI – American Iron & Steel Institute.
ASTM – American Society for Testing and Materials.
ANSI – American National Standard Institute.
AWS – American Welding Society.
ASME – American Society for Mechanical Engineers.
AWWA – American Water Works Association.

ASME Sections:
Section – I: - Rules for construction of power boilers.
Section – II: - Materials
   Part – A: - Ferrous Materials.
   Part – B: - Non-Ferrous Materials.
   Part – C: - Specification for electrodes and filler wire.
   Part – D: - Properties.
Section – IV: - Rules for construction of heating boilers.
Section – V: - Non-destructive examination.
Section – VI: - Recommended rules for care & operation of heating boilers.
Section – VII: - Recommended guidelines for care of power boilers.
Section – VIII: - Rules for construction of pressure vessels.
Section – IX: - Welding & brazing qualification.

ASME Piping Codes:
B31.1: - Power piping.
B31.2: - Fuel gas piping.
B31.3: - Chemical Plant and refinery piping.
B31.4: - Liquid petroleum piping.
B31.5: - Refrigerating piping.
B31.7: - Nuclear piping.
B31.8: - Gas Transmission piping.
B31.9: - Building service piping.
B31.10: - Cryogenic piping.
B31.11: - Slurry piping.

<u>PIPE</u>: - A pipe is a tube or hollow cylinder used to convey materials or as a structural component.
A pipe is generally specified by the internal diameter (ID or NB).

<u>TUBE</u>: - A tube is generally specified by the outside diameter (OD).

There are two common methods for designating pipe outside diameter (OD). The North American method is called NPS ("Nominal Pipe Size") and is based on inches (also frequently referred to as NB ("**Nominal Bore**")). The European version is called DN ("**Diameter Nominal**" / "**Nominal Diameter**") and is based on millimeters. Designating the outside diameter allows pipes of the same size to be fit together no matter what the wall thickness.

For pipe sizes less than NPS 14 inch (DN 350), both methods give a nominal value for the OD that is rounded off and is not the same as the actual OD. For example, NPS 2 inch and DN 50 is the same pipe, but the actual OD is 2.375 inch, or 60.325 mm. The only way to obtain the actual OD is to look it up in a reference table.

For pipe sizes of NPS 14 inch (DN 350) and greater the NPS size is the actual diameter in inches and the DN size is equal to NPS times 25 rounded to a convenient multiple of 50. For example, NPS 14 has an OD of 14 inches, or 366.5 mm, and is equivalent to DN 350.

14” onwards NB of pipe is equal to OD of pipe (NB = OD).

<u>Piping Materials</u>:
Carbon Steel: - ASTM A53 Gr. A/B, ASTM A106 Gr. A/B/C, ASTM A333 Gr.1/Gr.6.
Alloy Steel: - ASTM A335 Gr.P1/P2/P5/P7/P9/P11/P12/P22.
Stainless Steel: - ASTM A312 TP304/TP304L/TP304H/TP308/TP310/TP316/TP316L/ TP316H/TP317/TP321/TP321H/TP347/TP347H/TP348/TP348H.
Nickel Steel: - ASTM A333 Gr.3/Gr.8.

<u>Piping ASME Codes</u>:
Carbon Steel & Alloy Steel: - ASME B36.10 – Plain End.
ASME B36.10/B16.25 – Bevel End.
Stainless Steel: - ASME B36.19 – Plain End.
ASME B36.19/B16.25 – Bevel End.

<u>Based on the method of pipes manufacturing</u>:
1. Seamless
2. Welded
2.1 – Electric Resistance Welded (ERW).
2.2 – Electric-Fusion Welded (EFW).
2.3 – Spiral Welded.

2.4 – Furnace Butt Welded.
2.5 – Double Submerged Arc Welded.

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

Electrical Resistance Welded Pipe: - Pipes having longitudinal butt joint wherein coalescence is produced by the heat obtained from resistance of the pipe to flow of electric current in a circuit of which the pipe is a part, and by application of pressure.

Electric-Fusion Welded Pipe: - Pipes having a longitudinal butt joint wherein coalescence is produced in the performed tube by manual or automatic electric arc welding. Weld may be single or double.

Spiral Welded Pipe: - Pipes having a helical seam with a butt, lap, and lock seam joint which is welded using either an electrical resistance, electrical fusion or double submerged arc welding process.

Furnace Butt Welded Pipe: - Pipes having a longitudinal weld joints forge welded by mechanical pressure developed in passing the hot-formed and edge-heated skelp through round pass weld rolls.

Double Submerged Arc Welded Pipe: - Pipes having a longitudinal 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 or arcs between the bare metal electrode or electrodes and the pipe. Pressure is not used and filler material is obtained from electrode.

STANDARD PIPE FITTINGS:

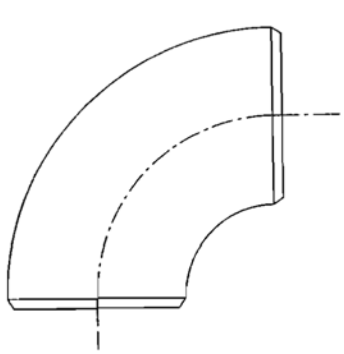
1. **Elbows: -** 45° Elbows.
   90° Elbows.
   LR Elbows (Long Radius).
   SR Elbows (Short Radius).
2. **180° Returns: -** SR Returns.
   LR Returns.
3. **Tees: -** Equal Tees.
   Reducing Tees.
4. **Cross: -** Equal Cross.
   Reducing Cross.
5. **Caps.**
6. **Reducers: -** Concentric Reducers.
   Eccentric Reducers.
7. **Stub ends: -** Long Stub ends.
   Short Stub ends
8. **Couplings: -** Full Couplings.
   Half Couplings.

Reducing Couplings.

9. **Swage Nipple: -** Concentric.
   Eccentric.

10. **Unions.**
11. **Special Fittings (Reinforced Branch Fittings): -** Weldolet.
    Sockolet
    Threadolet
    Elbolet
    Sweepolet
    Nippolet
    Latrolet

<u>Elbows</u>: - Elbows are used to make 90 deg. or 45 deg. changes in the direction of run pipe. There are two types of 90 deg. butt-welding elbows available for use. These are the long radius and short radius elbows. The long radius elbows have a bend radius of 1.5D, where D is the nominal size, whereas the short radius elbows have a bend radius of 1D. The 45 deg. elbows are of 1.5D. Radius.



2: Short Radius Elbow (R=1D)

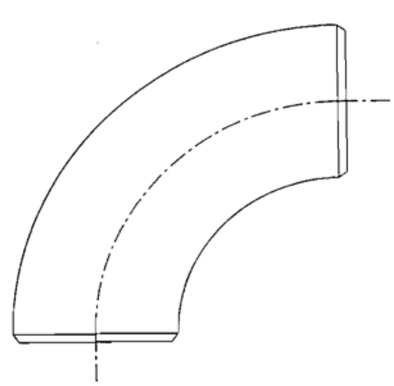


Fig. 2.3: Long Radius Elbow (R=1.5D)

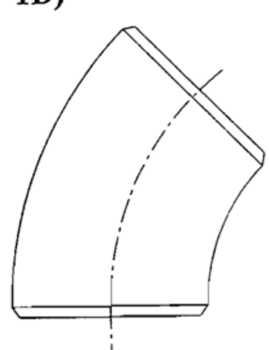
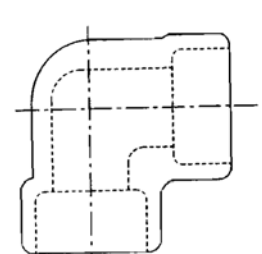


Fig. 2.4: Elbows - 45°



ig. 2.5: Elbows – Socket weld

<u>Returns</u>: - Returns change the direction through 180 deg. This is mainly used to heating coils, heat exchangers, etc. Returns with 1.5D radius and 1D radius are available.

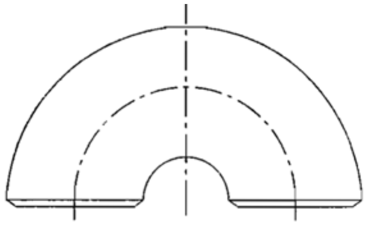
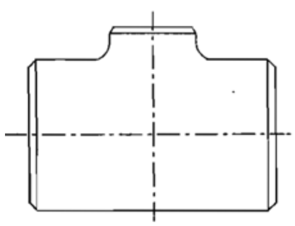
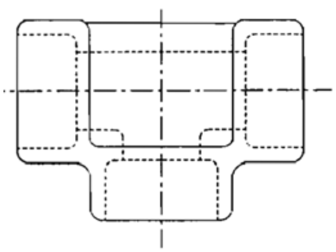


Fig. 2.8: Long Radius Return

<u>Tees</u>: - Tees are used for branching off. For low pressure services, branching off is done by direct welding of branch pipe to run pipe instead of using a standard tee. In certain cases, reinforcing pads are used for structural stability of such connections. The branching schedule specified along with piping specifications explains what sort of a branch connection is to use for that particular piping class.



g. 2.9: Tees – Butt weld



. 2.10: Tees – Socket weld

<u>Cross:</u> - This is a fitting very rarely used in piping system. There are two types of crosses, the straight and reducing. To reduce the inventory, it is preferred to use tees except where space is restricted as in marine piping.

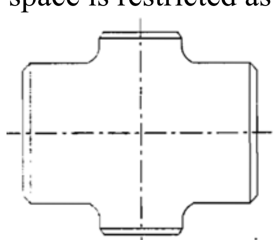
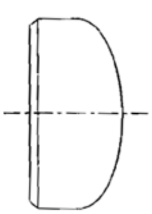


Fig. 2.11: Cross

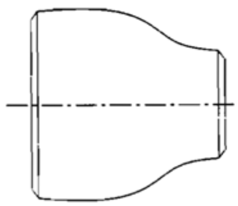


g. 2.14: Cap

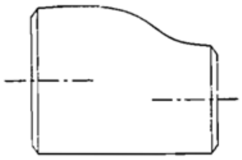
<u>Cap</u>: - A type of pipe fitting, often liquid or gas tight, which covers the end of a pipe. A cap has a similar function to a plug. In plumbing systems that use threads the cap has female threads.

<u>Reducers</u>: - There are two types of reducers available, the concentric reducers and the eccentric reducers.
When the center lines of the larger pipe and smaller pipe are to be maintained same, then concentric reducer is used. Pump discharge and vertical pipelines are also used.

When one of the outside surfaces of the pipelines are to be maintained same, then eccentric reducers is used. Pump suction to avoid cavitations and to maintain elevation (bottom of pipe) in rack are also used.



2.12: Concentric Reducer



'ig. 2.13: Eccentric Reducer

Stub Ends: - To reduce the cost of piping, stub ends are used with backing flanges for flange joints when exotic materials are used in piping. There are two types of stub ends available, the long stub ends and short stub ends. Stub ends are specifies two classes, class A with radius and class B with out radius at the corner. Class B can be used with slip-on flanges. Class A stub ends are used, the inner diameter of backing flange is chamfered for better seating.

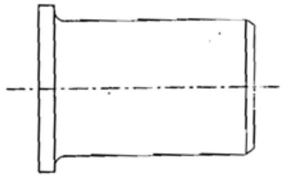
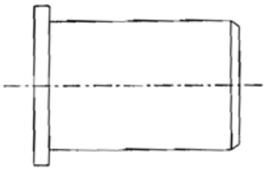
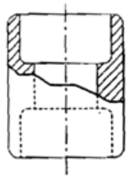


Fig. 2.15: Stub End – Class A

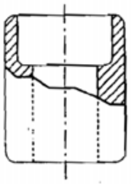


ig. 2.16: Stub End – Class B

Couplings: - Full couplings are used to connect to small bore pipes as projection of welding inside the pipe bore, when butt welding is used, reduce the flow area. Half couplings are used for branch connections and reducing couplings for size reduction. Reducing couplings maintain the pipe centerlines same and eccentric swage nipples are used to maintain the outside surface same for such systems.

