PIPING QUESTIONAIRE

Questions related to Codes & standard: -

1. What is the ASME code followed for design of piping systems in Process piping (Refineries & Chemical Industries)?

(i) B 31.1
(ii) B 31.3
(iii) B 31.5
(iv) B 31.9

Answer (II)

2. Which American institute standard does piping engineer refer?

Answer: -

A. The American Petroleum institute (API).
B. The American Iron & Steel institute (AISI).
C. The American Society for Testing and materials (ASTM).
D. The American National standard institute (AISI).
E. The American welding society (AWS).
F. The American Water Works Association (AWWA).
G. The American Society for Mechanical Engineers (ASME).

3. What is the different ASME 31 code for pressure piping?

Answer: -

A. ASME B31.1 - Power piping.
B. ASME B31.2 - Fuel Gas Piping.
C. ASME B31.3 - Process piping.
D. ASME B31.4 - Pipeline Transportation system for liquid hydrocarbon & other liquid.
E. ASME B31.5 - Refrigeration Piping.
F. ASME B31.8 - Gas transmission & distribution piping system.
G. ASME B31.9 - Building services piping.
H. ASME B31.11 - Slurry transportation piping system.

4. What are the different sections of ASME code? Where these sections are reffered?

Answer: -

A. ASME section I : - Rules for construction of power boiler.
B. ASME Section II : - Materials.
Part A – Ferrous materials.
Part B – Non-Ferrous materials.
Part C – Specification for electrodes & filler wire.
Part D – Properties.
C. ASME Section IV : - Rules for construction of Heating Boiler.
D. ASME Section V : - Non- destructive Examination.
E. ASME Section VI : - Recommended rules for care & operation of heating boiler.
F. ASME Section VII : - Recommended guidelines for care of power boiler.
H. ASME Section VIII : - Rules for construction of pressure vessels. (Division I & II)
I. ASME Section IX : - Welding & Brazing qualification.

5. Which American standard is reffered for selection of following piping element?
A. Flanges B. Butt Welded fittings C. Gasket D. Socket & Threaded fittings
E. Valves F. Pipes.

Answer: -

A. Flanges :-
I. ASME B16.1 : - Cast iron pipes flanges & flanged fittings.
II. ASME B16.5 : - Carbon steel pipes flanges & flanged fittings. (Up to 24")
III. ASME B16.47 : - Large Diameter steel flanges. (Above 24")

B. Butt welded fittings :-
I. ASME B16.9 : - Steel butt welding fittings.
II. ASME B16.28 : - Butt-welded short radius elbows & returns bends.

C. Gasket :-
I. ASME B16.20 / API -601: - Metallic gaskets for pipe flanges- Spiral wound, Octagonal ring Joint & Jacketed flanges.
II. ASME B16.21 : - Non metallic gasket.

D. Socket & Threaded fittings :
I. ASME B16.11 : - Forged steel socket welding & threaded fittings.

E. Valves :-
I. ASME B16.10 : - Face to face & end to end dimension of valves.
II. ASME B16.34 : - Flanged & butt-welded ends steel valves (Pressure &Temperature ratings) except Ball, Plug & Butter fly Valves.

F. Pipes :-
I. ASME B36.10 : - Welded & Seamless wrought iron pipes.
II. ASME B36.19 : - Stainless steel pipes.

Questions related to Materials: -

1. What is the ASTM code for the following?
A. Pipes :-
I. Carbon Steel II. Alloy Steel III. Stainless Steel IV. Nickel Steel.

B. Tubes: -
I. Carbon Steel II. Alloy Steel III. Stainless Steel IV. Nickel Steel.

C. Wrought Iron Fittings: -
I. Carbon Steel II. Alloy Steel III. Stainless Steel IV. Nickel Steel.

D. Forged Fittings: -
I. Carbon Steel II. Alloy Steel III. Stainless Steel IV. Nickel Steel.

E. Cast Fittings: -
I. Carbon Steel II. Alloy Steel III. Stainless Steel IV. Nickel Steel.
F. Plates: -
I. Carbon Steel II. Alloy Steel III. Stainless Steel IV. Nickel Steel.

Answer: -

A. Pipes:-

I. Carbon Steel : - ASTM A53 Gr. A/B, ASTM A106 Gr. A/B/C, ASTM A333 Gr.1/Gr.6
II. Alloy Steel :- ASTM A335 Gr.P1/P2/P5/P7/P9/P11/P12/P22.
III. Stainless Steel :- ASTM A312TP304/TP304L/TP304H/TP308/TP310/TP316/TP316L/ TP316H/TP317/TP321/TP321H/TP347/TP347H/TP348/TP348H.
IV. Nickel Steel :- ASTM A333Gr.3/ Gr.8.

B. Tubes:-

I.	**Carbon Steel**	**:-**	ASTM A178/179/192, ASTM A334 Gr.1/6.
II.	**Alloy Steel**	**:-**	ASTM A161T1, ASTM A213T1/T2/T5/T7/T9/T11/T12/T22.
III.	**Stainless Steel**	**:-**	ASTM A213 TP304/TP304L/TP304H/TP310/TP316/TP316L/TP316H/ TP317/TP321/TP321H/TP347/TP347H/TP348/TP348H, ASTM A608 HK40.
IV.	**Nickel Steel**	**:-**	ASTM A334Gr.3/Gr.8

C. Wrought Iron fittings :-

I.	**Carbon Steel**	**:-**	ASTM A234Gr.WPA/B, ASTM A420 Gr.WPL6.
II.	**Alloy Steel**	**:-**	ASTM A234 WP1/WP5/WP7/WP9/WP11/WP12/WP22.
III.	**Stainless Steel**	**:-**	ASTM A403 WP304/WP304L/WP304H/WP309/WP310/WP316/ WP316L/WP316H/ WP317/WP321/WP321H/WP347/WP347H/ WP348.
IV.	**Nickel Steel**	**:-**	ASTM A420WPL6/WPL8.

D. Forged Fittings : -

I.	**Carbon Steel**	**:-**	ASTM A181. ASTM A105, ASTM A350 LF1/2.
II.	**Alloy Steel**	**:-**	ASTM A182F1/F2/F5/F7/F9/F11/F12/F22.
III.	**Stainless Steel**	**:-**	ASTM A182F6/F304/F304L/F304H/F310/F316/F316L/F316H/F321/ F321H/F347/F347H/F348.
IV.	**Nickel Steel**	**:-**	ASTM A350 LF3, ASTM A522.

E. Cast Fittings: -

I.	**Carbon Steel**	**:-**	ASTM A216, ASTM A352 LCB/C.
II.	**Alloy Steel**	**:-**	ASTM A217 WC1/WC6/WC9/C5/C12.
III.	**Stainless Steel**	**:-**	ASTM A217 CA15, ASTM A296 CA15, ASTM A351 CF8/CF3/CH20/ CK20/CF 8M/CF 3M/CF 8C/HK40.
IV.	**Nickel Steel**	**:-**	ASTM A352LC3.

E. Plates: -

I.	**Carbon Steel**	**:-**	ASTM A285, ASTM A515, ASTM A516.
II.	**Alloy Steel**	**:-**	ASTM A387 Gr.2/Gr.5/Gr.7/Gr.9/Gr.11/Gr.12/Gr.22.
III.	**Stainless Steel**	**:-**	ASTM A240 TP410/TP405/TP430/TP304/TP304L/TP309/TP310S/ TP316/TP316L/TP317/TP321/TP347/TP348
IV.	**Nickel Steel**	**:-**	ASTM A203 Gr.D/Gr.E, ASTM A353.

2. What is the basic difference between Pipe specification A106 Gr.A / Gr.B/ Gr.C.?

Answer: -

Difference is due to the Carbon content.
% of carbon content in : -
I. ASTM A106 Gr. A – 0.25 %
II. ASTM A106 Gr. B – 0.30 %
II ASTM A106 Gr. C – 0.35 %.

3. What is the difference between pipe specification ASTM A312 TP 304 & ASTM A312 TP304L, ASTM A312 TP 316 & ASTM A312 TP 316L?

Answer: -

Difference is due to the Carbon content. The Letter “L” denotes lower percentage of carbon.
% of carbon content in : -
I. ASTM A312 TP 304 - 0.08 %
II. ASTM A312 TP 304L- 0.035%
III. ASTM A312 TP 316 - 0.08 %
IV. ASTM A312 TP 316L- 0.035%

Questions related to Pipe Fittings: -

1. How can flanges be classified based on Pipe Attachment?

Answer: -

Flanges can be classified based on pipe attachment as: -

Slip – on.	: -	The Slip-on type flanges are attached by welding inside as well as outside. These flanges are of forged construction.
Socket Weld.	: -	The Socket Weld flanges are welded on one side only. These are used for small bore lines only.
Screwed.	: -	The Screwed-on flanges are used on pipe lines where welding cannot be carried out.
Lap Joint.	: -	The Lap Joint flanges are used with stub ends. The stub ends are welded with pipes & flanges are kept loose over the same.
Welding Neck.	: -	The Welding neck flanges are attached by butt welding to the pipe. These are used mainly for critical services where the weld joints need radiographic inspection.
Blind.	: -	The Blind flanges are used to close the ends which need to be reopened.
Reducing.	: -	The reducing flanges are used to connect between larger and smaller sizes without using a reducer. In case of reducing flanges, the thickness of flange should be that of the higher diameter.
Integral.	: -	Integral flanges are those, which are cast along with the piping component or equipment.

2. How can flanges be classified based on Pressure- temperature ratings?

Answer: -

Flanges are classified based on pressure temperature ratings as: -

A. 150 #
B. 300 #
C. 400 #
D. 600 #
E. 900 #
F. 1500 #
G. 2500#

Pressure temperature rating carts in the standard ASME16.5 specify the non-shock working gauge pressure to which the flange can be subjected to at a particular temperature.

3. How can flanges be classified based on facing?

Answer: -

Flanges are classified based on facing as: -

A. Flat face. (FF)
B. Raised face. (R/F)
C. Tongue and groove. (T/G)
D. Male and female. (M/F)
E. Ring type joint. (RTJ)

4. How can flanges be classified based on face finish?

Answer: -

Flanges are classified based on face finish as: -

A. Smooth finish.
B. Serrated finish.

5. Where the smooth finish flange & serrated finish flange finds its use?

Answer: -

The smooth finish flange is provided when metallic gasket is provided and serrated finish flange is provided when non-metallic gasket is provided.

6. What are the types of serrated finish provided on flange face?

Answer: -

A. Concentric or
B. Spiral (Phonographic)

7. How the serration on flanges is specified?

Answer:

The serration on flanges is specified by the number, which is the **Arithmetic Average Rough Height (AARH).**

8. Where the concentric serration is insisted for face finish?

Answer: -

Concentric serration are insisted for face finish where the fluid being carried has very low density and can find leakage path through cavity.

9. How the Gaskets are classified based on the type of construction?

Answer: -

Based on the type of construction, gaskets are classified as: -

A. Full face.
B. Spiral wound metallic.
C. Ring type.
D. Metal jacketed.
E. Inside bolt circle.

10. What is the most commonly used material for Gasket?

Answer: -

Compressed Asbestos Fibre.

11. Which type of gasket is recommended for high temperature & high-pressure application?

Answer: -

Spiral Wound Metallic Gasket.

11. What are the criteria for selection of MOC of Spiral Wound metallic Gasket winding material?

Answer: -

The selection of material of construction for Gasket winding depends upon: -

A. The corrosive nature and concentration of fluid being carried.
B. The operating temperature of the fluid.
C. The relative cost of alternate winding material.

12. What are the most common materials used for spiral wound metallic gasket winding?

Answer: -

The most commonly used material for spiral wound metallic gasket winding is: -

A. Austenitic stainless steel 304 with asbestos filler.
B. Austenitic stainless steel 316 with asbestos filler.
C. Austenitic stainless steel 321 with asbestos filler.

13. Which material is used as filler material for spiral wound gasket in case of high temperature services?

Answer: -

For very high temperature services, graphite filler is used.

14. What is centering ring in connection to spiral wound gasket?

Answer: -

Spiral wound gaskets are provided with carbon steel external ring called centering ring.

15. What will be the AARH finish on flange face for using spiral wound gasket?

Answer: -

125-250 AARH finish.

16. On which type of flanges the use of spiral wound gasket are restricted?

Answer: -

ASME B16.5 does not recommend the use of 150 # rating spiral wound gasket on flanges other than welding neck and lapped joint type.

17. Up to what temperature limits the low strength carbon steel bolts should not be used for flanged joints?

Answer: -

Flanged joints using low strength carbon steel shall not be used above 200°C or below - 28°C.

17. How the pipe fittings are classified based on end connections?

Answer: -

Pipe fittings are classified based on end connection as: -

A. Socket weld fittings.
B. Screwed end fittings.
C. Beveled end or Butt weld fittings.
D. Spigot socket fittings.
E. Buttress end fittings.

18. Up to what temperature the carbon steel materials shall be used?

Answer: -

Carbon steel materials shall be used for temperature up to 425°C.

19. Which material is used for temperature above 426°C?

Answer: -

Alloy steel materials shall be used for temperature above 426°C.

20. Which type of material is used for corrosive fluid?

Answer: -

Stainless steel materials shall be used for corrosive fluid.

21. Which type of piping materials are used for drinking water, instrument air etc?

Answer: -

Galvanized steel materials shall be used for drinking water, instrument air and NI lines (LP).

22. What is the difference between Pipe and Tube?

Answer: -

Pipe is identified by NB and thickness is defined by Schedule whereas Tube is identified by OD & its thickness as BWG (Brimingham wire gauge or 1/100 inch).

23. From which size onwards NB of pipe is equal to OD of Pipe?

Answer: -

From the size 14” and onwards NB = OD of pipe.

24. What should be the radius of long radius elbow?

Answer:

1.5D (Where "D" is the diameter of the pipe.)

25. What should be the radius of short radius elbow?

Answer: -

1D(Where "D" is the diameter of the pipe.)

26. What is the basis of using of short radius & long radius elbow?

Answer: -

Long radius elbow are used for small pressure drop whereas short radius elbow are used for high pressure drops. For catalyst flows vary long radius elbows are used.

27. Normally where do we use the following?

A. Eccentric reducers.
B. Concentric reducers.

Answer:

A. Eccentric reducers = Pump suction to avoid Cavitation, To maintain elevation (BOP) in rack.
B. Concentric reducers = Pump discharge, vertical pipeline etc.

28. Concentric reducer is used in pump suction. (Yes / No). Explain.

Answer:

No. Air pockets may form if concentric reducer is used at pump suction, which results in cavitation and cause damage to Pump. To avoid this problem, Eccentric Reducer with flat side up (FSU) is used in Pump Suction.

29. Where the ERW spiral & longitudinal pipes are used?

Answer: -

Use depends upon the availability of pipes. Nothing functional difference.

30. Where the ERW & Seamless pipes are used?

Answer: -

Above 18" ERW pipes are used. Below 18" seamless pipes are used. Seamless pipes can sustain higher temperature & pressure.

31. What is the main use of ASTM A53 & A106 Gr.B pipes?

Answer: -

ASTM A53 pipes are mainly used for utility services whereas A106 Gr. B pipes are used for high Pressure & high temperature services.

32. From which side of pipe will you take a branch connection?

Answer: -

When fluid is Gas, Air or Steam and Cryogenic Service – Topside.
When Fluid is Liquid – Bottom Side.

33. Why don't we take a branch for Cryogenic Service from bottom side though the fluid is in liquid state?

Answer: -

There is the chance of ice formation during normal operation and since ice flows from the bottom of the pipe it will block the branch pipe connection.

33. Why do we provide High Point Vent (HPV) and Low Point Drain (LPD) in piping?

Answer:

HPV – For removing Air during Hydro-test.
LPD – For draining water after conducting Hydro-test.

34. What do you mean by Jacketed Piping?

Answer: -

Piping which is recognized as providing the most uniform application of heat to the process, as well as maintaining the most uniform processing temperatures where steam tracing is not capable of maintaining the temperature of fluid constant. Usually used for molten sulphur, Polymers service.

35. What is the minimum distance to be maintained between two welds in a pipe?

Answer: -

The thumb rule is that the minimum distance between adjacent butt welds is 1D. If not, it is never closer than 1-1/2". This is supposedly to prevent the overlap of HAZs. Minimum spacing of circumferential welds between centerlines shall not be less than 4 times the pipe wall thickness or 25 mm whichever is greater.

36. What do you mean by IBR and which lines comes under IBR purview?

Answer: -

IBR: Indian Boiler Regulation Act.
Steam lines with conditions listed bellow comes under IBR purview : –

- Lines for which design pressure is 3.5 kg/sq. cm and above.
- Line size above 10” having design pressure 1.0 kg/sq. cm and above.
- Boiler feed water lines to steam generator, condensate lines to steam generator and flash drum.