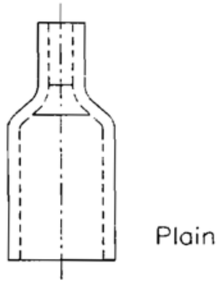


. 2.17: Full Coupling

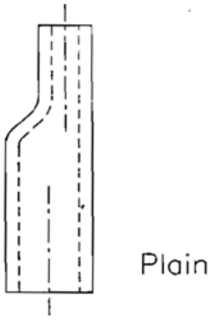


g. 2.18: Half – Coupling

Swage Nipples: - Swage nipples are like reducers but are used to connect butt welded pipe to smaller screw or socket welded pipe. There are two types of swage nipples, the concentric and eccentric.



): Concentric Swage Nipple



. 2.20: Eccentric Swage Nipple

Unions: - Unions are used in low pressure piping where dismantling of the pipe is required more often, as an alternative to flanges. Unions can be with threaded end or with socket weld ends. There are three pieces in a union, two end pieces to attach to the run pipe and the third threaded piece to connect these two. The ball type metal seating ensures sealing.

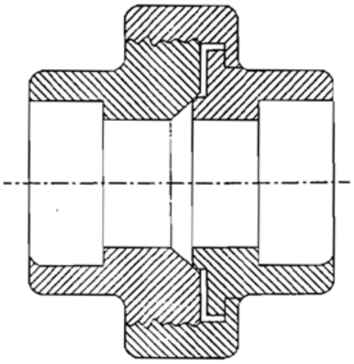


Fig. 2.21: Union

Special Fittings: -

Weldolet: - Weldolet is used for butt-weld branch connection where standard tee is not available due to size restriction and the piping if of critical/high pressure service.

Sockolet: - Sockolet is used for socket welding branch connections, which require reinforcing pad.

Threadolet: - Threadolet is used for threaded branch connections.

Elbolet: - Elbolet is used for branch connections on elbows and have the profiles made to suit the elbow.

Sweepolet: - Sweepolet is integrally reinforced butt weld branch connections.

Latrolet: - Latrolet is used for branch connections at an angle.

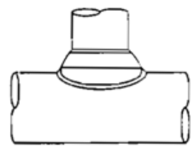


Fig. 2.22: Weldolet

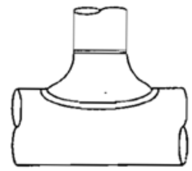


Fig. 2.23:Sweepolet

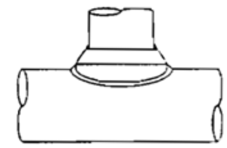


Fig. 2.24: Sockolet

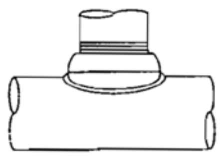


Fig. 2.25: Thredolet

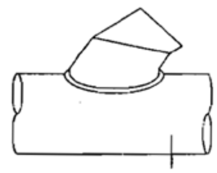


Fig. 2.26: Latrolet

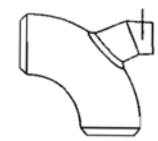


Fig. 2.27: Elbolet

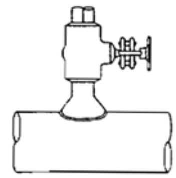


Fig. 2.28: Nipolet

<u>FLANGES</u>: - Flanges are used when the joint needs dismantling. These are used mainly equipments, valves and specialties. In certain pipe lines where maintenance is a regular feature, breakout flanges are provided at definite intervals on pipe lines. A flanged joint is composed of three separate and independent although interrelated components; the flanges, the gaskets and the bolting; which are assembled by yet another influence, the fitter.

Flanges can be classified based on pipe attachments:

1. Slip-on
2. Socket Weld
3. Screwed
4. Lap Joint
5. Welding Neck
6. Blind
7. Reducing
8. Integral

<u>Slip-on</u>: - The Slip-on type flanges are attached by welding inside as well as outside. Normally, these flanges are of forged construction and are provided with hub.

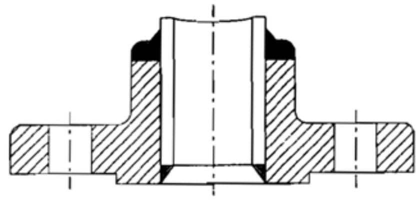


Fig. 3.1 : Slip-on Raised Face Flange

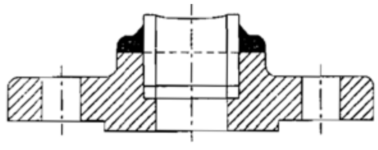


Fig3.2: Socket Welded Raised Face Flange

<u>Socket Weld</u>: - The Socket Welded flanges are welded only on one side and are not recommended for several services. These are used for small bore lines only.

<u>Screwed</u>: - The screwed-on flanges are used on pipe lines where welding cannot be carried out. Socket welding and threaded flanges are not recommended for service above 250°C and below -45°C.

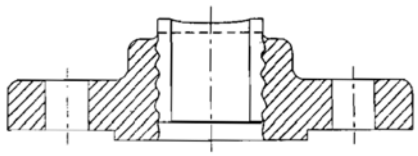


Fig. 3.3: Threaded Raised Face Flange

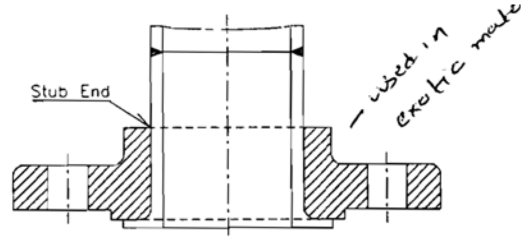


Fig. 3.4: Lap Joint Flange with Stub End

<u>Lap Joint</u>: - The Lap Joint flanges are used with stub ends when piping is of a costly material. The stub ends will be butt-welded to the piping and the flanges are kept loose over the same. The inside radius of these flanges is chamfered to clear the stub end radius.

<u>Welding Neck</u>: - The Welding Neck flanges are attached by butt-welding to the pipes. These are used mainly for critical services where all the weld joints need radiographic inspection.

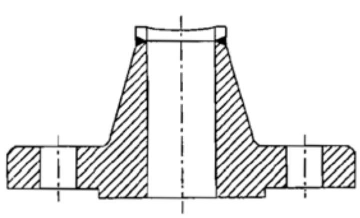


Fig.3.5: Welding Neck Raised Face Flange

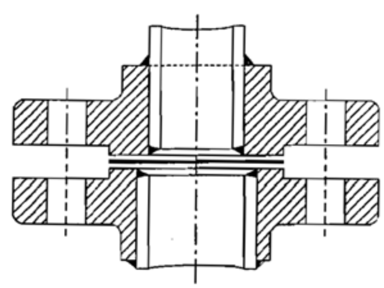


Fig.3.6: Reducing Slip-on Flange

<u>Blind</u>: - The Blind flanges are used to close the ends, which need to be reopened later.

Reducing: - The Reducing flanges are used to connect between larger and smaller sizes without using a reducer.

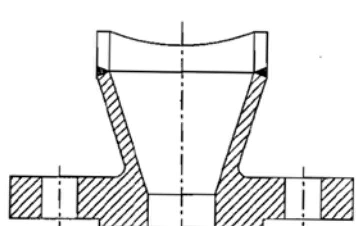


Fig.3.7: Expander or Reducer Flange

<u>Integral</u>: - Integral flanges are those, which are cast along with the piping component or equipment. Thickness of integrally cast flanges and welded on flanges differ in certain sizes.

Based on Facing:

1. Flat Face (FF)
2. Raised Face (RF)
3. Tongue and groove (T/G)
4. Male and Female(M/F)
5. Ring Type Joint (RTJ)

Raised face is used in higher ratings.
There are **two types** of finishes done on to the facings. They are the **smooth finish** and **serrated finish**.
The smooth finish flanges are specified when metallic gaskets are used.
The serrated finish flanges are specified when non-metallic gaskets are used.

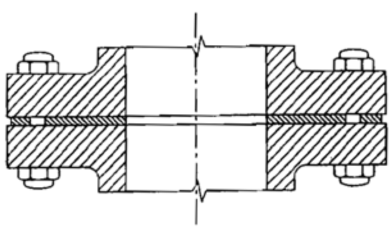


Fig. 3.8: Flat Face

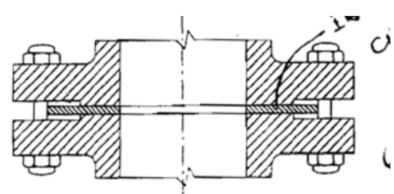


Fig. 3.9: Raised Face

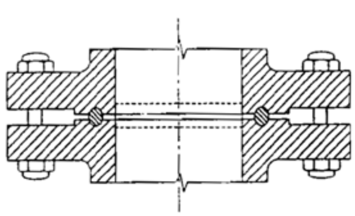
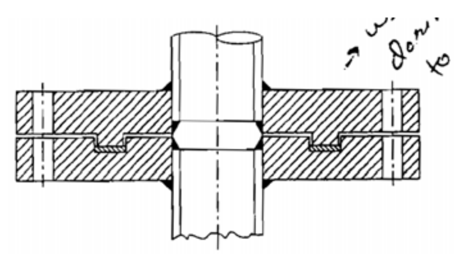


Fig. 3.10: Ring Joint



g. 3.11: Tongue and Groove Joint

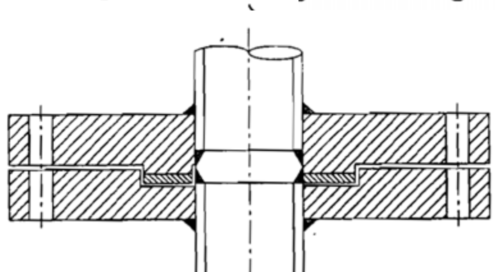


Fig. 3.12: Male / Female Joint

<u>GASKET</u>: - A gasket is mechanical seal that fills the space between two objectives, generally to prevent leakage between the two objectives while under compression.

- A gasket is a malleable material, which can be either soft or hard, that is inserted between two parts to prevent leakage between that joint.
- Pressure is applied by bolting or using a clamp to compress the gasket firmly in place.
- Gaskets are made from all different types of materials, depending on the temperature, pressure or fluid characteristics of the process.

Gaskets are used in valves for three major purposes: -

- To prevent leakage around the closure mechanism.
- To prevent leakage of fluid to atmosphere.
- To allow the function of internal mechanisms that depends on separate fluid chambers, such as pressure balance trim.

Types of Gaskets:

1. Full Face
2. Inside Bolt Circle
3. Spiral Wound Metallic
4. Ring Type
5. Metal Jacketed.

<u>Spiral Wound Metallic</u>: - For high temperature and high pressure applications spiral wound metallic gaskets are used.

<u>VALVES</u>: - Valves are essential part of any piping system that conveys liquids, gases, vapour, slurries and gaseous phases of various flows media. Starting with primitive means for stopping, allowing, or diverting water flow from source.

Selection of valves:

1. Based on pressure
2. Based on Temperature
3. Based on Fluid service
4. Based on material
5. Based on location.

Function of valves:

1. Isolation
2. Regulation
3. Non-Return
4. Special Purpose Valves

<u>Isolating Valve</u>: - A valve intended for use only in the closed or fully open position.

<u>Regulating Valve</u>: - A valve intended for use in any position between closed and fully open.

<u>Control Valve</u>: - A power-operated device which changes the fluid flow rate in a process control system.

<u>Valve Terminology</u>:
Seat: - The portion of the valve against which the closure member presses to effect shutoff.

Seat Ring: - A separate piece inserted in the valve body to form a seat against which the valve closure member engages to effect shutoff.