37. What are Weldolet and Sockolet? And where they are used?

Answer: -

Weldolet and Sockolet are basically self-reinforced fittings.
Weldolet is used for Butt weld branch connection where standard tee is not available due to size restrictions and the piping is of critical / high-pressure service. Sockolet is used for socket welding branch connection, which require reinforcing pad.

38. What is the MOC for Superheated high pressure Steam Lines?

Answer: -

A 335 Gr. P I / P 11, Composition: Cr. – ½ Mo (P1) / 1¼ Cr. – ½ Mo (P11)

39. What is the normal upstream and downstream straight length of orifice flow meter?

Answer: -

Upstream - 15D Downstream - 5D

Questions related to valves: -

1. What is the function of valves?

Answer: -

A. Isolation.
B. Regulation.
C. Non-Return.
D. Special purpose.

2. How the valves are classified based on their function?

Answer: -

A. Isolation.

1. Gate valve.
2. Ball valve
3. Plug valve.
4. Piston valve.
5. Diaphragm Valve.
6. Butterfly valve.
7. Pinch valve.

B. Regulation

1. Globe valve.
2. Needle valve.
3. Butterfly valve.
4. Diaphragm valve.
5. Piston valve.
6. Pinch valve.

C. Non- Return

1. Check valve.

D. Special purpose

1. Multi- Port valve.
2. Flush Bottom valve.
3. Float valve.
4. Foot valve.
5. Line blind valve.
6. Knife Gate valve.

3. How the valves are classified based on its method of operation?

Answer: -

Valves are classified based on its method of operation as: -

A. Self- operated valves.
B. Operated valves.

4. Name the Self – operated & operated valves?

Answer: -

Mainly the check valves are self-operated and all other valve types comes under operated valves.

5. How the valves are classified based on end connection?

Answer: -

Valves are classified based on end connection as: -

A. Screwed ends.
B. Socket ends.
C. Flanged ends.
D. Butt weld ends.
E. Wafer type ends.
F. Buttress ends.

End connection means arrangement of attachment of the valve with the equipment or the piping.

6. What are the types of check valves?

Answer: -

Check valves are divided into two types based on check mechanism as: -

A. Lift check valve.
B. Swing check valve.

7. What do you mean by special purpose valves?

Answer: -

Valves that perform duties other than the two-way isolation, control and check are called special purpose valves.

8. What are Glandless piston valves? Where these are used?

Answer: -

Glandless piston valves are regulating valves used in steam services.

Questions related to Welding/ Weld defects/Post heating/Post weld heat treatment/ Electrode/Filler wire.

1. What do you mean by following type of welding?

A. SMAW B. TIG

Answer: -

A. SMAW : - Shielded Metal Arc Welding.
B. TIG : - Tungsten Inert Gas Welding.

2. Mention the contents of TIG welding set?

Answer: -

A. Torch : Consist of hose for argon gas / welding lead / ceramic nozzle/ collet / tungsten rod as cathode to create arc.
B. Regulator with Pressure Gauge (HP & LP) & flow meter.
C. Argon cylinder – Gr.2 / Gr.1 depending upon requirements of the job.
D. Transformer / Rectifier.
E. Filler wire

3. While welding of pipe trunion to pipe/reinforcement pad you have to put a hole or leave some portion of welding why?

Answer:

For venting of hot gas which may get generated due to welding.

4. What is the thumb rule to calculate Current required for Welding?

Answer:

Current (Amp) = [Diameter of Electrode (mm) X 40] $\pm$ 20

5. What is the minimum thickness of cs pipe that requires stress relieving to be done as per B31.3?

Answer: - 19.05 mm thk.

6. Which is the Electrode & filler wire used for welding of following materials?

A. Alloy steel
I. ASTM A335PI
II. ASTM A335P2
III. ASTM A335P11
IV. ASTM A335P5
V. ASTM A335P9

B. Stainless steel
I. ASTM A312TP304
II. ASTM A312TP304L
III. ASTM A312TP304H
IV. ASTM A312TP308

V. ASTM A312TP310
VI. ASTM A312TP316
VII. ASTM A312TP316L
VIII. ASTM A312TP316H
IX. ASTM A312TP321
X. ASTM A312TP321H

Answer: -

		Covered Electrode	Bare electrode
Alloy Steel			
I.	ASTM A335PI	E7018	E70 S-1B
II.	ASTM A335P2	E8018-B1	---
III.	ASTM A335P11	E8018-B2	ER515
IV.	ASTM A335P5	E502	ER502
V.	ASTM A335P9	E505	ER505
Stainless Steel			
I.	ASTM A312TP304	E308	ER308
II.	ASTM A312TP304L	E308L	ER308L
III.	ASTM A312TP304H	E16-6-2	ER16-8-2
IV.	ASTM A312TP308	E309	ER309
V.	ASTM A312TP310	E310	ER310
VI.	ASTM A312TP316	E316	ER316
VII.	ASTM A312TP316L	E316L	ER316L
VIII.	ASTM A312TP316H	E16-8-2	ER16-18-2
IX.	ASTM A312TP321	E347	ER347
X.	ASTM A312TP321H	E16-6-2	ER16-8-2

7. What are the common welding defects?

Answer: -

A. Lack of penetration.
B. Lack of fusion.
C. Undercut.
D. Slag inclusion.
E. Porosity.
F. Crack.
G. Faulty weld size & profile.
H. Distortion.

A. <u>Lack of penetration</u>.

This defect occurs at the root of the joint when the weld metal fails to reach it or weld metal fails to fuse completely the root faces of the joint. As a result, a void remains at the root zone, which may contain slag inclusions.

Cause: -

A. Use of incorrect size of electrode in relation to the form of joint.
B. Low welding current.
C. Faulty fit-up and inaccurate joint preparation.

B. <u>Lack of fusion</u>.

Lack of fusion is defined as a condition where boundaries of unfused metal exist between the Weld metal & base metal or between the adjacent layers of weld –metals.

Cause: -

A. Presence of scale, dirt, oxide, slag and other non-metallic substance which prevents the weld metal to reach melting temperature.
B. Improper deslagging between the weld pass.

Precaution: -

A. Keep the weld joint free from scale, dirt, oxide, slag and other non- metallic substance.
B. Use adequate welding current.
C. Deslag each weld pass thoroughly.
D. Place weld passes correctly next to each other.

C. Undercut

This defect appears as a continuous or discontinuous groove at the toes of a weld pass and is located on the base metal or in the fusion face of a multipass weld. It occurs prominently on the edge of a fillet weld deposited in the horizontal position.

Cause: -

A. Excessive welding current.
B. Too high speed of arc travel.
C. Wrong electrode angle.

Rectification: -

The defect is rectified by filling the undercut groove with a weld pass. If undercut is deep & contains slag, it should be chipped away before rewelding.

D. Slag Inclusion

Non–metallic particles of comparatively large size entrapped in the weld metal are termed as slag inclusion.

Cause: -

A. Improper cleaning of slag between the deposition of successive passes.
B. Presence of heavy mill scale, loose rust, dirt, grit & other substances present on the surface of base metal.

Precaution: -

A. Clean the slag thoroughly between the weld pass.
B. Keep the joint surface (especially gas cut surface) and bare filler wire perfectly clean.
C. Avoid undercut & gaps between weld pass.
D. Use proper welding consumables.

E. Porosity

The presence of gas pores in a weld caused by entrapment of gas during solidification is termed as porosity. The pores are in the form of small spherical cavities either clustered locally or scattered throughout the weld deposit. Sometimes entrapped gas give rise to a single large cavity called Blowholes.

Cause: -

A. Chemically imperfect welding consumables, for example, deficient in deoxidiser.
B. Faulty composition of base material or electrode, for example, high sulphur content.
C. Presence of oil, grease, moisture and mill scale on the weld surface.
D. Excessive moisture in the electrode coating or submerged-arc flux.
E. Inadequate gas shielding or impure gas in a gas –shielded process.
F. Low welding current or too long an arc.
G. Quick-freezing of weld deposit.

F. Crack

Fracture of the metal is called crack. Two types of cracks: - Cold crack & Hot crack. Cold crack usually occur in HAZ of the base metal when this zone becomes hard and brittle due to rapid cooling after the weld metal has been deposited & sufficient hydrogen has been absorbed by the weld metal from the arc atmosphere.

Precaution: -

A. Use of low carbon equivalent materials.
B. Higher heat input during welding.
C. Preheating.
D. Use of low hydrogen electrode.

G. Faulty weld size and profile

A weld is considered faulty if it has lack of reinforcement, excessive reinforcement or irregular Profile.

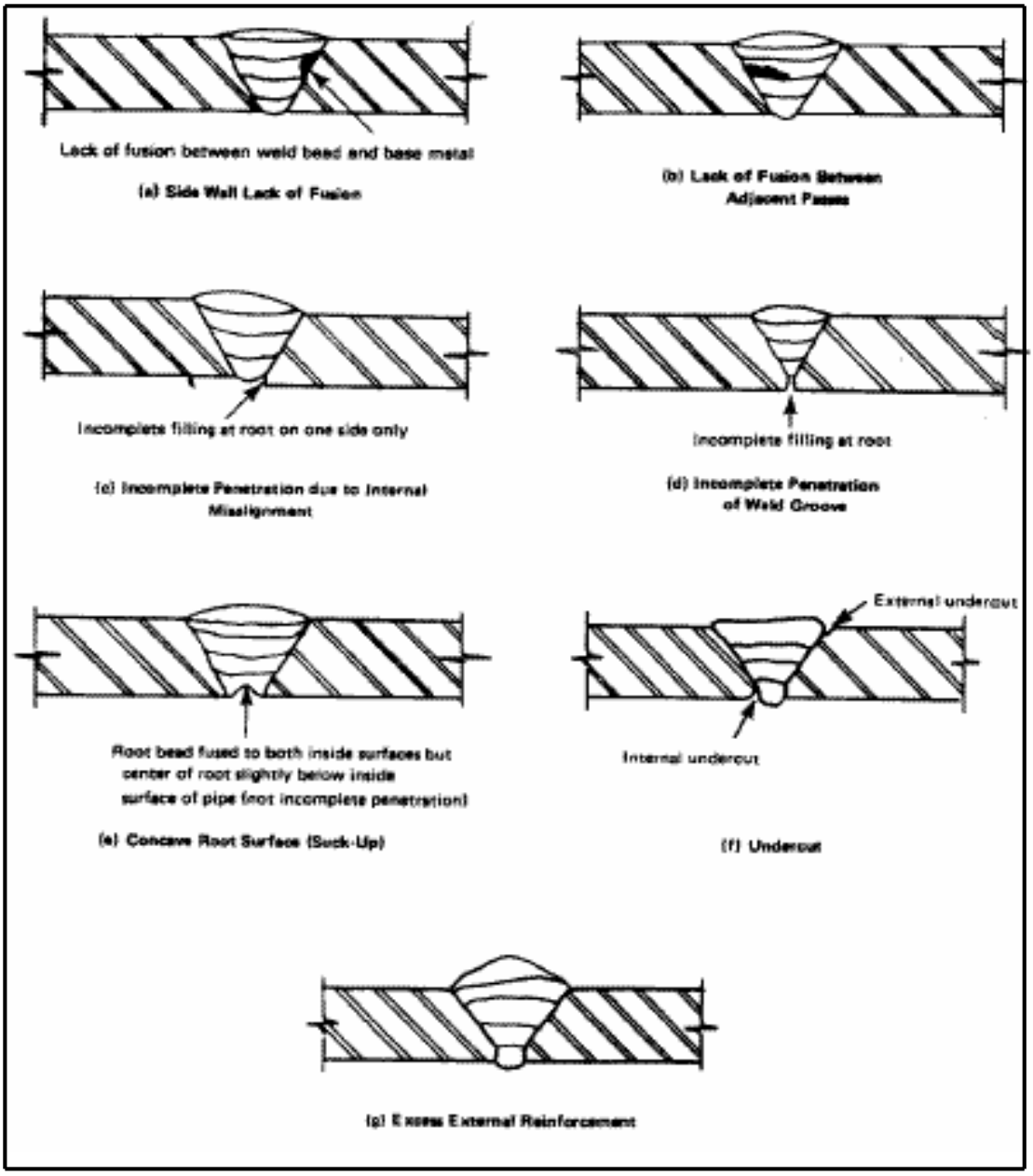
H. Distortion

Because a weldment is locally heated (by most welding processes), the temperature distribution in the weldment is not uniform and changes take place as welding processes. Typically, the weld metal and the base metal heat-affected zone immediately adjacent to it are at a temperature substantially above that of the unaffected base metal. As the molten pool solidifies and shrinks, it begins to exert shrinkage stresses on the surrounding weld metal and heat-affected zone area. When it first solidifies, this weld metal is hot, relatively weak, and can exert little stress. As it cools to ambient temperature, however, the shrinkage of the weld metal exerts increasing stress on the weld area and eventually reaches the yield point of the base metal and the heat-affected zone. Residual stresses in weldments have two major effects. First, they produce distortion, and second, they may be the cause of premature failure in weldments.

Distortion is caused when the heated weld region contracts nonuniformly, causing shrinkage in one part of the weld to exert eccentric forces on the weld cross section.

The distortion may appear in butt joints as both longitudinal and transverse shrinkage or contraction, and as angular change (rotation) when the face of the weld shrinks more than the root.

Distortion in fillet welds is similar to that in butt welds: transverse and longitudinal shrinkage as well as angular distortion results from the unbalanced nature of the stresses in these welds.



8. What is mean by 'PWHT'? Why it is required?

Answer: -

"POST WELD HEAT TREATMENT" This is done to remove residual stress left in the joint which may cause brittle fracture.

9. Why pre-heating is done on some pipe before starting welding?

Answer: -

To slow down the cooling rate.

10. Why post-heating is done on some pipe after the welding is over?

Answer: -

To maintain uniform homogeneous structure.

11. What is the pre-heat temperature for carbon steel above 19.05MM thk.

Answer: -

Pre –heat temperature for carbon steel above 19.05 mm is 80℃.

12. Is post heating required for carbon steel material above 19.05MM thk.

Answer: -

No. Post heating is not required for carbon steel material of any thickness.

13. What is the soaking temperature during stress reliving for carbon steel material?

Answer: -

Soaking temperature for carbon steel material during stress reliving is 620°C. (± 20°C)

14. What is the soaking period during stress reliving for carbon steel material?

Answer: -

Soaking period for carbon steel material during stress reliving is 1hr.

15. What is the rate of heating & cooling during stress reliving for carbon steel material?

Answer: -

The rate of heating & cooling for carbon steel material during stress reliving is 150°c/hr.

16. What is the pre-heat temperature during stress reliving for alloy steel materials?

Answer: -

Pre-heat temperature for AS materials is 180°C.

17. What is the soaking temperature during stress reliving for alloy steel material?

Answer: -

Soaking temperature for alloy steel material is 720°C(± 20°C).

18. What is the soaking period during stress reliving for alloy steel material?

Answer: -

Soaking period for alloy steel material is 2hrs.

19. What is the rate of heating & cooling during stress reliving for alloy steel material?

Answer: -

The rate of heating & cooling for alloy steel material is 100°C/hr.

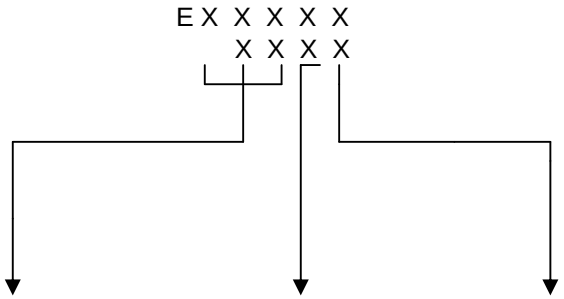
20. What is the post heat temperature for alloy steel material?

Answer: -

Post heat temperature for alloy steel material is 300°C.

21. What is a four or five digit coding for electrode as per AWS classification SFA 5.1?

Answer: -



The minimum UTS of the undiluted weld metal in psi. (UTS – Ultimate tensile strength).

Welding position.

Type of coating and current condition.

22. Where the use of electrode E7018 is recommended?

Answer: -

The use of electrode E7018 is recommended for welding the following: -

A. For high strength steel.
B. For high thickness carbon steel plates.
C. Higher carbon equivalent material.

23. Why the electrode E7018 is called low hydrogen electrode?

Answer: -

The low hydrogen electrodes have in their coating ingredient, which produces carbon di-oxide during melting. This CO_2 gives a gaseous shielding for the metal and prevents atmospheric hydrogen from entering in arc atmosphere. By this way the weld metal has low level of hydrogen.

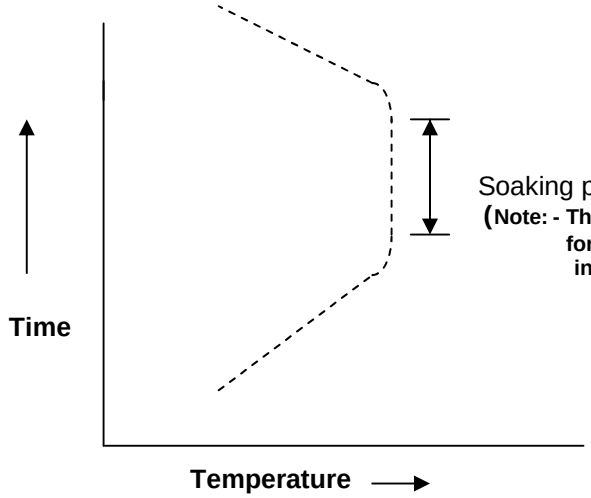
24. What should be the content of chlorine in water while conducting hydrotest for CS & SS pipes?

Answer: -

For CS – 250 PPM.
For SS – 30 PPM.

25. Draw the stress-reliving diagram for carbon steel & Alloy steel material?

Answer: -



Soaking period (1hr. for C.S & 2hrs. for AS)

(Note: - The stress reliving diagram remain same for both AS & CS. The difference is only in soaking temperature.)

26. What is the test positions for fillet & groove welding in case of plate & pipes?

Answer: -

Test positions for Fillet welds: -

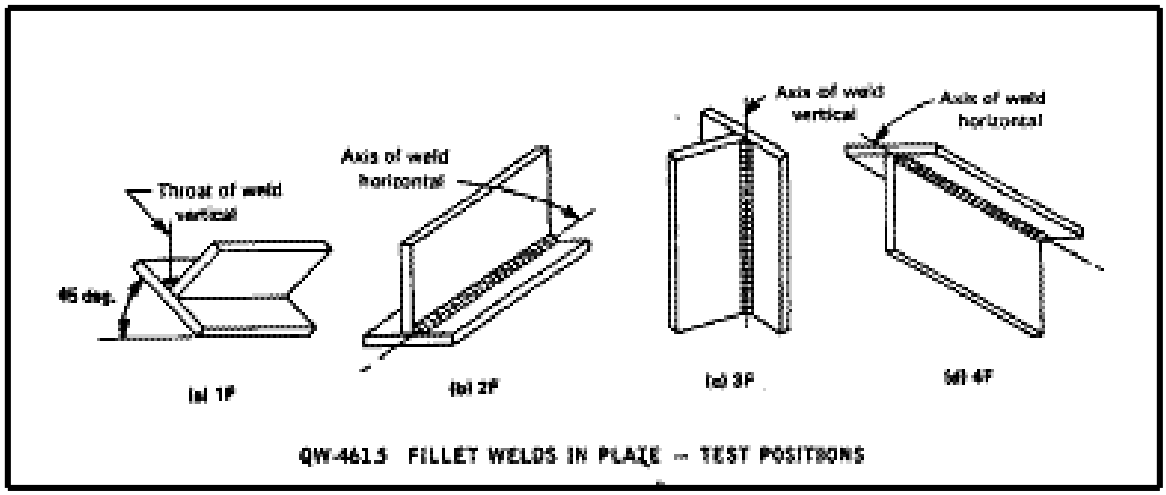
Plate positions: -

A. Flat Position 1F : - Plates so placed that the weld is deposited with its axis horizontal & its throat vertical. Refer sketch (a).

B. Horizontal Position 2F : - Plates so placed that the weld is deposited with its axis horizontal on the upper side of the horizontal surface and against the vertical surface. Refer sketch (b).

C. Vertical Position 3F : - Plates so placed that the weld is deposited with its axis vertical. Refer sketch (c).

D. Overhead Position 4F : - Plates so placed that the weld is deposited with its axis horizontal on the underside of the horizontal surface and against the vertical surface. Refer sketch (d).



QW-461.3 FILLET WELDS IN PLATE – TEST POSITIONS

Pipe positions: -

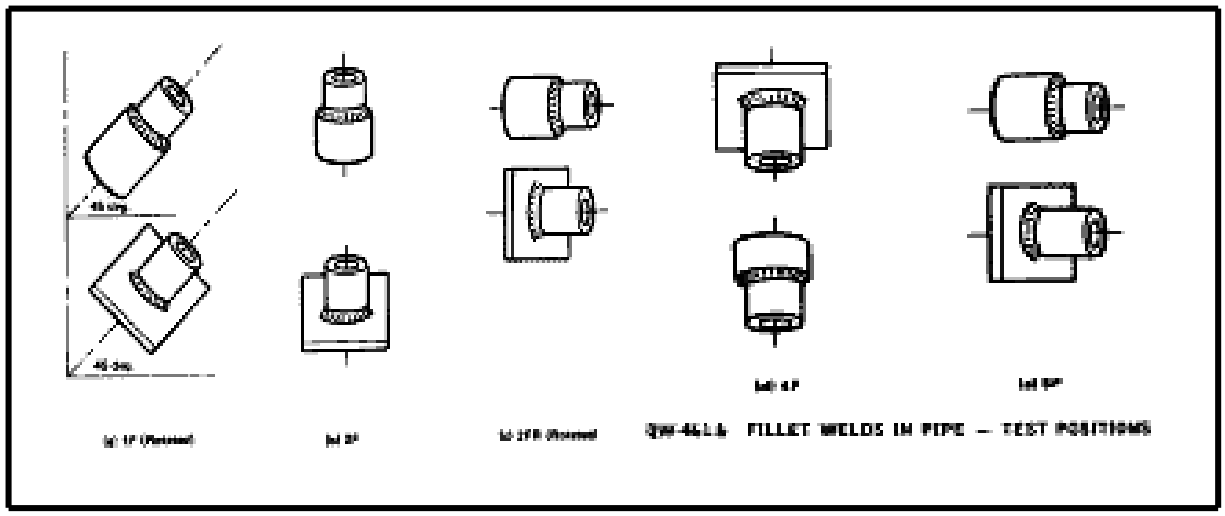
A. Flat Position 1F : - Pipe with its axis inclined at 45° to horizontal and rotated during welding so that the weld metal is deposited from above and at the point of deposition the axis of weld is horizontal and the throat vertical. Refer sketch (a).

B. 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. Refer sketch (b).

C. Horizontal Position 2FR: - Pipe with its axis horizontal and the axis of the deposited weld in the vertical plane. The pipe is rotated during welding. Refer sketch (c).

D. Overhead Position 4F : - Pipe with its axis vertical so that the weld is deposited on the underside of the horizontal surface and against the vertical surface. The axis of the weld will be horizontal and the pipe is not rotated during welding. Refer sketch (d).

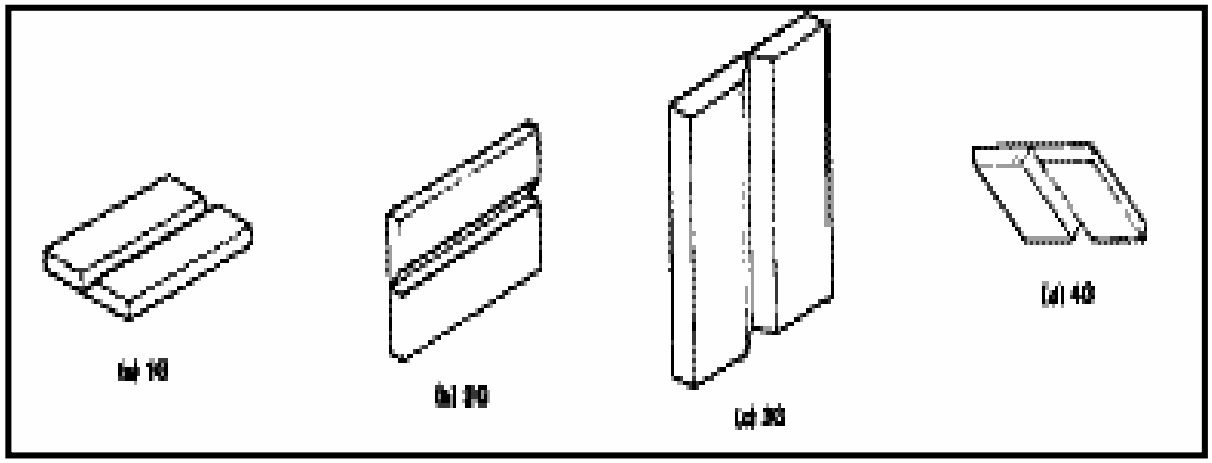
E. Multiple Position 5F : - Pipe with axis horizontal and the axis of the deposited weld in the vertical Plane. The pipe is not to be rotated during welding. Refer sketch (e).



Test positions for Groove welds: -

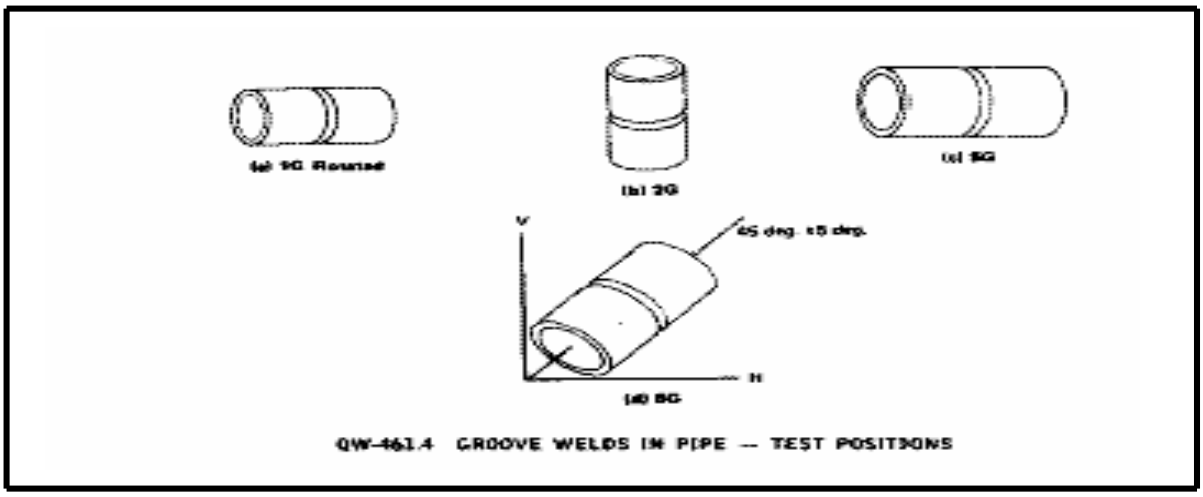
Plate positions: -

A. Flat Position 1G : - Plate in a horizontal plan with the weld metal deposited from above. Refer sketch (a).
B. Horizontal position 2G : - Plate in a vertical plane with the axis of the weld in horizontal. Refer sketch (b).
C. Vertical position 3G : - Plate in vertical plane with the axis of the weld vertical. Refer sketch (c).
D. Overhead Position 4G : - Plate in a horizontal plane with the weld metal deposited from underneath. Refer sketch (d).



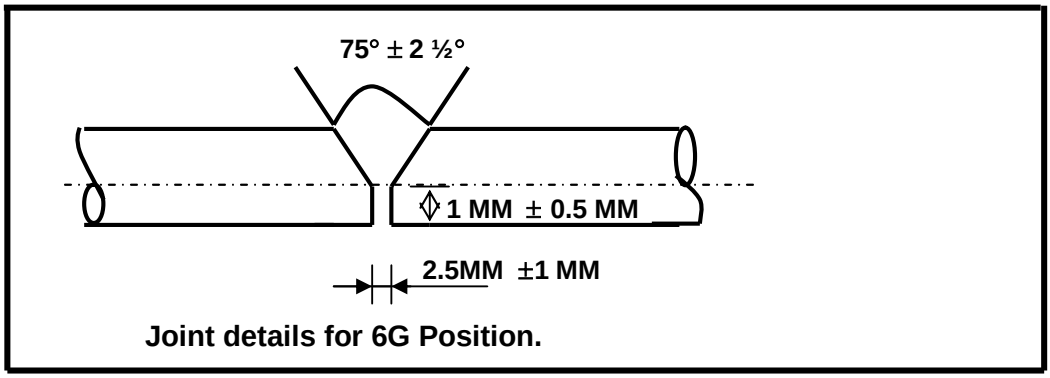
Pipe Positions: -

A. Flat Position 1G : - Pipe with its axis horizontal and rolled during welding so that the weld metal is deposited from above. Refer sketch (a).
B. Horizontal Position 2G : - Pipe with its axis vertical and the axis of weld in a horizontal plane. Pipe shall be not be rotated during welding. Refer sketch (b).
C. Multiple Position 5G : - Pipe with its axis horizontal and the welding groove in vertical plane. Welding shall be done without rotating the pipe. Refer sketch (c).
D. Multiple Position 6G : - Pipe with its axis inclined at 45° to horizontal. Welding shall be done without rotating the pipe. Refer sketch (d).



QW-461.4 GROOVE WELDS IN PIPE — TEST POSITIONS

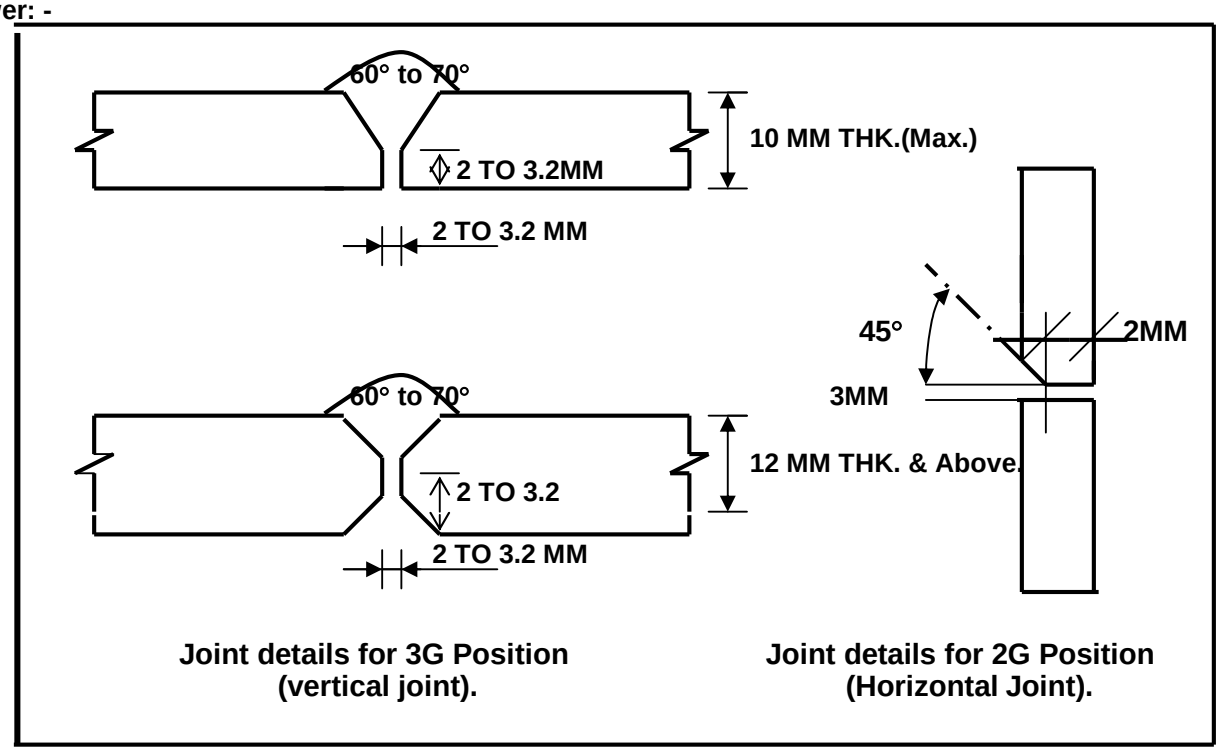
27. Draw the Groove details for 6G position in pipe?



Joint details for 6G Position.

28. Draw the Groove details for 2G & 3G position in case of plates?

Answer: -



Joint details for 3G Position (vertical joint).

Joint details for 2G Position (Horizontal Joint).

29. What is the affect if the quantity of hydrogen induced in weld metal is more?

Answer: -

When hydrogen is more in weld metal, it tends to make the material brittle & subsequently leads to cracking. These cracks are called hydrogen induced cracking or delayed crack. To avoid this the electrode before using is backed at 250°C to 300°C for one hour in mother oven & then cooled down to 100°C in the same oven & finally transferred to portable oven for use where temperature is maintained at 60°to 70°.

Questions related to pipes supports: -

1. What are the Criteria for Pipe Supporting?

Answer: -

Following are the points, which should be taken into account for proper supporting: -

A. Load of bare pipe + fluid + insulation (if any).
B. Load of bare pipe + water fill.
C. Load of valves and online equipment and instrument.
D. Thermal loads during operation.
E. Steam out condition, if applicable.
F. Wind loads for piping at higher elevation, if required.
G. Forced vibration due to pulsating flow.
H. Bare pipe with size above 12" shall be supported with Pad or Shoe.