Back Flow: - The flow that occurs in the opposite direction of the normal.

Linear: - Lining of protective materials applied on the inside surfaces of valve.

Throttling: - The process of regulating the fluid flow or pressure by controlling the position of the closure member between the full open and close.

Diaphragm: - Diaphragm is one type of adjustable disc.

Types of valves:

1.0 Isolation
1.1 Gate valves
1.2 Ball valves
1.3 Plug valves
1.4 Piston valves
1.5 Diaphragm valves
1.6 Butterfly valves
1.7 Pinch Valves

2.0 Regulation
2.1 Globe valves
2.2 Needle valves
2.3 Butterfly valves
2.4 Diaphragm valves
2.5 Piston valves
2.6 Pinch valves

3.0 Non-Return
3.1 Check valves

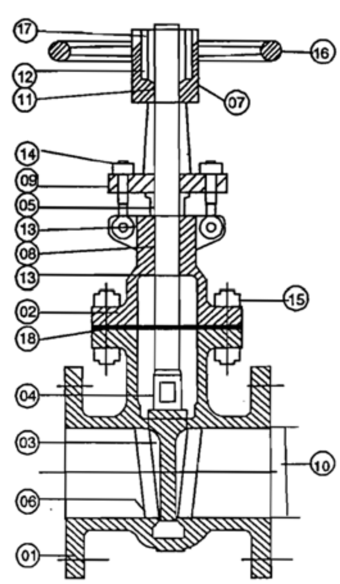
4.0 Special Purpose
4.1 Multi-port valves
4.2 Flush Bottom valves
4.3 Float valves
4.4 Foot valves
4.5 Line Blind valves

4.6 Knife Gate valves

Main valve Parts:
1. Body
2. Cover or Bonnet
3. Disc
4. Valve stem
5. Yoke
6. Gland
7. Valve seat

<u>APPLICATIONS OF VALVES</u>:

<u>Gate Valve</u>: -
Advantages: - 1. Good shutoff characteristics.
2. Pressure loss through the valve is minimal.
3. Bi-directional
Disadvantages: - 1. Not working with quickly.
2. Repairing or maintenance is difficult.
Applications: - Feed water, normal on/off requirements etc.



Gate Valve parts: - 1. Body
2. Bonnet
3. Wedge
4. Stem

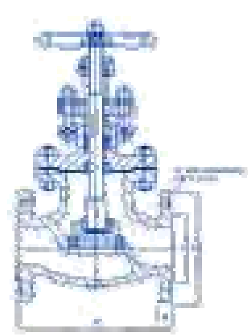
5. Gland
6. Seat ring
7. Yoke
8. Packing
9. Gland Flange
10. Valve port
11. Yoke Bush
12. Lantern
13. Back seat Bushing
14. Gland eyebolts & nuts
15. Bonnet bolts & nuts
16. Hand wheel
17. Bonnet Gasket

<u>Globe Valve</u>: -

Advantages: - 1. Moderate to good throttling capability.
2. Available in T, Y and angle patterns.

Disadvantages: - 1. High pressure drop.
2. Requires greater force to seat the valve.

Applications: - Cooling oil, Turbine seal and drain, chemical feed etc.

<u>Check Valve</u>: -

Advantages: - 1. Self direction controlling.
2. Fast acting.

Disadvantages: - 1. Valve disc can stick in open position.
2. We can’t see working properly or not.

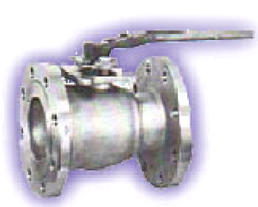
Application: - Air, Gas, Oil, Steam and Water.

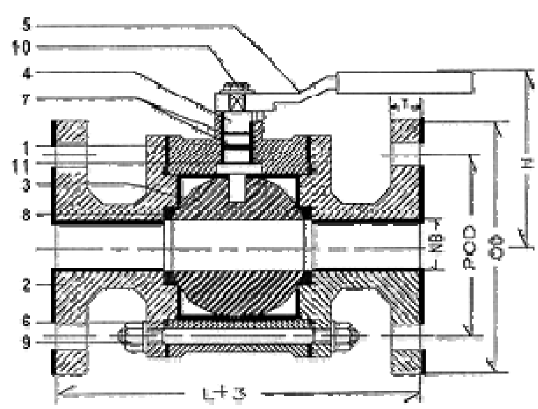
<u>Ball Valve</u>: -

Advantages: - 1. Quick working.
2. Lighter and smaller.
3. Can be used in slurry & clean.

Disadvantages: - 1. Not suitable for throttling application.
2. In slurry application suspended particles can settle and become trapped in body cavities causing wear, leakage or failure.

Applications: - Air, liquid, low point drains, high point vent etc.





<u>Butterfly Vale</u>: -

Advantages: - 1.Required less space, compared to gate, globe.
2. Quick acting to open or close.
3. Provide bubble-tight service.

Disadvantages: - 1. Disc movement is unguided and affected by the flow turbulence.
2. Throttling service is limited.

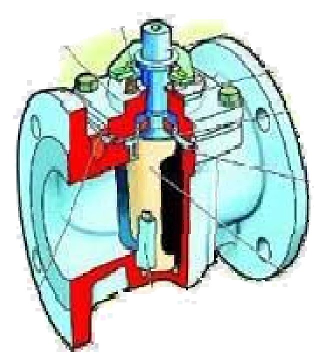
Applications: - Corrosive service, slurry service, cooling service etc.

<u>Plug Valve</u>: -

Advantages: - 1. Multiple port design helps reduce number of valves.
2. Offers minimal resistance to flow.

Disadvantages: - 1. Typically plug valve costly.
2. Requires greater force to actuate due to high friction.

Applications: - Vacuum and high pressure system, Air, Gaseous etc.

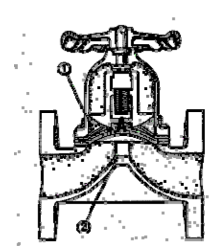


<u>Diaphragm Valve</u>: -

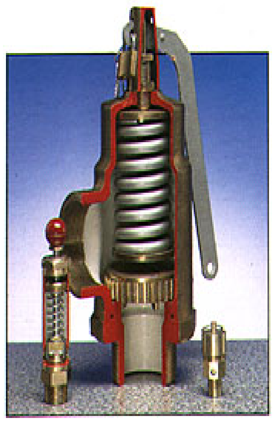
Advantages: - 1. Suitable for hazardous chemical and radioactive fluid.
2. Suitable for viscous fluids.

Disadvantages: - 1. Diaphragm may also limit the hydro testing pressure.
2. Working pressure and temperature are limited for diaphragm.

Applications: - Food processes system, in nuclear facilities.



<u>Safety Valve</u>: -
Advantages: - 1. Self actuated.
2. Protect the system.
Disadvantages: - Take more maintenance.
Applications: - Vessel, tank, heat exchanger, piping or other equipments.



<u>STRAINER</u>: -It used to remove solid particles from liquids. They generally have a permanent screen that can be cleaned by emptying, washing or blow down.
Strainers are generally placed in the main line so that all of the process fluid passes through them.
Strainers are either permanent plant components designed for the life of the plant or temporary components for the removal of construction residue during initial start up.

Types of Strainers

- Basket Strainers
- Y Strainers
- Start-up Strainers

Basket Type Strainer

<u>STEAM TRAPS</u>: - A steam trap is really a separating trap, which separates condensate and steam. When a steam trap discharges condensate it does so from a higher pressure to a lower pressure. With an inlet pressure greater than the outlet pressure, condensate will be discharged and depending on the pressure differential can be made to travel quite a long way.

<u>Classification of Traps:</u>

a) Mechanical
b) Thermodynamic
c) Impulse
d) Thermostatic.

Mechanical: - The operation of a mechanical trap is due to the difference in density between condensate and live steam. Mechanical traps such as the inverted bucket trap allow steam to enter, which raises the "bucket" and seals the valve against the valve seat. As the steam condenses or non-condensable gases get trapped in the bucket, the weight causes the bucket to drop. A relatively small hole in the bucket allows the non-condensable gases to escape and still avoid excessive steam loss.

Thermostatic: - Thermostatic traps operate based upon the difference in temperature between the steam and sub-cooled condensate. The valve is put into action by the expansion and contraction of a bimetallic element or a liquid-filled bellows. Unlike the bucket trap, thermostatic traps allow rapid purging of air at startup. The bucket trap cannot distinguish between air and steam and must purge air through a small hole. Until warmed by steam, the thermostatic trap's valve will remain opened, allowing air to leave. When the trap warms, its valve will close.

Thermodynamic: - Thermodynamic traps operate based upon the difference in pressure between the steam and condensate. There are three types, including disc, piston, and lever designs that all operate under the same principles. When sub cooled condensate enters the trap, the pressure increase lifts the disc off the valve seat and allows condensate to enter into a chamber and out of trap. A narrow inlet port causes increased velocity and a decrease in pressure. Because of the pressure drop, the condensate entering the trap flashes to steam and the disc snaps shut against the valve seat.

ASME STANDARDS: -

ASME B1.1 – Unified Inch Screw Threads
ASME B1.20.1 – Pipe Threads General Purpose
ASME B16.1 – Cast Iron Pipe Flanges and Flanged Fittings
ASME B16.3 – Malleable Iron Threaded Fittings
ASME B16.4 – Cast Iron Threaded Fittings
ASME B16.5 – Steel Pipe Flanges and Flanged Fittings
ASME B16.9 – Steel Butt weld Fittings
ASME B16.10 – Face to face and End to end dimensions of valves
ASME B16.11 – Forged Steel Socket welding and Threaded Fittings
ASME B16.20 – Metallic Gaskets for pipe flanges – ring joint, spiral wound and jacketed Flanges.

ASME B16.21 – Non-metallic gasket for pipe flanges.
ASME B16.25 – Butt welding Ends.
ASME B16.28 – Short Radius Elbows and Returns
ASME B16.34 – Steel valves, flanged and butt welding ends.
ASME B16.42 – Ductile Iron Pipe Flanges & Flanges Fittings – Class 150 and 300
ASME B16.47 – Large Diameter Steel Flanges – NPS 26 to 60
ASME B16.49 – Factory made Induction Bends
ASME B18.2.1 & 2 – Square and Hexagonal head Bolts and Nuts – (in & mm)
ASME B36.10 – Welded and Seamless Wrought steel Pipes
ASME B36.19 – Welded and Seamless Austenitic Stainless Steel Pipes.

ASTM Specifications for Carbon Steel

SEAMLESS PIPES : - ASTM A53 (Gr. A / B) or A106 (Gr. A / B)
WELDED PIPES : - ASTM A134 / A135 / A139
WROUGHT FITTINGS: - ASTM A234 (WPA / WPB)
FORGED FITTINGS : - ASTM A105
CAST PARTS : - ASTM A216 (WCB)

ASTM Specifications for Alloy Steel

Denomination	Alloy percentage	Grade	Grade for Castings
5Cr – 1/2Mo	5%Cr – 0.5%Mo	P5	C5
11/4Cr – 1/2Mo-Si	1.25%Cr – 0.5%Mo - Si	P11	(WC5)
1Cr – 1/2Mo	1%Cr – 0.5Mo	P12	(WC9)
21/4Cr – 1Mo	2.25Cr – 1%Mo	P22	(WC9)

SEAMLESS PIPE : - ASTM A335 (P5 – P11 – P12 – P22)
WELDED PIPE : - ASTM A358
WROUGHT FITTINGS : - ASTM A234 (WP5 – WP11 – WP12 – WP22)
FORGED FITTINGS : - ASTM A182 (F5 – F11 – F12 – F 22)
CAST PARTS : - ASTM A217 (C5 – WC5 – WC9)

ASTM Specifications for Stainless Steel

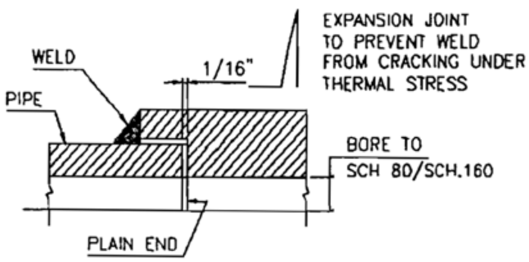
AISI	Denomination	Alloy Percentage	Grade for Castings
304/304L	18Cr – 8Ni	(18%Cr – 8%Ni)	CF3/CF8
316/316L	16Cr – 12Ni – 2Mo	(16%Cr – 12%Ni – 2%Mo)	CF3M/CF8M
321	18Cr – 10Ni – Ti	(18%Cr – 10%Ni – Ti)	Not Available

SEAMLESS PIPE : - A312 TP304 – 304L - 316 - 316L - 321
WELDED PIPE : - ASTM A249 TP304 - 304L - 316 - 316L - 321
WROUGHT FITTINGS : - ASTM A403 WP304 - 304L - 316 - 316L - 321
FORGED FITTINGS : - ASTM A182 F304 – 304L - 316 - 316L - 321
CAST PARTS : - ASTM A351 (CF3 – CF3M / CF8 – CF8M)

<u>PIPE ENDS</u>: -
Based on the material of construction and the pipe to pipe joint, the ends of the pipes are specified follows.

1. Plain ends
2. Beveled ends
3. Flanged ends
4. Screwed ends
5. Spigot ends
6. Buttress ends.

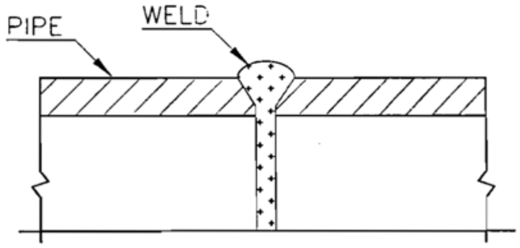
<u>Plain Ends</u>: -



Advantages: - 1. Easier alignment than butt welding.
2. No weld metal intrusion into bore.

Disadvantages: - 1. The 1/16" (1.5 mm) recess pockets liquid.
2. Use not permitted by code if severe erosion or crevice corrosion is anticipated.

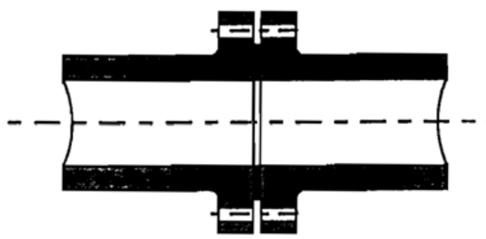
<u>Beveled Ends</u>: -



Advantages: - 1. Most practical way of joining big bore piping.
2. Reliable leak proof joint.
3. Joint can be radio graphed

Disadvantages: - 1. Weld intrusion will affect flow.
2. End preparation is necessary.

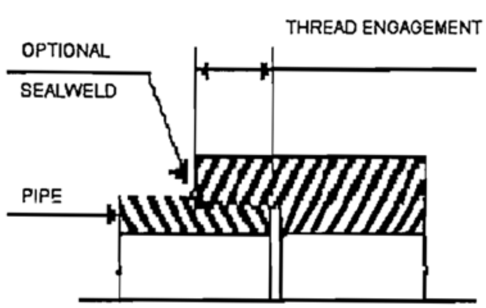
Flanged Ends: -



Advantages: - 1. Can be easily made at site.
2. Can be used where welding is not permitted due to material properties or fire hazard.
3. Dismantling is very easy.

Disadvantages: - 1. It is a point of potential leakages.
2. Cannot be used when piping is subjected to high bending moment.

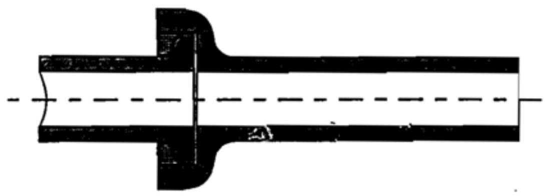
Screwed Ends: -



Advantages: - 1. Easily made at site.
2. Can be used where welding is not permitted due to fire hazard.

Disadvantages: - 1. Joint may leak when not properly sealed.
2. Use not permitted by code if severe erosion, crevice corrosion, shock or vibrations are anticipated.
3. Strength of pipe is reduced as threads reduce wall thickness.

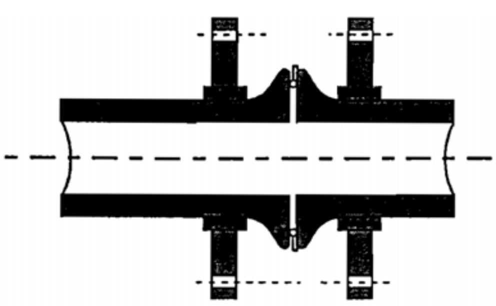
Spigot Ends: -



Advantages: - 1. Can be easily made at site.
2. Can accept misalignment up to 10° at pipe joints.

Disadvantages: - 1. Suitable for low pressure applications.
2. Special configuration at pipe ends required.

Buttress Ends: -



Use only for glass piping and not capable to hold high pressure.

WELDING POSITIONS

Fillet welds: -
Flat position 1F: - Pipe with its axis inclined at 45° to horizontal and rotated during welding so that the weld metal is deposited from above and at the point of deposition.

Horizontal position 2F: - Pipe with its axis vertical so that the weld is deposited on the upper side of the horizontal surface and against the vertical surface. The axis of the weld will be horizontal and the pipe is not to be rotated during welding.

Overhead position 4F: - Pipe with its axis vertical so that the weld is deposited on the underside of the horizontal surface. The axis of the weld will be horizontal and the pipe is not rotated during welding.

Multiple positions 5F: - Pipe with its axis horizontal and the axis of the deposited weld in the vertical plane. The pipe is not to be rotated during welding.

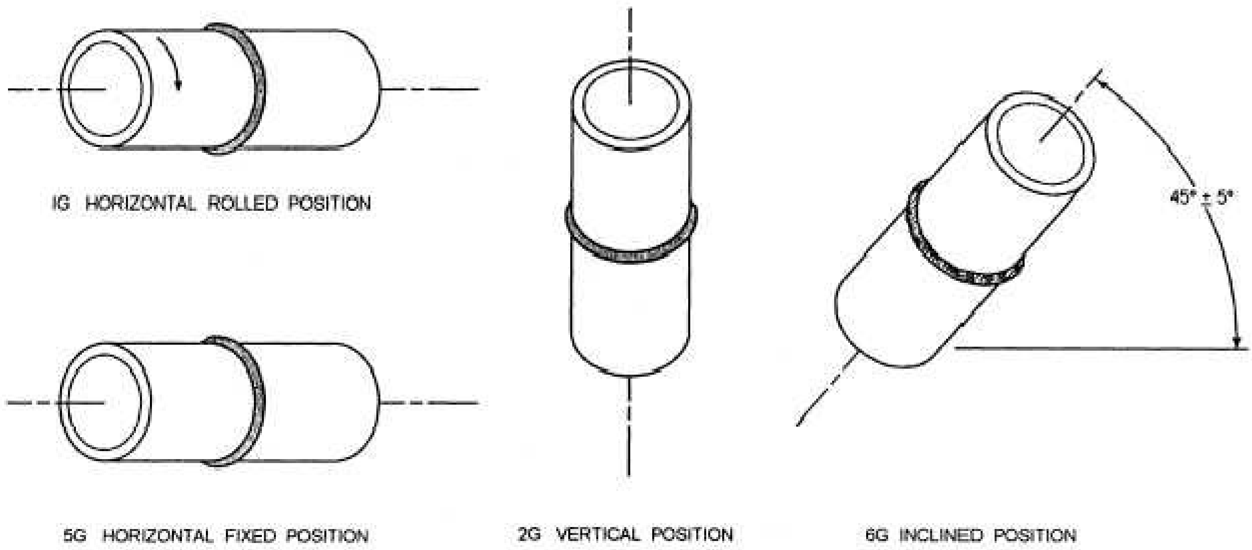
<u>Groove welds</u>: -

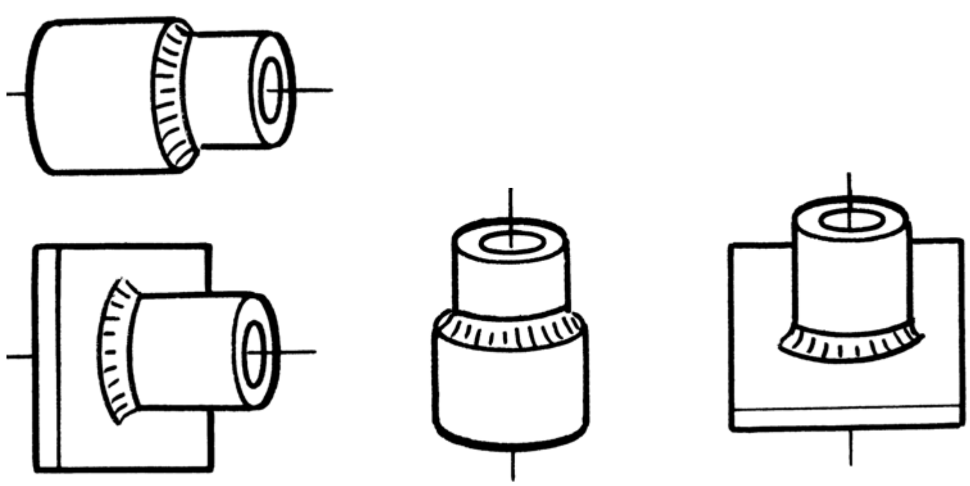
Flat position 1G: - Pipe with its axis horizontal and rolled during welding so that the weld metal is deposited from above.

Horizontal position 2G: - Pipe with its axis vertical and the axis of used in a horizontal plane. Pipe shall not be rotated during welding.

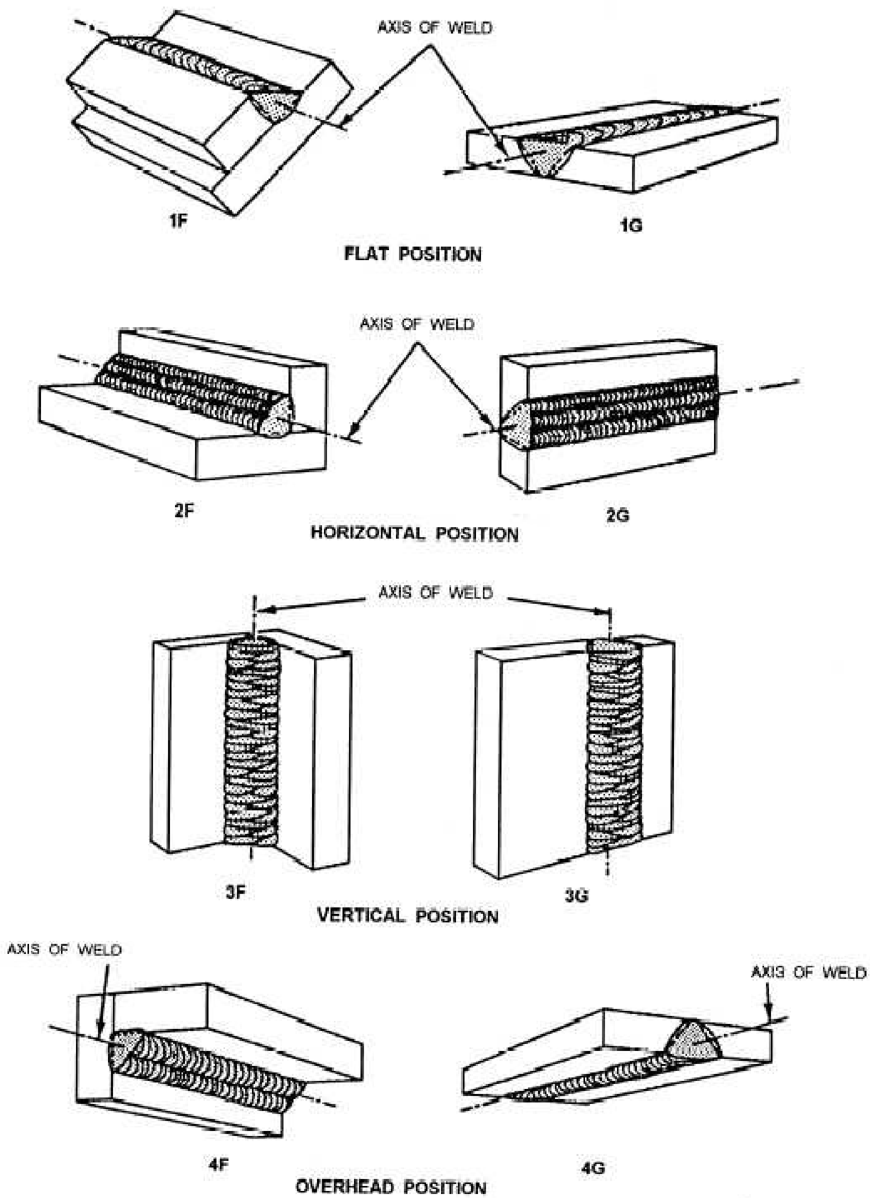
Multiple positions 5G: - Pipe with its axis horizontal and the welding groove in vertical plane. Welding shall be done without rotating the pipe.