2. What is the basic span of supports for 2"/6"/10"/24" pipe?

Answer: -

Basic Span is 5.5m / 9m / 11.5m / 15m respectively.

3. What is the function of providing the anchor, cross guide and guide for piping?

Answer: -

Anchor is provided to restrict all the axial and rotational movements of pipe, whereas cross guide is provided to restrict displacements of pipe along with the axis perpendicular to its centerline and Guide is provided to restrict the longitudinal movements of pipes along with its axis.

4. How is piping to Tank inlet nozzle is supported and why?

Answer: -

Piping to Tank Nozzle is supported with spring type support (first support from Nozzle) in order to make the nozzle safe from the loads which occurs due to the displacement of pipe (Displacement may be due to thermal expansion of pipe, tank material, tank settlement etc).

5. What are the types of flexible spring hangers?

Answer: -

1. Constant Spring Hanger 2. Variable Spring Hanger.

6. What is the purpose of providing Graphite Pads in supports below shoes?

Answer: -

To reduce the friction factor. The co-efficient of friction for Graphite Pads is 0.1

7. Where do you provide Anchor and Slotted Support of Heat Exchanger?

Answer: -

Anchor support of Heat exchanger is provided on the side from which Tube bundle will be pulled out for the purpose of maintenance work also it is based on the growth of the connecting piping as exchanger should grow with the piping.

8. What should be the material of shoes for supporting AS pipes & why?

Answer: -

If CS shoes are used then pad in contact with the pipe shall be of Alloy steel to avoid dissimilar welding at pipe. To avoid alloy steel welding and dissimilar welding, fabricated clamps either of CS or SS can be used.

9. What are sway braces?

Answer: -

Sway braces are essentially a double acting spring housed in a canister. Their purpose is to limit the undesirable movement. Undesirable movement means movement caused by wind loading, rapid valve closure, relief valve opening, two phase flow or earthquake.

10. What is the difference between variable spring hanger and constant spring hanger?

Answer: -

Variable spring Hanger: -

As the name itself indicates the resistance of the coil to a load changes during compression.

Constant spring Hanger: -

Constant spring hanger provides constant support force for pipes and equipment subjected to vertical movement due to thermal expansion.

Questions related to Radiography technology: -

1. What are the types of radiation emitted by isotopes?

Answer: -

There are three types of radiation as: -

A. Alpha particle (α- particle).
B. Beta particles (β- particle).
C. Gamma ray (γ - ray).

2. What is the charges on α- particle, β- particle and γ- ray & compare their relative penetration?

Answer: -

Charges on radiation are: -

A. Alpha particle (α- particle) : - Positive charge & less penetrating in comparison to β- particle & γ - Ray. They can be stopped by a thin sheet of paper.
B. Beta particles (β- particle) : - Negative charge & have definite range of penetration. Easily absorbed in the matter.
C. Gamma ray (γ- ray) : - No charge & highly penetrating.

3. Name the isotopes, which emits gamma ray?

Answer: -

Gamma ray source are: -

A. Iridium – 192
B. Cobalt – 60
C. Cesium – 137
D. Thulium – 170

4. Name the gamma ray source used for industrial radiography work?

Answer: -

A. Iridium – 192
B. Cobalt – 60

5. What is the depth of penetration in steel by cobalt – 60, cesium – 137, Iridium – 192 & Thulium – 170.

Answer: -

Penetration in steel by: -
A. Cobalt – 60 : - 9 inch.
B. Cesium –137 : - 3 ½ inch.
C. Iridium – 192 : - 3 inch.
D. Thulium–170 : - ½ inch.

6. What do you mean by photographic Density?

Answer: -

It is the quantitative measurement of film blackness. It is expressed as: -

$D = \text{Log } I_0/I_t$ …. … where, D is density.
I_0 - Light intensity incident on the film.
I_t - Light intensity transmitted through the film.

7. Name the instrument used for measuring density of photographic or radiographic film?

Answer: -
Densitometre is an instrument for measuring the density of photographic and radiographic film.

8. What are the factors on which the density of radiographic film depends?

Answer: -

The density of radiographic films depends upon the following: -
A. Total amount of radiation emitted by X-ray or gamma ray.
B. Amount of radiation reaching the specimen.
C. The amount of radiation passing through the specimen.
D. Intensifying action of the screen if used.

9. How the intensity of source is related with film distance?

Answer: -

Intensity of X-ray or gamma ray varies inversely with the square of the distance from focal spot or source of light. This relation is known as the Inverse square law.
Mathematically, it is expressed as: -

$$\frac{I_1}{I_2} = \frac{D_2^2}{D_1^2}$$

… Where I_1 and I_2 are intensities at the distance D_1 and D_2 respectively.

10. What are the governing factors for exposure from particular radioisotopes?

Answer: -

There are three factors for governing the exposure with a given kilovoltage for X- ray or with the gamma ray from particular radioisotopes.
A. Milliamperage (X-ray) or source strength (for Gamma ray).
B. Focal spot to film distance or source to film distance.
C. Time of exposure.

11. What is the relation between Milliamperage (source strength) and film distance?

Answer: -

The Milliamperage (M) is directly proportional to the square of the focus to film distance (D). The equation is expressed as: -

$$\frac{M_1}{M_2} = \frac{D_1^2}{D_2^2}$$

… Where, M_1 and M_2 are the Milliamperage.

D_1 and D_2 are the distance from focus to film.

12. What is the relation between exposure time & film distance?

Answer: -

The exposure time (T) is directly proportional to the square of the focus to film distances (D). The equation is expressed as :

$$\frac{T_1}{T_2} = \frac{D_1^2}{D_2^2}$$

13. What is the relation between Source strength & exposure time?

Answer: -

The Milliamperage (M) is inversely proportional to the time of exposure (T). The equation is expressed as: -

$$\frac{M_1}{M_2} = \frac{T_2}{T_1} \quad \text{or} \quad M_1 T_1 = M_2 T_2$$

… Where, M_1 and M_2 are the Milliamperage.

T_1 and T_2 are the time of exposure.

Note: The above relation is also called Reciprocity law and is true for direct X-ray or gamma ray with lead screen exposure. The above relation is not quit accurate for exposure to light.

14. How the source strength of radiographic isotopes expressed?

Answer: -

The source strength of radiographic isotopes expressed in terms of Curie.

15. What do you mean by exposure?

Answer: -

It is defined as the quantity of X or gamma radiation that produces in air , ions carrying 1 coulomb (C) of charge (of either sign) per Kg of air. The unit of exposure is C/Kg.

16. What do you mean by Roentgen?

Answer: -

Roentgen is the old unit for exposure. It is defined as the amount of X or gamma radiation which liberates 1e s u of charge of either sign in 1 C. C of air at S T P.

1R = 1e s u / C C of air at STP.

= 2.58×10^4 C/ Kg air.

17. What is Dose equivalent?

Answer: -

Dose Equivalent = Quality factor X absorbed dose.
Quality factor generally considered as:
A. 1 for X, γ or β.
B. 3 for Thermal neutrons.
C. 20 for α- particles.
The unit of dose equivalent is Sievert (SV).
Formerly, the unit of dose equivalent was 1 rem.
1 Sievert = 100rem (Roentgen).

18. What is the function of radiographic screens?

Answer: -

It intensifies the radiographic images on the film.

19. What are the types of radiographic screens generally used?

Answer: -

Types of radiographic screens generally used are: -
A. Lead screen.
B. Fluorescent screen or salt screens.

20. What are the types of Lead screens?

Answer: -
Types of Lead screens are: -
A. Lead foil screen.
B. Lead oxide screen.

21. What do you mean by intensification factor (IF)?

Answer: -

$$\text{Intensification factor} = \frac{\text{Exposure time required to produce required film density without screen.}}{\text{Exposure time for same density using screen.}}$$

In the above definition it is assumed that same film and radiation source used for the both the exposure.

22. What are the factors upon which the intensification factor depends?
Answer: -
Intensification factor due to metallic screens depends on the following: -
A. Metal of foil.
B. Thickness of foil.
C. Energy of radiation.
D. Specimen thickness.

23. How the intensification factor depends on metal of foil?

Answer: -

For a given radiation source, the number of electrons produced depends on the nature of the metal foil. Intensification factor increases with atomic number of the metal. For gamma ray radiography generally Lead screen are used.

24. How the intensification factor depends on thickness of foil?

Answer: -

The intensification factor increases with the increase in the thickness of the foil. Intensification increases maximum corresponding to the range of photoelectron in that metal. After further increase it remains practically constant. If the thickness further increased, greater number of gamma photons will be attenuated and this will reduce the produce of photoelectrons.

25. How the intensification factor depends on energy of radiation?

Answer: -

More is the energy of radiation, more is the intensifying action.

26. How the intensification factor depends on thickness of the specimen?

Answer: -

A specimen placed in between the source and film performs following two functions: -

A. It filters the primary radiation.
B. Gives low energy scattered radiation.

The radiographic screen can have different sensitivities for primary radiation and the radiation given by the above two effects. Hence the change in intensification factor with object thickness is expected. The intensification of low energy scattered radiation is more than the intensification of high energy filtered radiation.

27. Where the fluorescent screen finds its use?

Answer: -

The fluorescent screens are widely used for medical purpose to reduce the exposure time.

28. What are the main constituents of a radiographic film?

Answer: -

The radiographic films consist of the following: -

A. Base material.
B. Subbing layer.
C. Emulsion and
D. Protective layer/ Super coat.

29. What is the different base material tried so far for radiographic film?

Answer: -

The materials so far tried for base is: -

A. Glass.
B. Cellulose Nitrate.
C. Cellulose Acetate.
D. Cellulose Triacetate.
E. Polyester (Most suitable material to be used as base material).

30. What is the function of Subbing material, Emulsion & protective layer in radiographic film?

Answer: -

Subbing material	**: -**	It provides the sticky action to the emulsion, as the emulsion does not adhere directly on the base material.
Emulsion	**: -**	It contains silver bromide gelatin (Generally animal bone marrow)
Protective Layer	**: -**	It is coated on emulsion in order to protect the same from physical damage, abrasion and stress mark.

31. How the Radiographic films are classified?

Answer: -

The Radiographic films are classified as: -

A. Class – I : - Highest contrast, Lowest speed.
B. Class – II : - High contrast, Low speed.
C. Class – III : - Medium contrast, Medium speed.
D. Class – IV : - Low contrast, High speed.

32. What is the basis of classification of radiographic film?

Answer: -

Classification of Radiographic film is done on the basis of grain size of Silver Bromide (Silver Bromide Crystals). Finer the grain size of Silver Bromide in emulsion, slower will be the speed. Generally used crystal size is 0.22, 0.52, 0.68, 0.80 and 1 micron.

33. What is speed with reference to Radiography film?

Answer: -

It can be defined as the density records on the film resulting from a given exposure. It is inverse of exposure required to produce on radiograph of particular density under the specified conditions. A film requires less exposure to achieve particular density is called fast film and more exposure called slow film.

34. What type of film is generally used for Radiography?

Answer: -

Class – III type (D5,D7 – Agfa make) film is generally used for radiography.

35. What type of film is not used for industrial purpose (Used for Medical purpose)?

Answer: -

Class – IV type (D10 – Agfa make) film is not used for industrial purpose.

36. What do you mean by film processing?

Answer: -

When the film is exposed to the radiation, creates latent image or invisible image by converting the silver bromide present in the emulsion into metallic silver. The exposed film when processed converts latent image into visible image.

37. What are the main steps in film processing?

Answer: -

Main steps in film processing are: -

A. Developing
B. Stop bath.
C. Fixture.
D. Washing
E. Drying.

38. What are the ingredients of Developer?

Answer: -

A. Developing Agent : - Metol, Hydroquinone and Pencilone.
B. Accelerator : - Sodium carbonate.
C. Restrainer : - Potassium Bromate.
D. Preservative : - Sodium Sulphate.

39. What is the function of Accelerator present in Developer?

Answer: -

It encourages the developer to supply more electrons.

40. What is the function of Restrainer present in Developer?

Answer: -

It opposes to reduce the unexposed silver bromide. It acts as antifogging agent.

41. What is the function of Preservative present in Developer?

Answer: -

It prevents oxidation.

42. What is the affect of temperature on Developer?

Answer: -

The Developer supplies more electrons at high temperature and reduces the developing time. Opposite is the case when the temperature is lower.

43. What is the ideal developing temperature?

Answer: -

Below 18°C and above 24°C, developing is not recommended.

44. What is the developing time generally recommended?

Answer: -

5 to 8 minutes. Larger developing time increases the fog density. The developing time below 3 minutes is not recommended as the required density shall not be achieved and may miss minor discontinuities.

45. What is the ingredient of Stop Bath?

Answer: -

2% Acetic Acid.

46. What is the function of Stop Bath?

Answer: -

Stops the Developing action by neutralising the alkaline developer.

47. What are the ingredients of Fixer?

Answer: -

Fixing Agent A. Sodium thiosulphate commonly known as Hypo. Commonly used fixing agent.
B. Ammonium thiosulphate. Used as rapid fixing agent.

48. What is the function of Fixer?

Answer: -

It removes all unexposed silver grains and clouded film starts to become clear.

49. What is the recommended time for Fixer?

Answer: -

General recommendation is 5 to 15 minutes.

50. What is Radiographic sensitivity?

Answer: -

It is the combination of Radiographic contrast and Radiographic definition. The Radiographic sensitivity is judged by Image quality Indicator (IQI), also known as penetrametre. Judging the qualitative & quantitative quality of radiograph, a penetrametre is required. The image of IQI on the radiograph is the evidence that the radiographic inspection was conducted under proper condition and achieved the required sensitivity.

$$\% \text{ Sensitivity} = \frac{\text{Minimum visible wire diameter.}}{\text{Thickness of the job.}} \times 100$$

51. What is the general requirement of Radiographic Sensitivity?

Answer: -

General requirement of Radiographic sensitivity are: -

> 2% (Less then two percent) – Good.

< 2% (More ten two percent) – Not acceptable.

52. What are the commonly used IQI?

Answer: -

Commonly used IQI are: -

A. Wire type Penetrametre.
B. Plate type Penetrametre.
C. Step type Penetrametre.
D. Step- Hole type Penetrametre.

53. What are the criteria for selection of IQI or Penetrametre?

Answer: -

Penetrametre should be made of same material as that of the specimen.

The selection of IQI should be made as: -

A. For carbon Steel & Low Alloy Steel	: -	Carbon Steel IQI.
B. For High Alloy Steel & Stainless Steel	: -	Stainless Steel IQI.
C. For Aluminum & Aluminum Alloy	: -	Aluminum IQI.
D. Copper & copper Alloy	: -	Copper IQI.

54. Name some IQI?

Answer: -

Wire types IQI : - 1-ISO-7, 6-ISO-12,10-ISO-16

55. What do you mean by Radiographic contrast?

Answer: -

Density difference between the two adjacent areas of the radiograph is known as contrast.

Radiographic contrast is the combined effect of the following.

A. Subject contrast.
B. Film contrast.

56. What is subject contrast?

Answer: -

The factor of the specimen, which affects the contrast, is known as subject contrast.

57. What is film contrast?

Answer: -

The factor of the film, which affects the contrast, is known as Film contrast.

58. What are the factors, which affects subject contrast?

Answer: -

Subject contrast affected by: -

A. Thickness difference in the specimen.
   Uniform thickness of the specimen shows no contrast but thickness difference in the specimen sows good contrast.
B. Radiation Quality.
   Best contrast is achieved by ray of suitable low kilovoltage (Soft Radiation). By increasing the kilovoltage (Harder Radiation) penetration will increase but decrease the subject contrast.
C. Scattered Radiation.
   By reducing the scattered radiation (internal, side and back scatters) using diaphragm, masks, Filters, and lead screens increase the subject contrast.

59. What are the factors, which affects the film contrast?

Answer: -

Film contrast affected by: -

A. Type of film.
Grain size of the film controls the film contrast. Finer the grains (lower speed) of the film higher the film contrast.

B. Film processing.
Increasing the developing time increases the density as well as fog density and decreases the film contrast. Processing of film in fresh developer gives higher contrast then the exhausted developer.

C. Film Density.
At higher film density, the film contrasts is more and at low density the film contrast is less.

60. Where the IQI (Penetrametre) is placed?

Answer: -

The IQI or penetrametre should be placed as possible on the source side of the radiation. When it is not possible as in case of double wall single image radiography, it can be placed on the film side with a lead letter ' F ' near the IQI. The IQI should be placed in most unfavourable location with respect to the radiation beam.

61. What are the different types of Radiography or Exposure technique?

Answer: -

Different types of Radiography techniques are: -

A. Single wall single image (Panoramic Exposure).
B. Double wall single image.
C. Double wall double image.

Question related to Equipment and piping Layout: -

1. What are the steps involve in Plant design?

Answer: -

The mechanical design and development of the plant has three major steps as: -

A. Conceptual layout design.
B. Equipment layout design.
C. Piping layout design.

2. What is conceptual layout design?

Answer: -

It is the part of basic engineering package. It consists of following information: -

A. Essential process design requirement such as horizontal & vertical relationship of equipment.
B. Space allocation for basic plant requirement (space required for laboratories, office, storage etc.)
C. Planning for control room, motor control center room etc.

3. What is Equipment layout design?

Answer: -

It is the detailing of conceptual layout. It is the basic document of mechanical engineering design or in other words this document is the basis for development of construction drawing by all disciplines. It is sometimes also referred as plot plan for large outdoor plant.

It consists of following information: -

A. Floor space needed for the equipment and other facilities are shown.
B. Access, removal space, cleaning area, storage space and handling facilities are outlined.

4. What are the essential data/ documents required for preparation of equipment layout?

Answer: -

The essential data or documents required for preparation of equipment layout is as: -

A. Process flow diagrams (PFD) and Piping & instrument Diagrams (P& ID).

PFD/ P& ID indicates the interconnectivity of each equipment, information regarding solid handling, gravity feed, line slopes, loop sizes, venting requirement, special piping materials etc. which in turns governs the equipment location to a great extent.

B. Project design data.

This consists of following information as: -

- ❖ Geographic location, proximity to roads and railway, topography and local codes and regulations, weather conditions such as rainfall records, seasonal temperature differences, wind direction, outlet points for drains etc.
- ❖ The above information such as wind direction influences the location of cooling towers, furnaces, stacks etc. Similarly, the information regarding outlet drain points affects the design of storm water drains and requirements of enclosures.

C. Equipment sizes and Building.

This includes fabricated equipment such as vessels, Heat Exchangers, Reactors, Tanks and proprietary equipment like pumps, Compressors, Furnaces etc. For locating the above, the equipment is grouped to have optimum location for minimum pipe run as well as fallow the process flow sequence.

5. What are the two basic configurations for the equipment layout (unit plot plan)?

Answer: -

The equipment layout can basically be divided into two configurations:

A. The Grade Mounted Horizontal arrangement as seen in the refineries and petrochemical plants.

B. The vertical Arrangement as seen in many chemical process industries.

6. What is Grade mounted Horizontal Arrangement of equipment layout?

Answer: -

In the Grade mounted Horizontal Arrangement, the equipment is placed on the either side of the central pipe rack with auxiliary roads. Advantage of this arrangement is that the equipment is located at grade level, which makes it easier to construct, operate and maintain. Disadvantage is that it takes lot of ground area.

7. What is Vertical arrangement of equipment layout?

Answer: -

The structure mounted vertical arrangement has equipment located at multilevel in steel or concrete structure. This could be indoor or outdoor. Advantage is of small coverage area and ability to house the facility to suit process requirement or climate conditions.

8. What are the basic principles of locating the Equipment irrespect of the type of arrangement?

Answer: -

The certain basic principles to be followed while locating the equipment is as: -

A. Economic piping :

In order to minimize the cost of piping, the equipment should be located in process sequence and close enough to suit safety needs, access requirements and flexibility. The equipments are identified which forms the subsystem within the unit. The component within the subsystem to be arranged to have most economical piping and the whole subsystem to be arranged within the unit to have most economic interconnection.

B. Process Requirement:

The equipment layout should support requirement like minimum pressure drop, gravity feed and loop.

C. Common operation:

The equipment that requires common maintenance facilities, common utility and continuos operator attention shall be located the same area.

D. Underground Facilities:

Before deciding the equipment location, the facilities such as storm water drain, effluent drain, fire water, cooling water to be placed underground.

9. What is Line Routing Diagram?

Answer: -

A line routing diagram is a schematic representation of all process and utility-piping system drawn on a copy of plot plan. This diagram does not show the exact locations, elevations or interference but it locates the most congested area.

10. How do you calculate the width of Pipe rack?

Answer: -

W = (f X n X s) + A + B.

…Where, **f** **:** Safety Factor
= 1.5 if pipes are counted from PFD.
= 1.2 if pipes are counted from P&ID.

n **:** number of lines in the densest area up to size 450NB.
= 300 mm (Estimated average spacing)
= 225 mm (if lines are smaller than 250 NB)

A **:** Additional Width for: –
. : Lines larger than 450 NB.
: For instrument cable tray / duct.
: For Electrical cable tray.

s **:** 300 mm (estimated average spacing)
: 225 mm (if lines are smaller than 250 NB)

B **:** future provision
= 20% of (f X n X s) + A

11. Up to what limit the width of pipe Rack is restricted? What type of arrangement shall be done if the width of rack calculated is more then the restricted limited?

Answer: -

Normally pipe Rack width is limited to 6.00 Mtrs. If the width of rack calculated is more then the arrangement shall be done in multiple layers. The arrangements adopted are: -

A. Single column Rack 'T' type.
B. Double column Rack with a single tier.
C. Double column Rack with a double tier.

12. How much space is kept in between column of pipe rack?

Answer: -

Normally, 5 to 6 Mtrs. spacing is kept in between the column of pipe rack.

13. At which location the wide spacing (spacing more than the normal) in between the column is necessary?

Answer: -

Wide spacing is necessary at road crossing or where loading or access space is needed.

14. How much Headroom clearance is required under the following type of crossing?

A. Structures/ pipe lines inside operating area.
B. From top of the Rail.
C. Above crest of road for crane movement.
D. Above crest of road for Truck movement.
E. Above crest of road between process units.

Answer: -

The Headroom normally provided is as: -

A. Structures/ pipe lines inside operating area.	:	2200
B. From top of the Rail.	:	7000
C. Above crest of road for crane movement.	:	7000
D. Above crest of road for Truck movement**.**	:	6000
E. Above crest of road between process units.	:	4500

15. What sort of drawing/ layout is required for piping layout?

Answer: -

The following Drawing/ Layout are required for piping layout.

A. Piping & instrumentation Diagram (P& ID).
B. Equipment Layout.
C. Piping Specification.
D. Equipment Drawing.
E. Vendor Requirement for proprietary equipment.

16. What care shall be taken while routing piping for instruments?

Answer: -

Following points shall be taken care of while routing piping for instruments.

A. Flow measuring instrument needs certain straight length on upstream & downstream of the instruments. Normally, 15D on the upstream and 5D on the downstream is kept.

B. The pipe line in which flow meters such as magnetic flow meters, vortex meters, turbinemeters etc are located shall be routed in such a way that the line must be filled with liquid all the time. The pipe line shall be supported with robust support on both side of the meter.

C. Control valves are located at grade e.g. at about 500mm height from finished ground to provide convenient access for operation and maintenance. Block and bypass valve shall be located to have easy operation/ access from the grade. Locating control valve on the vertical line shall be avoided.

D. Isolation valves for level gauges and pressure gauges shall be made accessible. All primary and secondary indicators of pressure, temperature, flow, level, positioners etc shall be visible from the operating area.

E. Rotameter shall be placed on vertical line and the inlet shall be from the bottom of the instrument.

Question Related to Mechanical Design Fundamentals:-

1. What are the Failures with reference to the structural design?

Answer:-

Failure of a structural part can occur by:-

A. Excessive elastic deformation.

B. Excessive non-elastic deformation.

C. Fracture.

Any design has to guard against these perceived failures.

2. What are the factors upon which the mechanical properties of material are dependent?

Answer:-

Mechanical properties of any material of construction are dependent on:-

A. Chemical composition of the material.

B. Method by which the material is manufactured.

3. What is stress?

Answer:-

It is defined as the applied load per unit cross-section of the specimen. The common unit are psi (pound per square inch), kpa, Mpa, kg/cm^2.

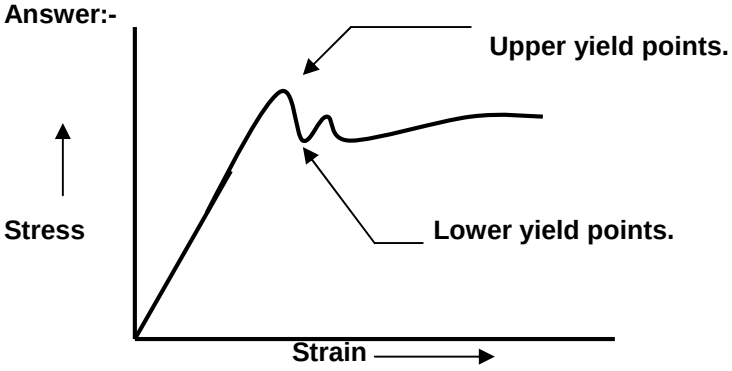
3. What is strain?

Answer:-

For tensile load, it is the ratio of increase in length of the specimen under constant sustained load to the original length of the specimen before the load is applied. For compressive load, it the ratio of decrease in length to the original length under sustained load. Strain is thus an observable and measurable quantity as the extension or compression of the specimen can be directly measured. It is a dimensionless quantity.

4. Draw the Stress- Strain curve showing the behavior of the specimen under stress?

Answer:-



When there is no load, there are no stresses and no strain. When a small tensile load is applied, the strain can be measured and stress derived. If the load is removed, the specimen returns to its original shape. That is there is no residual or permanent strain in the specimen. This situation continues up to a certain level of stress. A stress strain curve in this region is a straight line i.e. stress is proportional to strain. This region of curve is called the elastic region, as the MOC;s behavior is elastic like a rubber.

As the tensile load during the test is increased further, a situation arises when the specimen does not return to the original dimension even when the load is withdrawn. This is also the level or stress level at which the stress strain curve begins to deviate from the elastic straight- line behavior as shown in the graph. Thus, the metal / specimen are undergoing plastic deformation in addition to elastic deformation. When the load is withdrawn, the elastic deformation is recovered but the plastic deformation stays.

5. What is upper yield point with reference to above stress-strain Graph (Ultimate Tensile Strength)?

Answer:-

The highest stress that the metal can withstand under sustained load without continuing to elongate under same load is called the upper yield point.

6. What is lower yield point with reference to above stress- strain Graph?

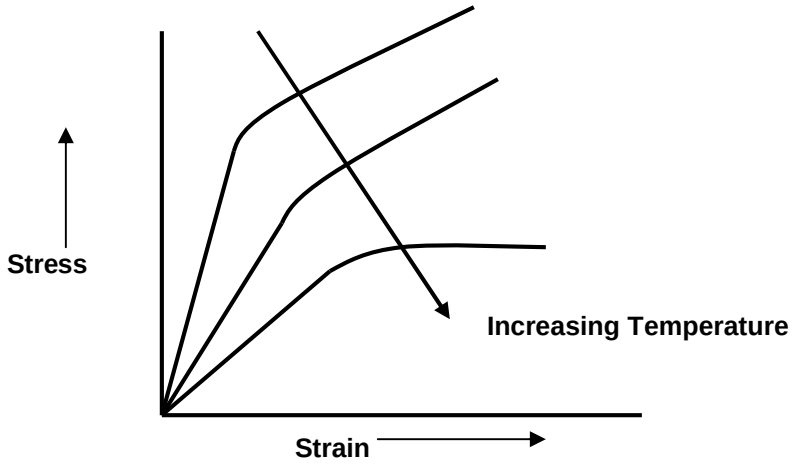
Answer:-

7. What is the effect on the specimen when subjected to a sustained load with higher temperatures?

Answer:-

As the temperature of the test increases, specimen of the same material would elongate more for the same load as compared to specimen tested at lower temperature. It means that the material becomes softer as it is subjected to higher and higher temperatures.

Stress-strain curves are different for different materials and at different temperatures for the same materials.



Stress- strain curves at different Temperatures.

8. What is Allowable Stress?

Answer:-

It is defined as ultimate tensile strength divided by factor of safety. The safety factor is obviously greater than 1. Design which ensure that the stress value anywhere in the structure is less than this allowable stress are considered safe as they do not allow the structure element to come anywhere close to the point where plastic instability leading to disruption or disintegration of element would set in.

9. What is the value of allowable stress if yield stress or 0.2% proof stress value is available at design temperature?

Answer:-

If the yield stress or 0.2% proof stress value is available at design temperature, the same shall be divided by a safety factor of 1.5 to get allowable stress.

10. What is the value of allowable stress if the yield stress is not available at design temperature but is available at room temperature?

Answer:-

If the yield stress is not available at design temperature but is available at room temperature, the same shall be divided by safety factor of 3.0 to get allowable stress.

11. What is the value of allowable stress if the stress value for rupture due to static fatigue or creep failure is available at design temperature?

Answer:-

If the stress value for rupture due to static fatigue or creep failure is available at design temperature, the same shall be divided by safety factor of 1.5 to get allowable stress.

Note: The safety factor considered above is recommended for carbon steel and low alloy steel.

12. How much design temperature shall be considered for the structural parts which are heated by steam, thermic fluid etc?

Answer:-

Design temperature shall be the highest expected temperature of the heating media or highest expected body part temperature plus 10° C. Here, 10° C is the safety margin.

13. What shall be the safety margin (temperature related) considered for fired vessel parts which are shielded (by Refractory) and the parts which are unshielded?

Answer:-

Safety margin for shielded parts : 20°C.
Safety margin for unshielded parts : 50°C.

Note: The above safety margins are just guidelines. What should be the safety margin would depends upon the severity of operation

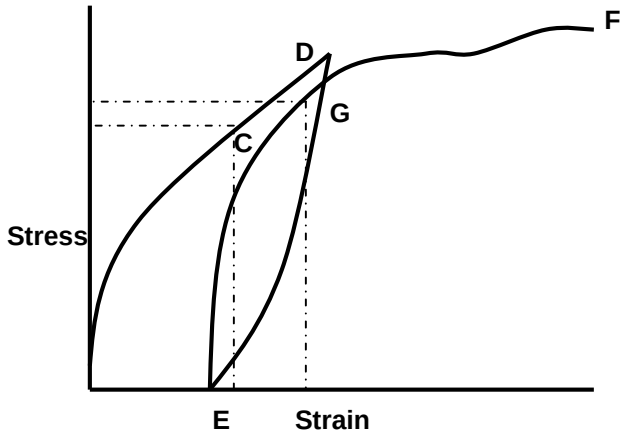
14. Define Proof Stress?

Answer:-

It is also called 0.2% proof stress. It is the stress for 0.2% strain. In simpler terms, it is the stress value for strain value of 0.002 on the stress strain curve.

15. How the proof stress in a material is altered (increased marginally)?

Answer:-



Increase in proof stress due to cold work.

Consider a stress strain curve as shown above. Let a fresh specimen be subjected to gradually increasing tensile loads. A 0.2% proof stress can be marked on the curve as the stress value corresponding to point C on the curve. Let the load be increased beyond this point up to point D on

the curve. The specimen has surely passed the elastic range and crossed over to plastic deformation. On withdrawal of the load, the specimen would return back to point E with a residual permanent strain as shown above. Tensile load test can now be conducted on this specimen which has seen plastic deformation or cold work previously. The specimen would now follow a stress- strain curve with strain zero at point E. Along this stress strain curve (EGF), 0.2% proof stress corresponds to point G which is higher than the proof stress for the fresh specimen.

The material in the above case seems to have hardened with its experience of stress earlier. Most material shows this marginal increase in their proof stress due to cold work.

16. What are the types of failures encountered in Piping?

Answer: -

1. Catastrophic Failure. **2**. Fatigue Failure.

17. Define catastrophic failure?

Answer:-

The failures which occurs suddenly as soon as the load crosses the threshold (Ultimate tensile strength). These failures take place on the first occurrence of the loads in excess of yield stress.

18. What is fatigue failure?

Answer:-

The failure which occurs due to damaging of the grain structure of the specimen subjected to prolonged application of sustained load and or tensile –compressive load cycle.

18. What are the types of Fatigue failure?

Answer:-

Types of fatigue failure are:-

A. Static Fatigue.
B. Cyclic Fatigue.

19. What is Static Fatigue?

Answer:-

The specimen which fails under sustained load subjected to considerable length of time. The total time for which the load was applied is important. Whether it is applied continuously or in installments is not important.

20. What is cyclic fatigue?

Answer:-

The specimen which fails under a load cycle subjected to considerable numbers of times. The total numbers of cycles for which the load was applied is important. Whether the cycle was frequent or infrequent is not important.

21. Explain the failure of the specimen subjected to cyclic load?

Answer:-

Consider a specimen subjected to a tensile load increasing from zero to X and then this load is gradually withdrawn till it is zero. Now compressive load applied gradually till it is X and then it is drawn till the load is zero. This comprises a cycle and is repeated again and again. With each cycle, the grains in the material get displaced relative to each other and get more and more interlocked. With each cycle, the material loses its ductility in small increments. A time comes when the grains are so badly interlocked that they cannot allow deformation to withstand load and a small crack develops. This crack grows with further cycles and failure occurs.

22. What is creep failure?

Answer:-

Occurrence of static fatigue failure when the material is under prolonged sustained load coupled with high temperature is called creep failure.