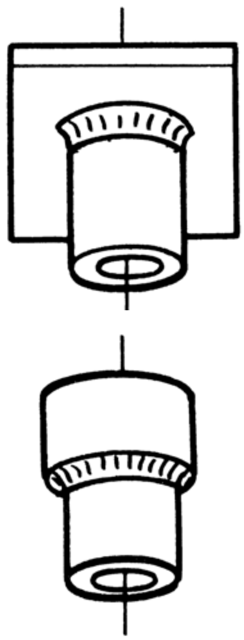
Multiple positions 6G: - Pipe with its axis inclined at 45° to horizontal. Welding shall be done without rotating the pipe.

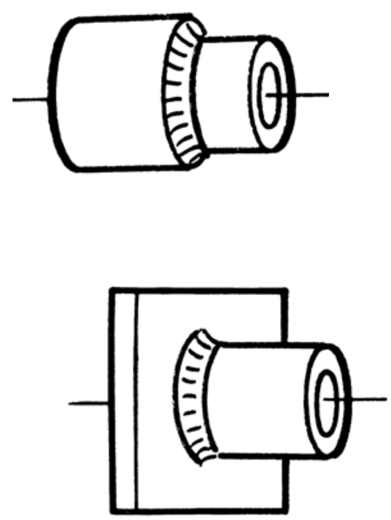




2FR (Rotated) **2F**


AXIS OF WELD
1F
1G
FLAT POSITION
AXIS OF WELD
2F
2G
HORIZONTAL POSITION
AXIS OF WELD
3F
3G
VERTICAL POSITION
AXIS OF WELD
AXIS OF WELD
4F
4G
OVERHEAD POSITION





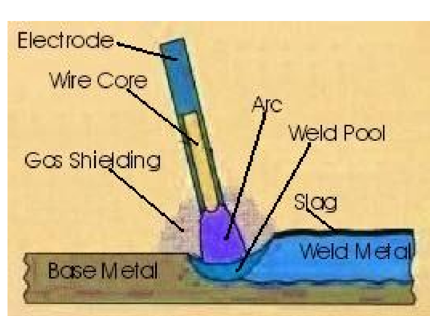
4F **5F**

<u>TYPES OF WELDING ARE USED IN PIPING</u>: -

1. **Shielded Metal Arc Welding (SMAW)**
2. **Gas Tungsten Arc Welding (GTAW)**

1. <u>Shielded Metal Arc Welding (SMAW)</u>: - Shielded Metal Arc Welding (SMAW) is frequently referred to as stick or covered electrode welding. Stick welding is among the most widely used welding processes.

The flux covering the electrode melts during welding. This forms the gas and slag to shield the arc and molten weld pool. The slag must be chipped off the weld bead after welding. The flux also provides a method of adding scavengers, deoxidizers, and alloying elements to the weld metal.



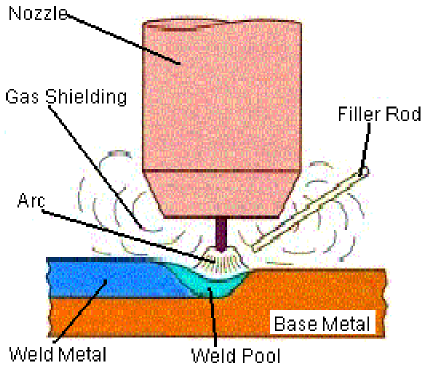
Stick welding benefits: - 1. Equipment used is simple, inexpensive, and portable.
2.Electrode provides and regulates its own flux.
3. Lower sensitivity to wind and drafts than gas shielded welding processes.
4. All position capability.

Weld Discontinuities: - 1. Undercut
2. Incomplete fusion
3. Porosity
4. Slag Inclusions
5. Cracks.

Stick Welding Problems: - 1. Arc Blow.
2. Arc Stability
3. Excessive spatter
4. Incorrect weld profile
5. Rough surface
6. Porosity

2. <u>Gas Tungsten Arc Welding (GTAW)</u>: - Gas Tungsten Arc Welding (GTAW) is frequently referred to as TIG welding. TIG welding is a commonly used high quality welding process. TIG welding has become a popular choice of welding processes when high quality, precision welding is required.

In TIG welding an arc is formed between a nonconsumable tungsten electrode and the metal being welded. Gas is fed through the torch to shield the electrode and molten weld pool. If filler wire is used, it is added to the weld pool separately.



TIG Welding Benefits: - 1. Superior quality welds.
2. Welds can be made with or without filler metal.
3. Precise control of welding variables (heat).
4. Free of spatter.
5. Low distortion.

GTAW Welding Limitations: - 1. Requires greater welder dexterity than MIG or stick welding.
2. Lower deposition rates.
3. More costly for welding thick sections.

Weld Discontinuities: - 1. Undercutting
2.Tungsten inclusions
3. Porosity
4. Weld metal cracks
5. Heat affected zone cracks.

TIG Welding Problems: - 1. Erratic arc
2.Excessive electrode consumption
3. Oxidized weld deposit
4. Arc wandering
5. Porosity
6. Difficult arc starting.

WELDING DEFECTS: -

1. Incomplete Penetration.
2. Lack of fusion.
3. Under cut.
4. Slag inclusion.
5. Porosity.
6. Crack.

1. **Incomplete Penetration: -** Occurs at the root of the joint due to improper size of electrode, low welding current and inaccurate joint preparation.

2. **<u>Lack of Fusion</u>: -** Defined as a condition where boundaries of unfused metal exist between weld metal and base metal. It occurs due to presence of scale, dirt, slag which prevents the base metal to reach melting temperature.

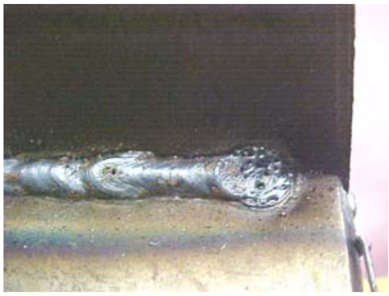
Caused By: - Current low, welding speed to high, incorrect torch/gun angle, incorrect edge preparation.

3. **<u>Under cut</u>: -** This defect appears as a continuous or discontinuous groove at the toes of a weld pass and is located on the base metal.

Caused By: - Excessive welding current, high speed of arc trave..

4. **<u>Slag inclusion</u>: -** Non metallic particles entrapped in weld metal are termed as slag inclusion. This occurs due to improper cleaning of slag between the depositions of successive pass. Also due to presence of loose rust, dust present on the surface of base metal.

5. **<u>Porosity</u>: -** The presence of gas pores in the weld is termed as porosity. This occurs due to chemically imperfect welding consumables, presence of oil, grease and moisture on the weld surface, excessive moisture in the weld coating, inadequate gas shielding or impure gas.



6. **<u>Crack</u>: -** Fracture of the metal is called crack. This occurs due to higher heat input during welding and use of low hydrogen electrode.

<u>WELDING ELECTRODES</u>: -

Sr. No.	Base Metal	Grade	Arc Welding		Argon Welding
			Root	Filler & Final	Filler Wire
1	C.S.	A 106 B	E 6010	E 7018	ER 70 S2
2	S.S.	A 312 TP 304	NOTE 1	E 308 L16	ER 308 L 16
3	S.S	A 312 TP 304 L	E 308 L16	E 308 L16	ER 308 L
4	C.S.	A 333 6	E 6013	E 7018 - 1	ER 80 S Ni-1
5	C.S.	A 516 70	E 6013	E 7018 - 1	ER 70 S2
6	A.S.	A 335 P11	E 6013	E 8018 B2	ER 80 S B2
7	A.S.	A 335 P22	E 6013	E 9018 B3	ER 90 S B3
8	S.S.	A 312 TP 316	NOTE 1	E 316	ER 316
9	S.S.	A 312 TP 304 H	NOTE 1	E 308 H	ER 308 H
10	S.S.	A 312 TP 347	NOTE 1	E 347	ER 347
11	C.S. TO S.S.	ALL	NOTE 1	E 309 L16	ER 306 L
12	A.S TO S.S.	ALL	NOTE 1	E NiCrFe-2	ER NiCr-3
13	S.S.	310	NOTE 1	E 310	ER 310
14	S.S	410	NOTE 1	E 410	ER 410
15	A.S.	A 335 P5	NOTE 1	E 8018 B6 / E 502	ER 80 S B6/ ER 502
16	A.S.	A 335 P9	NOTE 1	E 8018 B8 / E 505	ER 80 S B8/ ER 505

NOTE :-1 Argon Welding

AWS E7018: -

E – Designation of an electrode

70 – Minimum Tensile Strength 70 ksi (70000 psi)

1 – Welds in all position (Vertical, Flat, Overhead, Horizontal)

8 – Electrode as suitable for AC or DC operation, with a predominantly lime (Calcium Carbonate) coating.

AWS ER 70S – 2: -

E – Designation of an electrode

ER – Bare filler metal may be used as an electrode or welding rod

70 – Minimum Tensile Strength

S – Bare, Solid electrode or rod

2 – Chemical composition

POST WELD HEAT TREATMENT (PWHT): -

What is PWHT: - Post weld heat treatment (PWHT) services are defined as one of heat treatment done after welding/machining to improve the chemical mechanical properties of weldment/machined surfaces. In concept, PWHT covers many differential potential treatments. However, in steel fabrication, most common procedure used in stress Reliving.

When PWHT required: - Machining and/or welding induce stresses parts. The bigger and more complex the part, the more the stresses. These stresses can cause distortions in the part in long term. If the parts are clamped in service, then cracking could occur. Also whole locations can change causing them to go out of tolerance. For these reasons, stress relieving is often necessary.

1. **Stress Induced by welding: -** As a result of welding process used to join metals together. The base material near the weld metal and the heat-affected zones transform through various metallurgical phases. Depending upon the chemistry of the metals in their areas. Hardening occurs in various degrees, depending mainly upon the carbon content. This is particularly very true in the heat-affected zone adjacent to the weld metal deposit. The resultant stresses are highest due to melting and solidifications. Stresses, due to welding is of magnitude roughly equal to the yield strength of the base metal.