23. Write the sequence of stress values at failures for solid rod, sphere and cylinders?

Answer:-

A typical sequence of stress values at failure for solid rods and two most important shapes in process industry namely, sphere and cylinder is Rod > Sphere > Cylinder.

Questions Related to pipe under stress:-

1. What are Primary loads? Mention some of Primary Loads?

Answer:-

These are typically steady or sustained types of loads. These loads have their origin in some force acting on the pipe causing tension, compression, torsion etc leading to normal and shear stress. Primary loads are not self limiting. Some of the primary loads are as:-

A. Internal fluid pressure
B. External pressure.
C. Gravitational forces acting on the pipe such as weight of the pipe & fluid.
D. Forces due to relief or blow down.
E. Pressure waves generated due to water hammer effects.

2. What do you mean by self limiting?

Answer:-

It means that the stresses continue to exist as long as long the load persists and deformation does not stop because the system has deformed into a no-stress condition but because strain hardening has come into play.

3. What are secondary loads? Mention some of the secondary loads?

Answer:-

Secondary loads are caused by displacement of some kind. Some of the secondary loads are as:-

A. Force on piping due to tank settlement.
B. Vessel nozzle moving up due to expansion of vessel.
C. Pipe expansion or contraction.
D. Vibration due to rotational equipment.

4. What is the most used choice of co-ordinate system for defining the stresses?

Answer: -

In a pipe subjected to internal pressure or any other load, the most used choice of co-ordinate system is as:

A. Axial or Longitudinal direction.
B. Circumferential or Hoope's direction.
C. Radial direction.

The stresses in the pipe wall are expressed as axial(S_L), Hoope's (S_H) and Radial (S_R).These stresses which stretch or compress a grain/ crystal are called normal stress because they are normal to the surface of the crystal.

5. What do you mean by Hoop Stresses and how do you calculate it?

Answer: -

Stresses which are generated circumferentially due to the action of Internal pressure of pipe are called Hoop Stress. It is calculated by; -

Hoop Stress (S_h) $= Pd_o / 2t$
Where P = Force Acting from Inside.
d_o = OD of Pipe.
t = Pipe Thickness.

6. How does Hoop Stress affect the system?

Answer: -

As per membrane theory for pressure design of cylinders, as long as hoop stress is less than yield stress of Moc, the design is safe. Hoop stress induced by thermal pressure is twice the axial stress (SL). This is widely used for pressure thickness calculation for pressure vessel.

7. What are the other stresses against which the design of piping is safe guarded?

Answer:-

A. Principal stress.
B. Shear stress.

Apart from the stress which is normal to the surface of the crystal as mentioned in question No. 4, the grains would have been oriented in the pipe wall in all possible orientations. The above stresses (Axial, Circumferential and Radial stress) have stress component in direction normal to faces of randomly oriented crystal. Each crystal thus faces normal stresses. One of these orientations must be such that it maximizes one of the normal stresses. Normal stresses for such orientation (maximum normal stress orientation) are called principal stresses and are designated as S_1 (maximum), S_2 and S_3 (minimum).

Principal stresses are way of defining the worst case scenario as far as the normal stresses are concerned.

In addition to the normal stresses, a grain can be subjected to shear stresses as well. These stress act parallel to the crystal surface. The shear stresses occur if the pipe is subjected to torsion, bending etc. Just as there is an orientation for which normal stresses are maximum, there is an orientation which maximizes shear stress. The maximum shear stress in a 3-D state of stress can be shown to be as:-

$$\tau_{max} = (S_1 - S_3)/2$$

i.e. half of the difference between the maximum and minimum principal stresses.

8. What does the solid mechanics states regarding the Normal stresses?

Answer:-

Solid mechanic states that the sum of the three normal stresses for all orientation is always the same for any given external load as:-

$$S_L + S_H + S_R = S_1 + S_2 + S_3$$

9. Which component of normal stress is considered negligible?

Answer:-

In most pipe design cases, the radial component of normal stresses (S_R) is negligible as compare to the other two component (S_H and S_L).

10. How the two principal stresses and maximum shear stress are calculated?

Answer:-

Use of Mohr's circle allows calculating the two principal stresses and maximum shear stress as:-

$$S_1 = (S_L + S_H)/2 + [\{(S_L - S_H)/2\}^2 + \tau^2]^{0.5}$$

$$S_2 = (S_L + S_H)/2 - [\{(S_L - S_H)/2\}^2 + \tau^2]^{0.5}$$

$$\tau_{max} = 0.5\,[(S_L - S_H)^2 + 4\,\tau^2]^{0.5}$$

The third principal stress (minimum i.e. S_3) is zero.

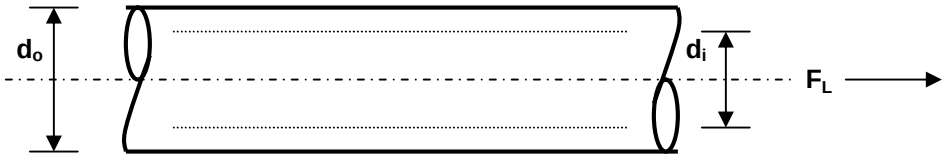
11. What are the potential loads faced by pipes during normal operation? Write their relationship to the stresses developed?

Answer:-

The potential loads faced by a pipe are:-

A. Axial load.
B. Internal/ External pressure load.
C. Bending load.
D. Shear load.
E. Torsional load.

A. Axial Load:-



Pipe under Axial load (Tensile)

A pipe may face an axial force (F_L) as shown in figure. The load may be tensile or compressive. In figure only tensile load acting on pipe is shown. The load (F_L) leads to normal stress in axial direction (S_L). The load bearing cross-section is the cross-sectional area of the pipe wall normal to the load direction, A_m. The stress developed is given by:-

$$S_L = F_L / A_m$$

The load bearing cross- section is calculated as:-

$$A_m = \pi (d_o^2 - d_i^2)/4 \text{ (rigorous)}$$
$$= \pi (d_o + d_i)\, t/2 \text{ (based on average Diameter.)}$$
$$= \pi d_o\, t \text{ (based on outer Diameter.)}$$

Some examples of cause of axial load are as:-

1. The metal cross- section at the base of the column is under the weight of the column section above it including the weight of other column accessories such as insulation, trays, ladders etc.

2. Sometimes the pipe is intentionally cut a little short than the end- to- end length required. It is than connected to the nozzle by forcibly stretching it. The pipe as assembled is under axial tension. When the hot fluids starts moving through the pipe, the pipe expands and the compressive stresses are generated. The cold tensile stresses are thus nullified.

B. Internal / External pressure Load:-

A pipe used for transporting fluid is subjected to the internal pressure load. This internal or external pressure induces stresses in the axial as well circumferential (Hoope's) directions. The pressure also induces stresses in the radial direction but is often neglected.

<u>Axial Stress</u>

The internal pressure exerts an axial force equal to pressure times the internal cross-section of pipe as:-

$$F_L = P [\pi d_i^2/4]$$

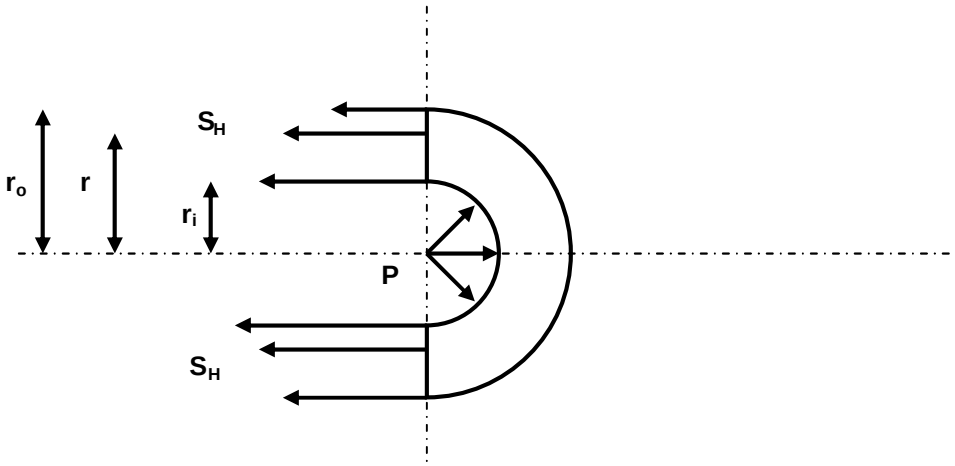
This then induces axial stress calculated as:-

$$S_L = Pd_o/4t$$

(Outer diameter is used for calculating metal cross-section as well as pipe cross- section.)

Hoope's or Circumferential Stress

The internal pressure also induces stresses in the circumferential direction as shown in figure.



Hoope's Stress Due to Internal Pressure.

The stresses are maximum for grains situated at the inner radius and minimum for those situated at the outer radius. The Hoope's stress at any point in between radial position (r) is given as:-

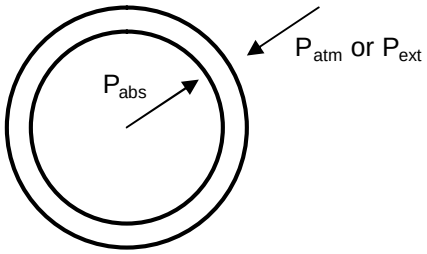
S_H at r = P ($r_i^2 + r_i^2 r_o^2$)/ $r_o^2 - r_i^2$) ---------- (Lame's equation)

From membrane theory, S_H is calculated as:-

$S_H = Pd_o/ 2t$ or $Pd_i/ 2t$

Radial Stress

For thin walled pipes, the radial stress variation can be neglected.
Radial stresses are also induced due to internal pressure as shown in figure.



Radial Stresses Due to Internal Pressure.

At the outer skin, the radial stress is compressive and equal to the atmospheric pressure (P_{atm}) or external pressure (P_{ext}) on the pipe. At the inner radius, it is also compressive but equal to absolute fluid pressure (P_{abs}). In between it varies. But it is often neglected.

C. Bending Load:-

Pipe bending is caused mainly due to two reasons:
A. Uniform weight load
B. Concentrated weight load.

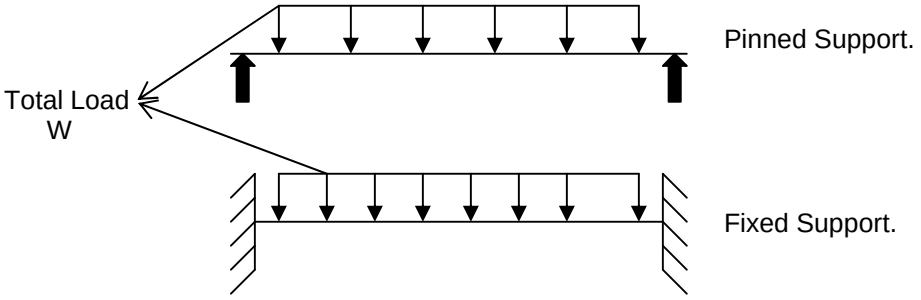
Uniform Weight Load.

A pipe span supported at two ends would sag between the supports due to the following:

A. Self weight of the pipe and weight of the insulation when not in operation.
B. Self weight and weight of hydrostatic test fluid during hydrostatic test.
C. Self weight, weight of insulation and weight of fluid it is carrying during operation.

All these weights are distributed uniformly across the unsupported span and lead to maximum bending moment either at the centre of the span or at the end points of the span.

Let the total weight of the pipe, insulation and fluid be W and the length of unsupported span be L as shown in figure.



Uniformly Distributed Load.

The weight per unit length, $w = W/L$

The maximum bending moment (M_{max}) which occurs at the centre for the pinned support. $M_{max.} = wL^2/8$

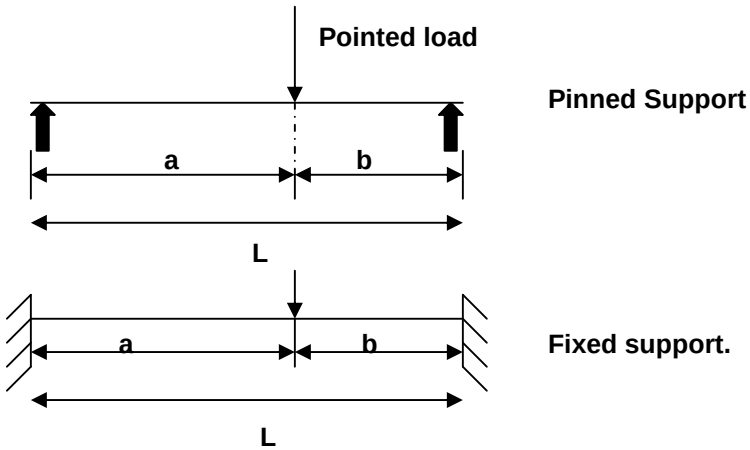
For fixed support, the maximum bending moment occurs at the end. $M_{max} = wL^2/12$

The pipe configuration and support used in process industry do not confirm to any of the above ideal support and is considered somewhere in between. The common practice is to use the following average formula to calculate bending moment for practical pipe configuration.

$$M_{max.} = wL^2/10$$

Concentrated Weight Load.

The example of concentrated load is a valve on a pipe run.



The load is acting at the centre of gravity of the valve and the maximum bending moment occurs at the point of loading for pinned support is given by:

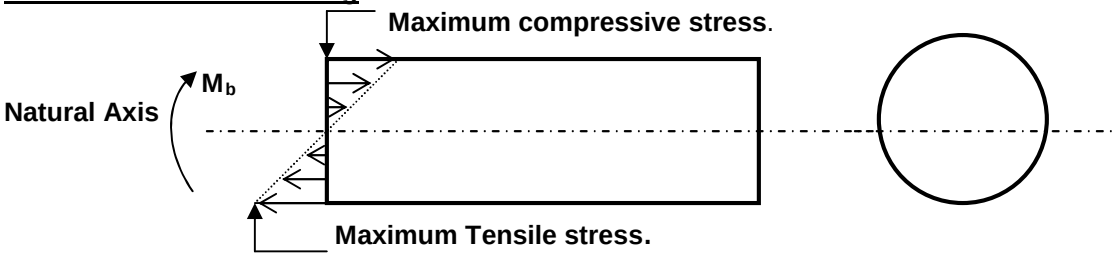
$$M_{max.} = W\ a\ b\ /\ L$$

For rigid support, the maximum bending moment occurs at the end nearer to the pointed load and is given by:

$M_{max.} = Wa^2b/L^2$ ('a' is taken as the longer of two arm in using the formula.)

The bending moment in the above case can be reduced to zero by making either 'a' or 'b' zero i.e. locating one of the supports right at the point where the load is acting. In actual practice, it would mean supporting the valve itself. As it is not possible, the common practice is to locate one of the supports as close to the valve (or any other pointed and significant load). By this, the bending moment due to pointed load is minimal and can be neglected.

Axial Stress due to Bending



Whenever the pipe bends, the skin of the pipe wall experiences both tensile and compressive stresses in the axial direction as shown in the figure. The axial stress changes from maximum tensile on one side of the pipe to maximum compressive on the other side. Obviously, there is natural axis along which the bending moment does not induce any axial stress. This is also the axis of the pipe.

The axial tensile stress for bending moment M_b at location c as measured from natural axis is given by:

$$S_L = M_b \, c / I$$

I is the moment of inertia of the pipe cross-section. For a circular cross-section pipe, I is given by:

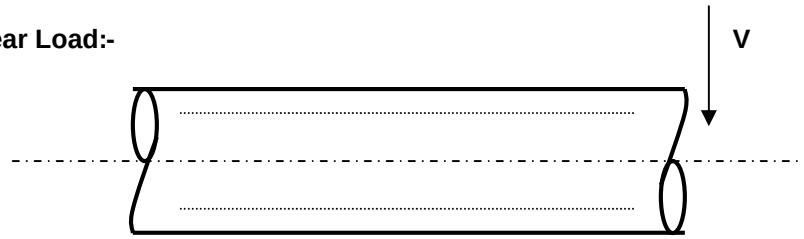
$$I = \pi(d_o^4 - d_i^4) / 64$$

The maximum tensile stress occurs where c is equal to the outer radius of the pipe and is given by:

S_L at outer radius = $M_b \, r_o / I = M_b/Z$

Where $Z (=I/r_o)$ is the section modulus of the pipe.