2. **Stress induced by Machining: -** Machining induces stresses in parts. The bigger and more complex the parts, the more stresses. These stresses can cause distortions in the part in long term. Cracking could occur and location changes causing parts to go out of tolerances. Stress Reliving heat treatment is used to reduce the stress that remain locked in a structure as a consequence of the various manufacturing processes. Stress Reliving, as the name implies, is designed to relieve these imposed stresses by reducing the hardness and increasing the ductility, and by these, reducing the danger of cracking in the weldment.

How is Stress Reliving done: - Stress Reliving is done by uniformly heating-fabricated equipment or the vessel or vessel part to a sufficient high temperature, but below the low transformation temperature range, then subjecting it to a thermal retardation for a sufficient time depending upon the material thickness and the finally uniformly cooling it which is also of utmost importance.

Advantages of Post Weld Heat Treatment – Stress Reliving: -

1. The much greater dimensional stability is obtained and maintained.
2. The potential of stress induce cracking is reduced.
3. Metallurgical structure is improved.
4. Strength of the material and life of the equipment is enhanced.

PREHEATING: - Preheating shall be required as stipulated for the various materials listed in the various "P" groups, as follows:

A. Preheating of materials listed under "P" numbers 1 and 2 is not mandatory but under certain conditions is recommended. Under field conditions or otherwise where the ambient temperature is less than 32 degrees Fahrenheit, local preheating to a hand-hot condition is suggested for all materials listed in "P" numbers 1 and 2. Experience has indicated that preheating to 250 degrees Fahrenheit is advisable (regardless of ambient temperature) when welding those materials listed under "P" number 1 which have minimum tensile properties of 70,000 psi or higher.

B. Preheating to 300 degrees Fahrenheit minimum shall be required when welding all materials listed under "P" number 3.

C. Preheating to 375 degrees Fahrenheit minimum shall be required when welding all materials listed under "P" number 4.

D. Preheating to a temperature of 450 degrees Fahrenheit minimum shall be required when welding material listed under "P" numbers 5 and 6.

E. Preheating of material listed under "P" number 7 shall be a matter of agreement between the manufacturer or contractor and the purchaser.

F. Preheating of the austenitic stainless grades of material listed under "P" number 8 is optional and is not a requirement of this code.

G. When welding dissimilar materials having different preheat requirements, the preheating temperature shall be that established in the procedure specification.

Preheating may be accomplished by any suitable method provided that it is uniform and that the temperature is maintained above the minimum during the actual welding operations.

The preheating temperature shall be checked by the use of temperature indicating crayons, thermocouple pyrometers, or any other suitable method to assure that the required preheat temperature is obtained prior to and maintained during the welding operation.

STRESS RELIEVING: - Unless otherwise provided in other sections of this code, the following stress relieving schedule will apply:

A. Welded joints in carbon steel materials as listed under "P" number 1, shall be stress relieved when the pipe wall thickness is three-fourths inch or greater. In unreinforced and reinforced branch connections, the thickness of the run shall govern. When flanges are attached by fillet welds, the thickness of the pipe shall govern.

B. Welded joints in wrought iron pipe as listed under "P" number 2 shall require stress relieving only as a matter of agreement between the purchaser and the fabricator.

C. Welded joints in carbon molybdenum steel material listed under "P" number 3, shall be stress relieved when the pipe wall thickness is one-half inch or greater.

D. Welded joints in all other alloy materials listed under "P" number 3, and all materials listed under "P" numbers 4, 5, and 6, shall be stress relieved without regard to wall thickness.

E. Stress relieving or other post weld heat treatment of the high alloy ferrite materials listed under "P" number 7 and the austenitic stainless grades of material listed under "P" number 8 is not a requirement of this code, but may be performed as a matter of agreement between the purchaser and the fabricator. If stress relieving or heat treatment is agreed upon, it should be compatible with the analysis of both the base metal and the weld metal and should be determined as most suitable for the particular service application.

F. In welds between dissimilar ferrite materials, if either material requires stress relieving, the joint shall require stress relieving.

G. In welds between austenitic and ferrite materials, stress relieving or other post weld heat treatment of the welded joint is optional. Stress relieving or heat treatment, if used, shall be a matter of agreement between the contractor and the purchaser. Due to differences in the coefficient of thermal expansion existing between dissimilar materials, careful consideration should be given to the selection of a heat treatment, if any, that will be beneficial to the welded joint.

Stress relieving temperature: - Stress relieving should not be confused with other post weld heat treatments which, if required, shall be a matter of agreement between the manufacturer and the purchaser. Such post weld heat treatments may or may not obviate the necessity of stress relieving depending upon the maximum temperature attained in the post weld heat treatment and the rate of cooling from the temperature.

Stress relieving shall be performed at a temperature of 1,100 degrees Fahrenheit or over for carbon steels, and 1,200 degrees Fahrenheit or over for ferrite alloy steels. The exact temperature range shall be established in the procedure specification.

When stress relieving a joint between dissimilar ferrite materials or between austenitic and ferrite materials, having different stress relieving requirements, the temperature used shall be that established in the procedure specification.

The parts heated shall be brought uniformly to the required temperature and held at that temperature for a period of time proportioned on the basis of at least one hour per inch of pipe wall thickness, but in no case less than one-half hour, and shall be allowed to cool slowly and uniformly.

Methods of stress relieving: - Methods of stress relieving are:

A. Heating the complete structure as a unit.

B. Heating a complete section containing the weld or welds to be stress relieved before attachment to other sections of work.

C. Heating a part of the work by heating slowly a circumferential band containing the weld at the center. The width of the band which is heated to the required temperature shall be twice that of the weld reinforcement but need not exceed the width of the weld reinforcement by more than two inches. Extreme care should be used to obtain a uniform temperature around the entire circumference of the pipe. The temperature shall diminish gradually outward from the ends of this band.

D. Branches or other welded attachments for which stress relief is required, should preferably be furnace stress relieved. Where furnace stress relief is impractical, local stress relief may be accomplished by heating a circumferential band around the pipe on which the branch or attachment is welded with the branch or attachment at the middle of the heated band. The width of the band shall be at least two inches greater than the diameter of the weld joining the branch or attachment to the header. The entire band shall be brought up to the temperature and held for the time specified.

Equipment for local stress relieving.

Stress relieving may be accomplished by electric induction heating, electric resistance heating, fuel fired ring-burners, fuel fired torch, or other suitable means of heating provided a uniform temperature is obtained and maintained during the stress relieving cycle.

Checking temperature.

The stress relieving temperature shall be checked by the use of thermocouple pyrometers or other suitable equipment to be assured that the proper stress relieving cycle has been accomplished.

DYE PENETRATE TEST (DPT): - A liquid penetrant test is non-destructive type. It detects flaws that are open to the surface e.g., cracks, seams, laps, lack of bond, porosity, cold shuts, etc. It can be effectively used not only in the inspection of ferrous metals but is especially useful for non-ferrous metal products and on non-porous, non-metallic materials such as ceramics, plastics and glass.

The steps involved in dye penetrant test are

1. Clean the surface of the component free of dust and dirt with a piece of cloth.
2. Brush the surface of the component to remove scale, rust, paint etc., by a soft wire brush.
3. Spray the cleaner to remove oil, grease, etc
4. Apply the dye penetrant (by spraying) adequately to cover the area to be tested. Allow 3 to 5 minutes or more for dye to penetrate into the cracks.
5. Wipe off the excess penetrant on the surface with a rag.
6. Again spray the surface with the cleaner to remove the remnants of the red dye.
7. Spray the developer evenly on the surface to give a thin even layer. This layer absorbs the penetrant from the cracks and red spots or lines appear on t e stir ace to give a visible indication of the flaws.
8. The crack if any will be indicated with the red dye absorbed by the white absorbent.

<u>RADIOGRAPHY TEST</u>: - Radiography is one of the most useful of the non-destructive tests which can be applied for assessing the quality of the welded joints. Radiograph has been used for the inspection of welds of all types and thicknesses ranging from minute welds in electronic components to welds up to half meter thick employed in heavy fabrications.

Radiography can detect flaws or discontinuities in welds such as:
(i) Cracks.
(ii) Porosity and blow holes.
(iii) Slag, flux or oxide inclusions.
(iv)Lack of fusion between the weld metal and the parent metal
(v) incomplete penetration.

Principle
Radiography technique is based upon exposing the components to short wavelength radiations in the form of X-rays (wavelength less than 0.001 x 10-8 cm to about 40 x 10-8 cm) or gamma (y) rays (wave length about 0.005 X 10-8 to 3 X 10-8 cm) from a suitable source such as an X-ray tube or cobalt-60.
The characteristic feature of X-ray and y-ray which makes them to work is their power to penetrate matters opaque to light. X-rays operating at 400,000 volts can inspect steel objects having thickness up to 62 mm.
γ -rays given off by radium and radioactive isotopes such as cobalt-60, lridium-192 and caesium-167 can penetrate and thus inspect joints of bigger thickness than examined by X-rays.

Procedure: -

Diameter & Thickness: - ½’’ to 56’’ diameter & 2.77 to 50mm.

Type of weld joint: - Butt Weld.

Radiation source/size: - Iridium-192 (2 to 50 Ci)/2mm

Intensifying Screen: - Lead Screen F/B-0.125/0.125.

Geometric Relationship: - Max. UG below 2’’ material thick = 0.02’’

2’’ to 3’’ material thick = 0.3’’

Limit of film coverage: - As marked (area) on the film. Minimum overlap between two adjacent films shall be one inch. Repaired area shall be covered with at least one inch more on either side of the actual repaired weld length.

Technique/setup: - Pipe size of 21/2’’ and below performed by the elliptical (DWE-EWV) Projection technique with at least two exposures 90deg, apart. Pipe size of 3’’ and above shall be performed by DEW-SWV or SWE-SWV as per site condition.

Film type and make: - Fine gain Low speed – Agfa D4/Indu.

Up to 10mm thickness: - NDT 55/Fuji/Kodak.

Above 10mm thickness: - Fine gain medium speed – Agfa D7/Indu. NDT 05/Fuji/ Kodak.

Exposure Time: - As per Technique Diaz, Thick, Source, Strength etc.

HOLIDAY TEST: - The procedures to be used for determining holidays in epoxy coatings on ferrous materials are described in this method. This method uses an electrical current flow through a low resistance path to trigger an alarm (buzzer) to indicate to the operator the presence of a holiday.

Holidays are defined as pinholes and voids in non-conducting coatings that allow current pass through the protective coating to the metal base material. These continuous are such that they may not be visible to a person with normal or corrected vision.

APPARATUS: -

1. A low v voltage holiday detector tester having an electrical source of 67.5 to 100 V DC that meets the requirement of ASTM G 62 Section 1.2, Method A.
Example: Tinker & Razor, Model M/1
Holiday Detector.
2. A cellulose sponge with an insulated handle. The sponge is wired to the positive contact electrode.
3. A grounding clamp/magnet and wire to the negative (ground) terminal. This provides the system connection to the low resistance base metal.
4. Tap water. Plain, if measuring pinholes and voids in coating thickness up to 10 mils.
5. A non-sudsing type wetting agent. Use the following dilution factor for measuring pin holes and voids in coating thickness up to 20 mils: One ounce agent to one gallon of tap Water. Reference: Tinker & Razor Water-Wetter.
6. An 80,000-ohm, ½ watt resistor mounted on an insulated terminal board for checking proper audio indication and the drop in battery voltage with this resistance load. (This test resistance may be built in to newer models of the holiday tester.)

TEST PROCEDURE: -

Wet the sponge with sufficient wetting solution to assure moisture penetration of any defect in the surface coating.
Squeeze out any excess.