D. Shear Load:-

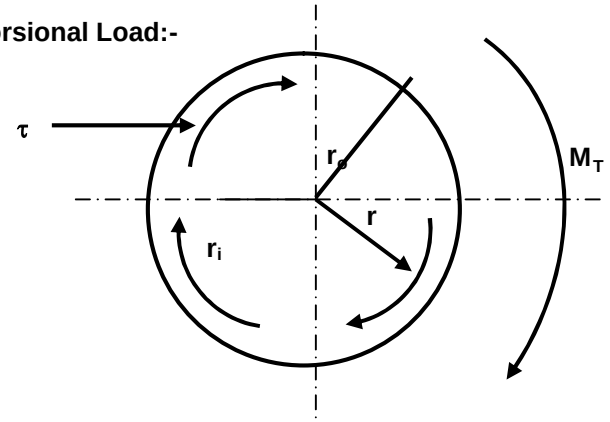


Shear Force on a pipe

Shear force (V) acting on the pipe is shown in the figure. It causes shear stresses which are maximum along the pipe axis and minimum along the outer skin of the pipe. This is exactly opposite of the axial stress pattern caused by bending moment. These stresses are small in magnitude hence not taken in account in pipe stress analysis. If necessary these are calculated as:

$\tau_{max.} = VQ/A_m$ where, Q is shear form factor and A_m is metal cross-section.

E. Torsional Load:-



This load causes shear stresses. The shear stress caused due to torsion is maximum at outer pipe radius. The Torsional moment is given by:

$$\tau \text{ (at } r = r_o) = M_T \, r_o / R_T = M_T \, r_o / (2I) = M_T / 2 \, Z$$

where, RT is the Torsional resistance = twice the moment of inertia.

12. What are the Theories of failure?

Answer:-

Important theories in common use are:-

A. Maximum Stress Theory or Rankine Theory.
B. Maximum Shear Theory or Tresca Theory.
C. Octahedral Shear Theory or Von Mises Theory.

13. What is Maximum stress theory?

Answer:-

According to this theory, failure occurs when the maximum principal stress in a system (S_1) is greater than the maximum tensile principal stress at yield in a specimen subjected to uniaxial test. In uniaxial test, the applied load give rise to axial stress (S_L) only and Hoope's stress (S_H) & Radial stress (S_R) as well as the shear stress are absent. In a specimen under uniaxial tension test at yield the following holds.

$S_L = S_Y$, $S_H = 0$, $S_R = 0$
$S_1 = S_Y$, $S_2 = 0$, and $S_3 = 0$

The maximum tensile principle stress at yield is thus equal to the conventionally reported yield stress (load at yield / cross- sectional area of specimen)

The Rankine theory thus says that the failure occurs when the maximum principal stress in a system (S_1) is more than the yield stress of the material (S_Y).

14. What is Maximum Shear Theory?

Answer:-

According to this theory the failure occurs when the maximum shear stress (τ_{max}) is greater than the maximum shear stress at yield in a specimen subjected to uniaxial tension test.

$$\tau_{max.} = 0.5 [(S_L - S_H)^2 + 4\tau^2]^{0.5}$$

Since, in the uniaxial tension test SH and τ is Zero. Thus,

$$\tau_{max} = S_L/2 = S_Y/2$$

The Tresca Theory thus says that the failure occurs when the maximum shear stress in a system (τ_{max}) is more than half the yield stress of the material.

15. What is Octahedral Shear Theory?

Answer:-

According to this theory, the failure occurs when the octahedral shear shear stress in a system ($\tau_{oct.}$) is greater than the octahedral shear stress at the yield in a specimen subjected to uniaxial tension test. The octahedral shear stress is given by:

$$\tau_{oct} = 1/3 [(S_1 - S_2)^2 + (S_2 - S_3)^2 + (S_3 - S_1)^2]^{0.5}$$

The octahedral shear stress at yield in the specimen subjected to uniaxial tension test is given by:

$$\tau_{oct} = 2/3\ S_Y^{0.5}$$

Questions Related to Stress Analysis:-

1. What is the objective of stress analysis?

Answer: -

A. To ensure that the stresses in piping components in the system are within allowable limits.
B. To solve dynamic problems developed due to mechanical vibration, fluid hammer, pulsation, relief valves, etc.
C. To solve problems associated due to higher or lower operating temperature as: -
I. Displacement stress range.
II. Nozzle loading on connected equipment.
III. Pipe displacements.
IV. Loads & moments on supporting structure.

2. What are the steps involved in stress analysis (or any stress package carries out)?

Answer: -

A. Identify the potential loads that the piping system would encounter during the life of the plant.
B. Relate each of these loads to the stresses and strains developed.
C. Get the cumulative effect of the potential loads in the system.
D. Decide the allowable limits the system can withstand without failure as per code.
E. After the system is designed to ensure that the stresses are within safe limits.

3. How the loads are classified in stress analysis package?

Answer: -

A. Sustained Loads : Those due to forces present during normal operation.
B. Occasional Loads : Those present during rare intervals of operation.
C. Displacement Loads : Those due to displacement of pipe.
(Self-limiting stresses due to thermal effects).

4. What are the sources of sustained load generated in piping system?

Answer: -

A. Internal fluid pressure.
B. Dead weight of Pipe with fluid and its attachments.
Sustained load is calculated as: -
Weight of Pipe with Fluid + Internal fluid pressure load + Load due to springs (W+P1).

5. What are the Inputs required for stress analysis of a piping system?

Answer: -

A. Pipe Size.
B. Fluid Temperature.
C. Pipe Material.
D. Model.
E. Design pressure.
F. Insulation Thickness.
G. Specific gravity.
H. Friction coefficient.

6. How do you calculate the operating load?

Answer: -

W+P1+T1
T1 – Load due to thermal expansion.

7. Give some Examples for occasional Loads.

Answer: -

A. Wind load.
B. Seismic load.
C. Forces due to relief or blow down.
D. Pressure wave generated due to water hammer effects.

8. What is the failure theory subscribed under ASME B31.3?

A. Maximum principal stress theory (Rankines Theory).
B. Maximum Shear Theory.
C. Octahedral Shear Theory.

Answer: - A. Maximum principal stress theory or Rankines theory.

9. Select the failure stress range for fatigue failure due to thermal expansion as per B31.3?

A. $S_A = (S_c + S_h)\ 1.6f$
B. $S_A = 1.25\ (S_C + S_h)$
C. $S_A = (1.25\ S_c + 0.25 S_h)f$
Where, S_A = Allowable Expansion stress Range.
S_c and S_h = Basic Allowable material stress in cold & hot conditions respectively.
f = Stress range reduction factor (1 for 7000 cycles.)

Answer: - C

10. What is the desired life cycle for Piping in operation?

Answer: -

Desired life cycle for Piping in operation is 20 Years (7000 Cycles).

The normal no. of cycles for which the displacement or thermal stresses are designed is 7000 cycles.

11. How do you calculate the stress developed due to thermal expansion?

Answer: -

Stress developed, $\varepsilon = E \times \alpha$, $(\alpha = \Delta L/L)$

……. Where, E = Young's Modulus.

ΔL = Increase in length due to thermal expansion.

L = Original Length of the pipe.

12. How do you calculate the thermal expansion in a pipe?

Answer: -

$$\Delta L = \alpha \times \Delta T \times L$$

In the codes and many reported calculations, α is used as inclusive of ΔT. Thus the above formula is written as:-

$$\Delta L = \alpha \times L$$

Where, α = Coefficient of thermal expansion from ambient to operating temperature.

L = Length of the pipe.

13. What do you mean by Stress Intensity Factor (SIF)? Give some examples.

Answer: -

Stress Intensity Factor (SIF) is the ratio of maximum stress intensity to normal stress. It is used as safe factor to account for the effect of localised stress on piping under respective loading. In piping it is applied to welds, fittings, branch connections etc where stress concentration and possible fatigue failure may occur.

Example: - SIF for Reducer and Weldneck Flange is 1.0

SIF for socket weld flange is 1.3

14. How much should be the pressure for Hydro-Test?

Answer: -

Hydrotest pressure should be calculated as follow except as provided against point No D.

A. 1.5 Times of Design Pressure.

B. For a design temperature above the test temperature, minimum test pressure can be calculated as:

$$P_t = (1.5 \times P \times S_t) / S$$

……..Where, P_t : Minimum Test Pressure.

P : Internal design pressure.

S_t: Allowable stress at test temperature.

S : Allowable stress as design temperature.

.

C. If a test pressure as per above would produce a stress in excess of the yield strength at test temp.the test pressure may be reduced to maximum pressure that will not exceed the yield strength at test temp.

D. If the test pressure of piping exceeds the vessel pressure and it is not considered practicable to isolate piping from vessel, the piping and vessel may be tested together at test pressure of the vessel when approved by owner and provided the test pressure for vessel is not less than 115% of piping design pressure adjusted for temperature as per point No.B.

15. How do you calculate the pipe spacing?

Answer: -

Pipe Spacing (mm) = $(D_o + D_t) / 2$ + 25mm + Thickness of Insulation (mm).

Where: D_0 : OD of Small size Pipe (mm).

D_t: OD of Flange of Large size Pipe (mm).

16. Which fluid is used in Heat Exchanger in shell side and tube side?

Answer: -

Generally corrosive fluid is used from the tube side (as tube can be easily replaced) and cleaner fluid is used from shell side. Sometimes Hot fluid is also used from the shell side.

17. What is Reynolds number and what is the value of Reynolds number upto which the flow is laminar?

Answer: -

It's a dimensionless number to classify the nature of flow.

$R_e = a\ v\ d / f$

…….Where, R_e : Raynold's no.
a : Density of fluid.
d : Diameter of Pipe.
v : Average velocity of fluid.
f : Viscosity of fluid.

Flow is laminar upto Re=2100

18. Why do we provide Drip Leg in Steam Line?

Answer: -

To remove condensate when there is a rise of same in the pipe along the flow direction. If drip leg is not provided in steam line, the condensate which forms inside the pipe will result in Water Hammer effect causing damage to piping system.

19. What is the design standard followed for the calculation of allowable forces / Moments in nozzles of centrifugal compressor & Steam turbines nozzle?

Answer: -

The strain sensitive equipment piping to be routed and supported to limit nozzle loading and moment in equipment within allowable limits furnished by respective vendors or in absence of vendor data API 560/610/615/621/661 & NEMA SM23. (Referred by API 617) is used for compressor & steam turbine nozzle.

20. What is the mill tolerance to be considered for the thickness of pipe during stress analysis as per ASME B31?

(i) 1%
ii) 2.5%
(iii) 7.5%
iv) 12.5%

Answer : iv

21. Differentiate between static load and dynamic load?

Answer: -

Static loads are those which are applied slowly enough so that the system has time to react and internally distribute the loads, thus remaining in equilibrium. In equilibrium, all forces and moments are resolved (i.e., the sum of the forces and moments are zero), and the pipe does not move.

Dynamic loads are those which changes quickly with time. The piping system may not have time to internally distribute the loads, so forces and moments are not always resolved & resulting in unbalanced loads, and therefore pipe movement. Since the sum of forces and moments are not necessarily equal to zero, the internally induced loads can be different either higher or lower than the applied loads.

22. Give different types of dynamic loads with example?

Answer: -

A. Random – Wind, Earthquake.
B. Harmonic – Equipment Vibration, Pulsation, Acoustic Vibration.
C. Impulse – Fluid Hammer, relief valve opening, slug flow.

23. What is Dynamic Analysis and why it is used?

Answer: -

Dynamic analysis is performed for all two phase lines in order to ensure that the line supported is safe from vibrations loads which may occur during normal operation as well as in start up or any upset condition. (Diesel mixed with hydrogen in DHDT process).

24. What are WRC 107 / WRC 297?

Answer: -

Localised stresses at Nozzle to Shell is calculated by WRC 107 / 297 and these computed stress values shall be limited in accordance with ASME Sec VIII for Pressure Vessels.

25. Why loop is provided in piping system?

Answer: -

To adjust thermal expansion.

26. What is the maximum expansion absorbed in loops in normal design?

Answer: -

10 Inches.

27. What is the allowable stress range for CS pipes?

Answer: -

2070 kg/cm^2.

Question related to Non- destructive Testing: -

1. Describe different types of destructive and non-destructive tests?

Answer: -

DESTRUCTIVE TEST: Bend test, Tensile test, Impact test, and Hardness test.
NON-DESTRUCTIVE TEST: DPT, MPT, Radiography and ultrasonic test.

2. What are the different types of hardness tests carried out?

Answer: -

Brinell Hardness Test.
Rockwell Hardness Test.
Vicker Hardness Test.

3. What is the relation between Brinell Hardness No. and Rockwell Hardness No.?

Answer: -

22 HRC (Rockwell Hardness) = 238 BHN (Brinell Hardness No) Harder.

Questions related to wrapping & coating/ insulation/ cathodic protection: -

1. What is the procedure for application of wrapping and coating?

Answer: -

Procedure for application of Coating and wrapping: -

A. Prior to application of wrapping & coating, the surface of pipe should be made free from all loose Mill scale, dirt, rust, grease, moisture and other foreign material. This is achieved by blast cleaning to grade Sa 2 ½ .

B. The pipe exterior surface or blast surface shall be coated with primer within four hours of shot blasting. The primer shall not be applied when the pipe surface temperature is below 7°C and above 70°C. when moisture is present on the surface, the same is heated for sufficient time to dry the surface.

C. The pipe after priming shall be coated with two-flood coat of hot enamel incorporating the simultaneous application of inner & outer wrapping.

2. What is the content of primer applied on the pipe surface before coating?

Answer: -

The primer consists of processed coal – tar pitch and refined coal – tar oil.

3. What is the enamel applied on the pipe surface for coating?

Answer: -

The enamel is plasticised coal tar pitch suitable for hot application and filled with inert mineral filler which have minimum tendency to settle down in fluid state.

4. Which material is used as inner and outer wrapping?

Answer: -

Fibre glass tissue consisting of a uniformly porous mat of chemically resistant boro – silicate glass containing not less then 5% B_2O_3.

5. What should be the minimum thickness of enamel on any point on pipe?

Answer: -

The enamel shall have minimum thickness of 2.4 mm when measured on top of the weld with an overall thickness of 4mm.

6. How much should be the depth of pulling of inner Fibre – glass tissue into the hot enamel?

Answer: -

The inner wrap of Fibre – glass tissue pulled in such a manner that the same is imbedded half way into the enamel without touching the steel surface.

7. What should be the overlap between inner & outer wrap?

Answer: -

The inner and outer wraps shall be overlapped by 25mm.

8. What should be the minimum staggering of inner & outer wraps/

Answer: -

The overlaps of the inner and outer wraps shall be staggered from each other by minimum distance of 100mm.

9. What is cold type of wrapping?

Answer: -

PVC backed bituminous compound tape used for field wrapping is called cold wrapping.

10. What is the minimum overlap of field wrapping (cold Tape) on shop wrapping?

Answer: -

Wrapping shall start and finish to give a minimum 75mm overlap onto the adjoining shop coating.

11. What is the material applied on the flanges or valves to obtain smooth surface for application of cold Tape?

Answer: -

Moulding compound shall be hand applied to obtain the smooth surface for application of cold tape on flanges / valves.

12. What is the device used to locate the defects on surface of coating & wrapping?

Answer: -

Holiday Detector.

13. How much crest voltage of Holiday Detector shall be set?

Answer: -

The crest voltage of Holiday Detector shall be set as high as practical.

14. What is the test to ensure the proper thickness, adhesion and the position of inner wrap?

Answer: -

A square of 25mm X 25mm shall be cut from wrapping for determination of thickness, adhesion and position of the inner wrap. This shall be carried out at the rate of one pipe per 50 coated.

15. What are different types of Anodes used in cathodic protection?

Answer: -

Different types of Anodes are Magnesium, Zinc, High Silicon Iron, Aluminum etc.

16. What are Insulating Gasket Kits?

Answer: -

Insulation gasket kits are designed to restrict the effects of corrosion often found in flanged pipe systems. The most common example is fire water line running inside the ground and turned upward on above ground with flanged connection.

It consists of following kits: -

A. Gasket : - Neoprene faced Phenolic /Glass Reinforced Epoxy (G10).
B. Insulation sleeve : - Reinforced Phenolic/Nylon/Polyethylene/(G10).
C. Insulation washer : - Reinforced Phenolic/Nylon/Polyethylene/(G10).
D. Plated Washer : - Electro plated steel washer.

17. What is the temperature limit for application of insulation for personnel protection?

Answer: -

Insulation for personnel protection shall be required when the line operating temperature exceeds 60°C.

18. What short of paint is applied on the inside surface of Aluminium metal Jackets for pipe insulation?

Answer: -

All pipe insulation shall be provided with an Aluminum metal jacket with site applied moisture barrier of bituminous paints.

19. Which material is used for securement of insulation on pipe?

Answer: -

For securement of insulation following material are applied:

A. Stainless steel wire (SS –304) of 1 mm thickness with 225 mm intervals.
B. Aluminium bands of 0.6 X 20 mm with 225 mm intervals.

20. What shall be layers of insulation for different thickness?

Answer: -

The insulation shall be single layer up to 75mm thickness and double layer at 90mm thickness and greater.

21. What care shall be taken before applying insulation?

Answer: -

The surface to be insulated shall be free from oil, grease and all other foreign matter and shall be free from moisture prior to the application of any insulation.

22. What is the minimum circumferential lap of metal jacket applied on the insulation?

Answer: -

Questions related to Pump/ Alignment/ pump piping: -

1. What are different types of pumps?

Answer: -

Basically there are two types of pumps.