1. Before starting the testing process, place the moist sponge on one end of the 80,000-ohm resistor and place the magnet contact on the other end. Verify that an audible alarm is given. Weekly, check the voltage (with a high impedance volt/ohm meter) across the tester terminals when the system is loaded with the 80,000-ohm resistor. If the voltage less than 90 % of required voltage, replace the system battery.
2. If the sample bar ends are coated, grind the coating off one end of the bar being tested. This is for the ground contact.
3. Place the magnet with the attached ground wire on the bare end of the bar. The magnet should be in direct contact with the base metal.
4. Test the connections by contacting the bare end with the sponge. The audible alarm should be triggered.
5. Test the coated metal sample by sweeping the moist cellulose sponge up and down the deformation sides and the ribbed sides of the sample. The sweep rate shall not exceed 2½ inches per second. Count the alarm indications, mark the spots and record the total number detected.

HYDROSTATIC TEST PROCEDURE: -

Test Procedure: -

1. Preparation for pressure testing: -

1.1 Blind flanges, blanks, caps or plugs with adequate pressure rating shall be installed to isolate piping system and equipment as indicated on the test diagrams.

1.2 All temporarily installed items (blanks, gaskets, spools, strainers, etc.) shall be adequately marked using paint or tags for easy traceability.

1.3 Items not to be subjected to the pressure test shall be removed.

Items to be removed or blanked off prior to testing/flushing shall include, but shall not be limited to:

* Equipment not included in the test system.
* Relief valve and rupture discs.
* Orifice plates, flow nozzles or other similar restrictions.
* Venturi type flow meters (flanged).
* Internals of equipment (trays, demisters, level instrument floats, float cages, etc.), if included in the test system.
* Flanged control valves (for welded-in type control valve internals shall be removed).
* Flanged check valves unless internals are removed (for butt-weld or socket weld check valves internals shall be removed).
* All instruments (unless otherwise approved by construction supervision contractor).
* Any items not designed to withstand the test pressure (e.g. pressure gauges).
* Internals of strainers and filters.

1.4 Instrument piping shall be tested together with the piping system up to the piping block valve nearest to the instrument. When a union is provided downstream of an instrument block valve, it shall be broken to prevent dirt or foreign matter from being introduced into the instrument.

1.5 If the test pressure on both sides of flanged control valve is equal and when block valves and bypass are installed, the block and bypass valves shall be left open with the control valve removed and with blinds or a spool piece installed.

1.6 If test pressure up and downstream of a control valve are not equal, the spool piece between the control valve and the downstream block valve shall be tested in combination with the upstream part.

1.7 Piping supported by counterweight or spring without “down travel stop” shall be temporarily supported prior to filling of the line with water.

1.8 A spring with "down travel stop" shall have the "stop" (wedges or block) I inserted prior to filling of the line with water.

1.9. Piping designed for vapor or gas shall (when necessary) be provided with additional temporary supports to support the additional weight of the test liquid.

1.10. All open valves in the test system, which have a back seat (gate and globe valves) shall be fully opened until the stem seat contacts the back seat and then the hand wheel shall be turned twice in the direction of closing to assure that gland packing is subjected to full line test pressure.

1.11. Open ends of atmospheric lines to be "full of liquid" tested shall be left open during testing.

1.12. For pneumatic testing or service testing with air or nitrogen, screwed and flanged joints shall be prepared for soap testing by taping with masking tape and punching a 3 mm diameter hole through the tape.

1.13. When electronic leak testing will be applied, taping with masking tape will not be required.

PRESSURE TESTING: -

2.1. After acceptance of the preparations for pressure testing by construction supervision contractor, the piping system will be released for pressure testing.

2.2. All systems shall be properly vented (at the high points) while filling. Special attention shall be paid to the direction of filling when check valves are installed in the system.

2.3. Test pressure shall be applied by means of a suitable test pump or other pressure source. This pump shall be positively isolated from the system except when being used to pressurize the system.

2.4. At least two (2) pressure gauges per test system shall be in stalled. One at the test pump discharge and one (1) at or near the highest point of the test system. For large systems, more pressure gauges shall be installed at suitable locations, in coordination with construction supervision contractor.

2.5. The test pump shall be constantly attended during the test by an authorized person. Before the pump is left unattended, it shall be positively disconnected from the system, while the pressure gauge remains connected to the test system.

2.6. The test pressure shall be as indicated in the test index as provided by construction supervision contractor.

2.7. Retesting of a system (when required) shall be performed at the same pressure as originally specified for the test.

2.8. The pressure shall be increased gradually. For test pressures over 100 kg/cm2, the pressure shall be increased in steps of 25 kg/cm2, providing sufficient time to check for leaks and to allow the piping to equalize strains during the test.

2.9. The outside surface of the test system shall be clean and dry before and during testing.

2.10. The test pressure shall be maintained for at least half an hour prior to start of inspection and long enough to enable a visible inspection of the complete test system by the inspection team. A pressure recorder may be installed.

2.11. Atmospheric lines to be "full of liquid" tested shall be filled with water for at least 24 hours before visible inspection of the complete test system by the inspection team.

2.12. In case hydro testing through equipment is required, construction supervision contractor will provide special instructions {e.g. maximum differential pressures on shell and tube side of heat exchangers) where applicable.

Hydro Test Pressure: -

Hydro Test Pressure: - 1.5 times of the maximum working pressure.

$PT = 1.5*P*ST/S$

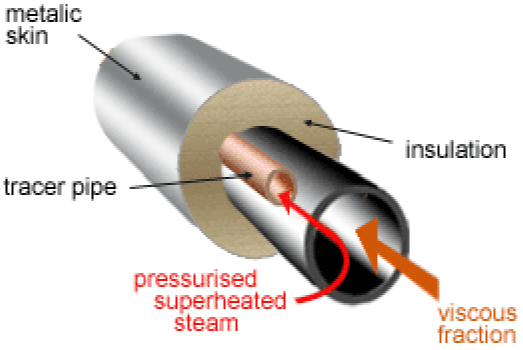
Where PT = Hydrostatic Test Pressure, kg/cm^2

P = Maximum working pressure, kg/cm^2

ST = Allowable stress at 304°c, kg/cm^2

S = Allowable stress at design temperature, kg/cm^2.

STEAM TRACING: - Heat tracing is used to prevent heat loss from process fluids being transported in process fluid pipes, when there is risk of damage to piping, or interference with operation such as fouling or blockage, caused by the congealing, increase in viscosity, or separation of components, in the fluid below certain temperatures, or when there is risk of formation of corrosive substances or water due to condensation in corrosive services. This prevention of heat loss is accomplished by employing electrical tracing, or Steam tracing, and insulating both the process fluid pipe and the tracer together, using appropriate insulation materials & metal lagging is vital on any application, in an attempt to reduce heat loss from the pipe and tracer to their surroundings.



Pipe Supports: -

Support: - Pipe supports hold in the pipe in position and when properly spaced prevent excessive deflections due to the weight of the pipe, fluid, external insulation and other loads.

1. **Guide: -** Pipe guides prevent lateral (side-to-side) movement of the pipe. Guides are required to prevent the pipe from buckling under compressive loading.
2. **Anchor: -** Pipe anchors restrain the pipe against axial movement or applied forces. These forces may result form thermal loads, water hammer, vibrating equipment, or externally applied mechanical loads.

COATING AND WRAPPING OF UNDER GROUND PIPING: -

Primer: - The primer shall consist of processed coal – tar pitch and refined coal tar oils only, suitably blended to produce a liquid coating which may be applied cold by brushing or spraying without runs or curtains. The primer shall contain no benzol or other toxic or highly volatile solvents and no added pigments or inert fillers, or other substances, and shall show no tendency to settle out in the container. The coverage shall be approximately 10 to 15 square meters per liter.

Coal Tar Enamel: - The enamel shall be plasticized coal tar pitch suitable for hot applications and uniformly filled with inert mineral filler which shall have the minimum tendency to settle in the fluid state. The filler used shall be slate flour or talc; limestone or asbestos shall not be used. No asphalt of either petroleum or natural base shall be acceptable as part of the ingredients.

Inner Wrap: - The inner wrap or reinforcement to the coal – tar enamel shall be non – woven fiber glass tissue consisting of a uniformly porous mat of chemically resistant boro-silicate glass not less than 5%B2O3 as defined by ASTM definition C162-52. Glass fiber filaments making up the material shall be in random arrangement bonded with phonemic or urea type resin, compatible with hot coal – tar enamel. Continuous longitudinal filament or longitudinal continuously bonded slivers of staple glass fiber to provide longitudinal reinforcement shall be embodied in the matt at a maximum of 25mm centers.

Outer Wrap: - The outer wrap shall be uniform, flexible and with random pin holes to facilitate the release of hot gases and to allow sufficient bleed-through of the enamel to achieve satisfactory adhesion of the outer wrap. The surface of the outer wrap shall be lightly dusted with talc or other approved mineral powder, in sufficient quantity to prevent sticking in the roll under conditions likely to be met in application at site.

PIPING EXECUTION PROCEDURE: -

Activities to be done before starting work: - Collect the following documents

* Plot Plan – IFC
* P & ID (Process & Utility) – IFC
* G.A.D for all Areas
* Isometric drawings
* Drawing Index (P & ID, G.A.D, ISO)
* Line detail schedule (L.D.S)
* Pipe Rack support details
* Support standard
* Equipment drawings for erection purpose
* Tapping point list
* Piping related civil drawings (Man Hole, Catch Basin etc)
* M.T.O (U.G & A.G) piping
* U.G piping drawings

From Plot Plan: -

* Preparing equipment list with all the necessary details.
* Approach of crane placement for Heavy Lift/Static & Rotary equipment

erection.

* Locations of Heaters, U.G Vessel, Flare K.O.D. etc.

<u>From P & ID</u>: -

* Prepare Nozzle analysis sheet.
* Prepare piping specification sheet.
* Prepare scope of work (I.M/I.D) for unit/rack.

<u>From G.A.D</u>: -

* Compare with ISO & P&ID.
* Line routing & nozzle orientation with ISO.
* Check the Instrument tapping; identify type & number of valves, orifice flanges, location of supports with ISO & P&ID.
* Prepare list of small bore lines system wise.
* Prepare the small bore isometric Bill of Material, Inch Meter (I.M) & Inch Diameter (I.D).
* List out the types of supports.
* Prepare the list of U-bolts & anchor fasteners.

<u>From M.T.O (Material Take off)</u>: -

* Compare isometric B.O.M with main M.T.O.
* Prepare total scope Spec wise for preparing requisition for contract.
* Material uploads in I.M.M.S system.

<u>From Isometric Drawings</u>: -

* List total number of ISO system wise, with Revision numbers.
* If required mark scope of I.M, S.W (Shop weld), and F.W (Filed weld) spool numbers in each ISO.
* Prepare total scope S.W, F.W number of spools I.M. from all isometrics.
* Prepare a list of types of supports.
* Prepare B.O.M for steel structure.

<u>Drawing Index</u>: - Check with index whether we received all the Drawing's or not.

<u>U.G. piping Drawing</u>: -

* Check if any line crosses the road.
* Identify scope of work
* Prepare contract requisition

<u>Before Starting Pipe Fabrication</u>: -

* Check the availability of material.
* Collect marked up ISO, GAD, MTO.
* Finalize the total scope of fabrication in I.D. & no of spools in System wise & Spec wise.
* Locate space & location of fabrication yard.
* Required power connection

* Finalize the contractor & mobilization
* Arrange trailer, hydra, crane etc. for material handling.
* Prepare spec wise material storage yard
* Collect the required material from warehouse
* Make fabrication schedule I.D per day/ required man power.
* Required machinery as per main schedule.
* Prepare temporary spool for Fabrication.
* Prepare fabricated spool yard & Sand Blasting yard, dark room.
* Prepare standard format for inspection of fit-up, weld, weld visuals, D.P. Daily progress report & man power report.
* Record daily, material received from warehouse & issued to site isometric drawing wise.
* Prepare WPS (welding procedure specification)/PQR (performance qualification record) with pipe specifications & welder test for fabrication (QA/QC).
* Pipe & fitting sandblasting.

Office planning work: -

* Mark the system number in P&ID & list out the total number of system.
* Mark the loop number in each system.
* Prepare list of system with loop number.
* Prepare list of lines/ Isometric in each loop.
* Prepare list of loop files with all related documents.
* Make separate list for utility & process.
* Collect daily progress report from contractor.
* Make weekly progress report & give to planning department.
* Record of MTO & material availability in warehouse & issue material to contractor (all records required).
* Record all the latest drawings/documents & give to concern engg.
* Record the total scope & daily progress report, unit wise.
* Arrange the shortage material.

Fabrication work: -

* Fabrication starts from pipe rack & then unit.
* During fabrication, make daily fit-up report & signature. Check the following
\- Punching/painting the joint number, line number, spool number.
\- Pipe schedule/class & dimensions as per drawing.
* After signature of fit-up, spool will be released for welding
\- Put the welder number in each joint after welding
\- Grinding, cleaning of joints.
\- Prepare the welding report.
\- Offer the spool for weld visual & signature from QA/QC.
\- Send the spool for radiography.
\- Send the fabricated spool to the spool yard.
\- Colour coding in isometric drawings fit-up/weld/weld visual.
* During fabrication if any shortage of fittings/pipe inform to planning department & record in isometric drawings.

<u>Pipe Erection</u>: -

* Mobilize the contractor at site with office, tools & machineries.
* Power connection for erection work as per requirement.
* Prepare area for spool unloading & F.W. fittings & valves.
* Arrange transportation for shifting the spools, F.W. fittings at erection site.
* Collect one set of drawings, MTO, support details etc. at site.
* Mark the line number on the pipe rack tire beams as per drawing/dimensions.
* Prepare hand sketch drawing for pipe rack piping form GAD.
* Collect the pipe rack support details & schedule & start fabrication of support (only pipe rack).
* Start the erection work from the pipe rack.
* After release of front from equipment, start unit piping.
* Make daily erection progress report, ID, IM (unit wise).
* Make proper erection schedule & increase man power & machinery to achieve the schedule.
* During the erection of spools parallels support work can be started.
* Radiography, Stress Reliving, NDT as per requirement.
* Start the utility line erection as per schedule.
* After completion of some lines, start Mechanical Clearance (MC) of loop.
* After MC, loop file handed over to QA/QC department.
* QA/QC will check NDT part, Radiography, DP, UT etc. & release for Hydro-test.
* After completing hydro-test of a system, release the system for format – I to operation/ maintenance.
* Operation/maintenance will give format – II with punch points.
* Clear the punch points & release the format – III.

<u>CHECK LIST FOR ISOMETRICS</u>: -

1) Line Nos.
2) Line Specs
3) Start Point Location
4) End Point Location
5) Branch Connection
6) Valve Accessibility
7) Support
8) Insulation (For Insulated Line Only)
9) Instrument Connection
10) Flow Arrow
11) High Point Vent, Low Point Drain
12) Hydro Test Vent And Drain
13) Nozzle Connection
14) Nozzle Nos.
15) Equipment Nos.
16) Coordinates And Elevations
17) Iso North

18) Bill Of Material
19) Valve Tag Nos.
20) Instruments Tag Nos.
21) Continuation Sheets or Iso. Nos.
22) Grid Location and Nos.

POINTS TO REMEMBER IN ISOMETRICS CHECKING: -

1) Pump Suction Is Bigger Than Discharge Line
2) Eccentric Reducer (Flat Side Top) Using For Pump Suction Line This Is Using For Avoid The Air Block In Pump Suction.
3) Pump Suction Line And Compressor Suction Line Keep Always Downward Position, No Loops Permitted To Pump Suction.
4) Psv Outlet Always Rising Position.
5) Check The Valve Accessibility For Maintenance Purpose. Valve Operating Height Min 250mm To 1200mm From Floor Level.
6) Lift Check Valve Always Horizontally Using. Swing Check Valve Vertically and Horizontally Using.
7) Control Station Operating Height 500mm to 750mm from Floor Level.
8) Shoe Not Required For Trunion. (Insulated Lines)
9) Headroom Clearance Minimum 2.2m from Ground/Floor Level.
10) Drip leg required for Steam Line Header.
11) Shoe Required For Insulated Lines (Steam, Chilled Water, Brine, and Steam Condensate).
12) Shoe Not Required For Condensate Line When Line Will Be On Pipe Rack.
13) Nozzle Orientations Should Be Keeping As Per Piping Requirement.
14) Avoid The Obstacles. Keep A Piping Routing Neat And Clearly.
15) Control Stations Locates Side Of Near The Walls Or Columns
16) Give A Trunion Supports To Control Station Both Side Of Control Valves.
17) Use a Dike Wall Around The Equipments For Avoid The Liquid To Spread In The Plant Area. The Volume Of Dike Wall Is 1.5 Times More Than Total Capacity Of Equipments.
18) Use Weld neck Flange for Pressure Piping.

SHORT CODE: -

1)	Ibr	Indian Boiler Regulation Act
2)	Astm	American Society Of Testing Material
3)	Ansi	American National Standard Institute
4)	Smls	Seamless
5)	Thd	Threded
6)	Bw	Butt Welded
1)	Sw	Socket Welded
2)	Ecc. Red.	Eccentric Reducer
3)	Conc.Red.	Concentric Reducer
4)	Eq.Tee	Equal Tee
5)	Red. Tee	Reducing Tee
6)	Clpg	Coupling

7) Vlv	Valve
8) Str	Strainner
9) T	Trap
10) Elb	Elbow
11) Fof.El.	Finish Floor Elevation
12) Ptfl.El.	Platform Elevation
13) Gr.El	Ground Elevation
14) Sch	Schedule
15) Thk	Thickness
16) Eqpt	Equipment
17) Sorf	Slipon Rase Face
18) Soff	Slipon Flat Face
19) Wnrf	Weldneck Rase Face
20) Wnff	Weldneck Flat Face
21) Bop.El.	Bottom Of Elevation
22) Cl.El.	Center Line Elevation
23) Pcd	Pitch Circle Dia.
24) Nb	Nominal Bore
25) Ns	Nominal Size
26) Be	Beveled End
27) Isi	Indian Standard Institute
28) Fst	Flat Side Top
29) Fsd	Flat Side Down
30) Suc.	Suction
31) Disch.	Discharge
32) Wp.El.	Work Point Elevation
33) Ga	General Arrangement
34) P&Id	Piping And Instrument Diagrames
42) HPP	High Paving Platform

DRAWINGS: -

1) Study Layout
2) General Arrangement Drawings
3) Piping And Instrument Diagrams
4) Sectional Layouts
5) Civil Layouts
6) Equipment Layouts
7) Fabrication Details Drawing
8) Foundation Details Drawings
9) Structural Layout
10) Isometrics
11) Piping Details Layout
12) Nozzle Orientations
13) Plot Plan
14) Flow Diagrams

IBR APPROVAL PROCEDURE: -

Indian Boiler Regulations (IBR) Approval procedure: -
All steam; boiler feed water and selected condensate piping systems exceeding 3.5Kg/sq.cm gauge or254 mm internal diameter shall come within the purview of IBR. This procedure is issued to establish a uniform approach to collating the documentation required to form a design, fabrication and installation approval package of piping systems under the jurisdiction of the Indian Boiler Regulations. (IBR)

Responsibilities: - The Design Package shall consist of following document:
a) Isometrics of System and Detail Sheet.
b) Stress Analysis Report, Calculations, and System Stress Isometric and Pipe Support Types & Locations.
c) Copy of the relevant piping material classes.
d) Pipe Wall Thickness calculations.
e) Piping Fabrication Details including branch reinforcement calculations.
f) Copy of the system Line List.
g) Safety Valve details including set pressures.
h) Equipment List.
i) System Description.

1. MATERIAL CLASSES
A hard copy of the relevant material class for each line together with any supplementary testing or inspection requirements shall be submitted.

2. PIPE WALL THICKNESS CALCULATIONS
Pipe Wall Thickness calculations shall be based on the requirements of the IBR rule 350 and be included as part of the design package.

3. PIPING FABRICATION DETAILS
Drawings showing the piping fabrication details based on the IBR requirements and to include any branch reinforcement calculations.

4. SYSTEM P&ID OR BLOCK DIAGRAM
A copy of the system P&ID relevant to the system isometric or Block Diagram.

5. SYSTEM LINE LIST
A copy of the system line list relevant to the isometric of system.

6. SAFETY VALVE DETAILS
A copy of the Safety Valve Data Sheets applicable to the system isometric shall be added. Details shall include manufacturers name, model number, rating and set pressures. Safety valves with orifice sizes less than 19mm (orifice G) will not be permitted.

7. EQUIPMENT LIST

A list of equipment which either uses, Transports or generates steam, feed water or condensate shall be formulated as the examples shown in attachment.

For Design Approvals Outside India: -

1. The assembled design package shall be issued to the IBR approved third party for design approval. Isometrics issued to site, IFC, shall not be fabricated until design approval has been granted.
2. The originals of the approved package shall be issued to the site, for further additions.

For Design/Fabrication Approvals Inside India: -

1. The assembled design package shall be issued to the site inclusion of the following documents:-

a) Copies of the approved Weld Procedures and Qualification Records. (IBR Form XII).
b) Copies of the Material/Test Certificates covering all materials shown on each Isometric. These are the supplier completed FORM III A, B, C, D, E or F depending on the material content.
The certificates must apply to all materials listed on each isometric. The materials to which the certificates apply must be segregated into individual isometric piles and isolated until approval to fabricate is received from the IBR.
c) Copies of the Approved Hydrostatic Test Procedure.

2. The assembled package shall be issued .for approval by IBR authorities.
3. Phased inspections by the IBR are required during the fabrication period.
4. IBR approval to install all piping is required before installation commences.

Fabrication Package (For Design Packages Approved Outside India): -

1. RESPONSIBILITIES

Fabrication package for submittal to state IBR representative through clients site representative shall consist of:
a) The Approved Design Package.
b) Copies of the Approved Weld Procedures and Qualification Records.
c) Copies of Material/Test Certificates. (Form III A, B, C, D, E or F)
d) Copies of the Approved Hydrostatic Test Procedure.

1. APPROVED DESIGN PACKAGE

The Approved Design Package shall be as it is received from Engineering and the contents shall not be changed or altered in any way what so ever. Any changes from the approved contents may invalidate the approval process and be the cause of resubmission for approval, thus affecting the schedule. All routing changes that may become necessary due to site requirements shall be carried out with the prior approval of the local IBR Inspector.

2. WELD PROCEDURE SPECIFICATION AND QUALIFICATION RECORDS

The site shall attach copies of the previously approved Weld Procedure Specification and Qualification Records (IBR FORM XII) to the Fabrication Approval Package.

3. MATERIAL/TEST CERTIFICATES

The site shall attach copies of the Supplier completed FORM III A, B C, D, E or F, previously received with the piping materials from suppliers/vendors. The certificates must apply to all materials listed on each isometric. The materials to which the certificates apply must be segregated into individual isometric piles and isolated until approval to fabricate is received from the IBR.

4. HYDROSTATIC TEST PROCEDURE
A copy of the hydrostatic test procedure shall be attached to the fabrication package by the site. The IBR allows hydrostatic testing of the installed systems instead of individual spools but, this needs to be agreed with the IBR beforehand.

5. Phased inspections by the IBR are required during the fabrication period.

6. The site shall complete the transmittal log for each package to ensure all of the additional documents are included.

7. IBR approval to install all piping is required before installation commences.

8. The assembled package shall be issued to the IBR inspectors for approval to fabricate site representative.

RECORDS: -
1. On successful completion of the system hydrostatic test "As Built", information shall be incorporated on all drawings

2. On approval of the "As Built" drawings or with the prior approval of the local IBR Inspector the line may be charged with steam.