A. Centrifugal Pump.
B. Positive Displacement pump.

2. What are the different types of centrifugal pump?

Answer: -

Different types of Centrifugal Pump are: -

A. Single Stage or
B. Multi-stage

3. What is the basic difference between single stage and multi-stage centrifugal pump?

Answer: -

The Single stage pump has one impeller and multi-stage pump has two or more impellers in series. The discharge of one impeller is the suction of the next one and the head developed in all the stages are totaled.

4. How many types of centrifugal pump are available based on the Suction and Discharge arrangement?

Answer: -

Based on the suction and discharge arrangement, the type of centrifugal pumps available is: -

A. End Suction Top Discharge.
B. Top Suction Top Discharge.
C. Side Suction Side Discharge.

5. What are the main components of a centrifugal pump?

Answer: -

A centrifugal pump has two main components as:-

A. A rotating component comprised of an impeller and a shaft.
B. A stationary component comprised of a casing, casing cover, and bearings.

The general components, both stationary and rotary are shown in Figure B.01.

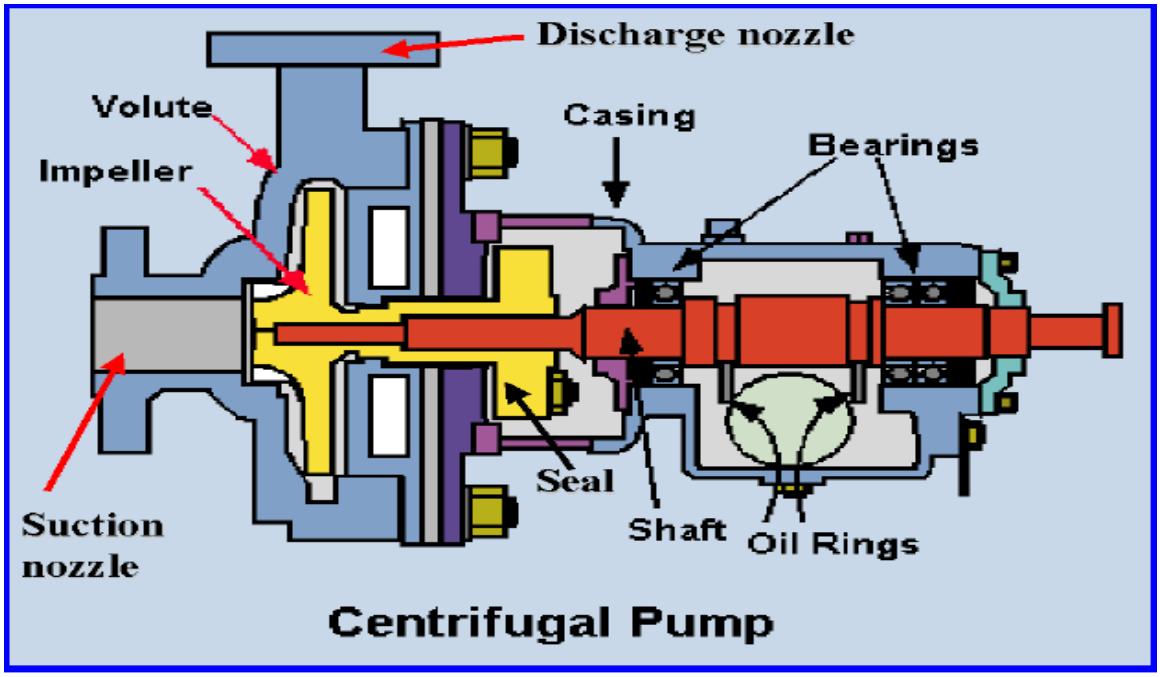


Figure B.01: General components of Centrifugal Pump

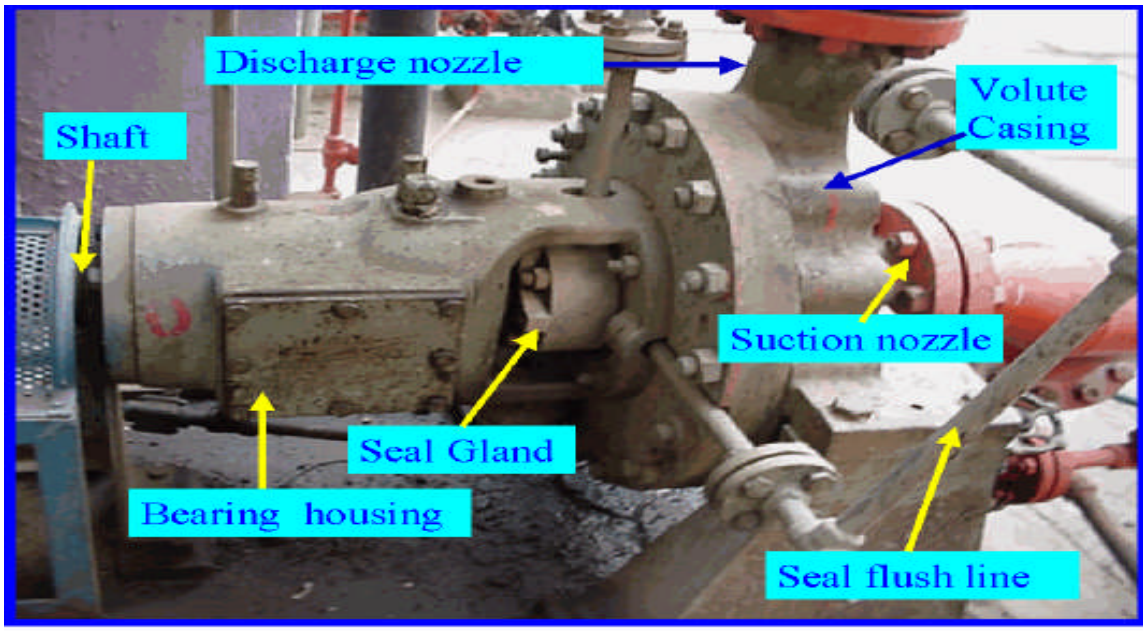


Figure B.02: General components of a Centrifugal Pump

6. What are the different types of casing?

Answer: -

Casings are generally of two types: volute and circular. The impellers are fitted inside the casings.

7. Define the working mechanism of centrifugal pump?

Answer: -

A centrifugal pump is one the simplest pieces of equipment in any process plant. Its purpose is to convert energy of prime mover (an electric motor or turbine) first into velocity or kinetic energy and then into pressure energy of a fluid that is being pumped. The energy changes occur by virtue of two main parts of the pump, the impeller and the volute or diffuser. The impeller is rotating part that converts drivers energy into the kinetic energy. The volute or diffuser is the stationary part that converts the kinetic energy into pressure energy.

8. How the centrifugal force generated in the centrifugal pump?

Answer: -

The process liquid enters the suction nozzle and then into the eye (center) of the revolving device known as an Impeller. When the impeller rotates, it spines the liquid sittings in the cavities between the vanes outward and provides centrifugal acceleration. As the liquid leaves the eye of the impeller a low – pressure area is created causing more liquid to flow towards the inlet. Because the impeller blades are curved, the fluid is pushed in a tangential and radial direction by centrifugal force. The figure below depicts a side cross-section of a centrifugal pump indicating the movement of the liquid.

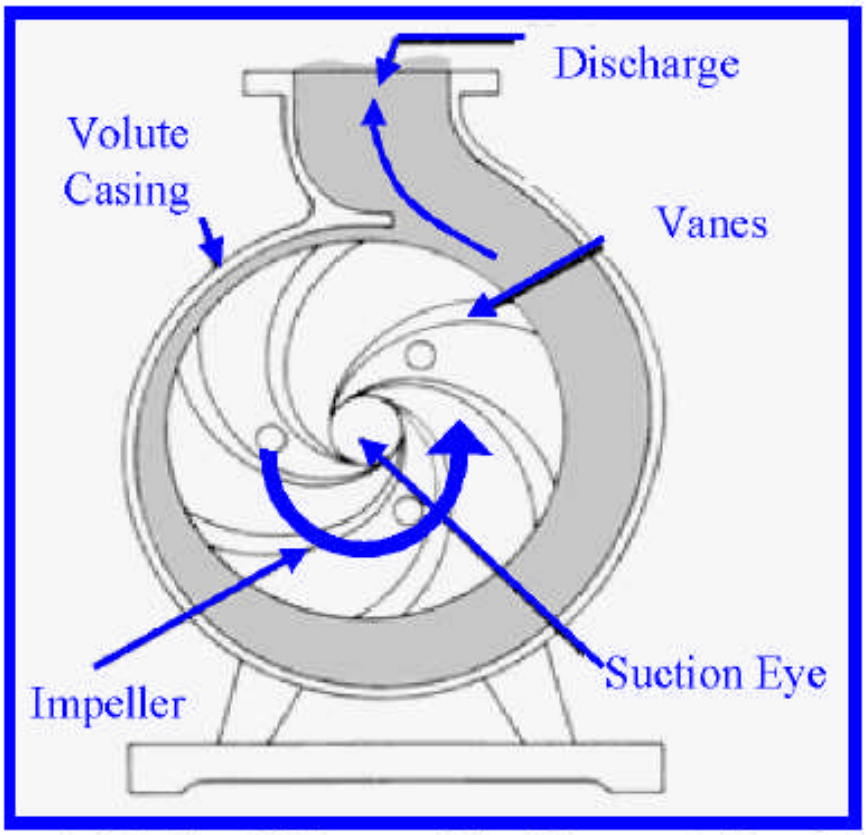


Figure A.01: Liquid flow path inside a centrifugal pump

9. How the kinetic energy created by centrifugal force is converted to pressure energy?

Answer: -

The energy created by centrifugal force is kinetic energy. The amount of energy given to the liquid is proportional to the velocity at the edge or vane tip of the impeller. The faster the impeller revolves or the bigger the impeller is then the higher will be the velocity of the liquid at the vane tip and the greater the energy imparted to the liquid. This kinetic energy of the liquid coming out of an impeller is harnessed by creating a resistance to the flow. The first resistance is created by the pump volute (casing) that catches the liquid and slows it down. In the discharge nozzle, the liquid further decelerates and its velocity is converted to pressure according to Bernoulli's principle.

Therefore, the head (pressure in terms of height of the liquid) developed is approximately equal to the velocity energy at the periphery of the impeller expressed by the following formula as: -

$$H = v^2 / 2g$$

Where,
H = Total head developed in feet.
V = Velocity at periphery of impeller in ft/sec.
G = Acceleration due to gravity-32.2ft/sec^2

Formula for calculating peripheral velocity:

$$V = \frac{NX\ D}{229}$$

Where,
V = Peripheral velocity in impeller in ft/sec.
N = The impeller rpm (Revolution per minute)
D = Impeller diameter in inches.

One fact that must always be remembered: A pump does not create pressure, it only provides flow. Pressure is a just an indication of the amount of resistance to flow.

10. What do you mean by Cavitation in Pump?

Answer: -

A pump is designed to handle liquid, not vapor. The satisfactory operation of pump requires that vaporization of the liquid does not occur at any condition of operation. This is so desired because when a liquid vaporizes its volume increases very much. For example, 1 ft^3 of water at room temperature becomes 1700 ft^3 of vapor at the same temperature. The vaporization begins when vapor pressure of the liquid at the operating temperature equals the external system pressure, which in an open system is always equal to atmospheric pressure. Any decrease in external pressure or rise in operating temperature can induce vaporization. The vapor pressure occurs right at the impeller inlet where a sharp pressure drop occurs. The impeller rapidly builds up the pressure, which collapses vapors bubbles causing cavitation and damage the pump internals. This is avoided by maintaining sufficient NPSH. (Cavitation implies cavities or holes in the fluid we are pumping. These holes can also be described as bubbles, so cavitation is really about the formation of bubbles and their collapse. Bubbles form whenever liquid boils. It can be avoided by providing sufficient NPSH.)

11. What do you mean by NPSH or NPSH$_r$?

Answer: -

When the liquid passes from the pump section to the eye of the impeller, the velocity increases and the pressure decreases. There are also pressure losses due to shock and turbulence as the liquid strikes the impeller. The centrifugal force of the impeller vanes further increases the velocity and decreases the pressure of the liquid. Thus, the Net positive suction Head required (NPSH$_r$) or sometimes in short as NPSH is the total head at the pump section to overcome these pressure drops in the pump and maintain the majority of the liquid above its vapor pressure.

The term "NET" refers to the actual pressure head at the pump section flange and not the static section head. NPSH required is a function of the pump design and is determined based on actual pump test by vendor.

12. What do you mean by $NPSH_a$ (Net positive suction head available)?

Answer: -

Net Positive Suction Head Available is a function of the system in which the pump operates. It is the excess pressure of the liquid in feet absolute over its vapor pressure as it arrives at the pump suction, to be sure that the pump selected does not cavitate. It is calculated based on system or process conditions. NPSHa calculation is stated below:

$$NPSH_{aS} = hp_s + h_s - hvp_s - hf_s$$

Where,

Hp_s = Pressure Head i.e. Barometric pressure of the suction vessel converted to head.

h_s = Static Suction Head i.e. the vertical distance between the eye of first stage impeller centerline and suction liquid level.

hvp_s = Vapor pressure Head i.e. vapor pressure of liquid at its maximum pumping temperature converted to Head.

hf_s = Frication Head i.e. friction and entrance pressure losses on suction side converted to Head.

Note:

1. It is important to correct for the specific gravity of the liquid and to convert all terms to units of "feet absolute" in using the formula.
2. Any discussion of NPSH or cavitation is only concerned about the suction side of the pump. There is almost always plenty of pressure on the discharge side of the pump to prevent the fluid from vaporizing.

NPSHa in a nutshell

In a nutshell, NPSH available is defined as:

NPSHa = Pressure head + Static head - Vapor pressure head of the product - Friction head loss in the piping, valves and fittings. "All terms in feet absolute"
In an existing system, the NPSHa can also be approximated by a gauge on the pump suction using the formula:

NPSHa = hps - hvps ? hgs + hvs

- **hps** = Barometric pressure in feet absolute.
- **hvps** = Vapor pressure of the liquid at maximum pumping temperature, in feet absolute.
- **hgs** = Gauge reading at the pump suction expressed in feet (plus if above atmospheric, minus if below atmospheric) corrected to the pump centerline.
- **hvs** = Velocity head in the suction pipe at the gauge connection, expressed in feet.

Significance of NPSHr and NPSHa

The NPSH available must always be greater than the NPSH required for the pump to operate properly. It is normal practice to have at least 2 to 3 feet of extra NPSH available at the suction flange to avoid any problems at the duty point.

13. What care shall be taken while doing layout for pump piping?

Answer:-

The following point shall be taken care of while doing layout for pump piping.

A. Pump location affects the piping routing and its supporting. Pumps dedicated for hydrocarbon services and carrying materials above 230° C shall not be located below pipe rack, structures, air fin coolers and vessels. Pumps which are dedicated for non – flammable service may be located beneath the pipe rack without obstructing the access bay and other maintenance requirements of the respective process unit.

B. Pump shall be located as close to the source of suction in order to minimize pressure drop in the system.

C. A preliminary piping layout (study layout) shall be made to determine the requirement of spacing between pumps especially in case of side suction/ side discharge, top suction/ top discharge pumps where straight length requirement/ platform /CPS requirement etc have to be considered.

D. Eccentric reducer in pump suction lines shall be flat on top side in order to prevent cavitation.

E. Reducers in pump suction lines shall be as close as possible to the pump suction nozzle.

F. Normally reducers in pump discharge shall be concentric type. Eccentric reducers may be used in both suction and discharge piping for top suction/ top discharge pump in order to obtain clearance between suction and discharge piping.

G. Piping for lube oil and seal oil system of pump shall be such that it shall not block access to the pump seal and bearing. For very large pumps these may be separate on skids.

H. As per OSID- 118 (Oil industries Safety Directorate stipulation) there shall be minimum 1 meter spacing between pumps e. g a minimum space of 1 meter must be provided in between the pumps and any potential obstructions (large block valves, steam turbine piping and tee type support from grade.)

I. Auxiliary piping shall be such that it shall not obstruct inspection covers, bearing caps, upper halves of casing or any other items which require access for operation or maintenance. Piping for lubricating oil, seal oil etc shall not be routed in the vicinity of hot process or hot utility pipes in order to avoid fire hazard.

J. Cooling water lines to pumps and compressors shall not be less than 20NB. Pipes 25NB or less shall have the take-off connection from the top of the header in order to prevent plugging during operation.

K. Every efforts must be made to minimize maintenance obstructions by running the piping either outside the area directly over the pump or at high enough elevation to permit the removal of the pump or driver.

L. The pump shall be placed in such a manner that the suction nozzle elevation is always below the vessel /tank nozzle and suction pipe shall be routed to prevent any pockets in the line.

M. Pump in the vacuum service operates at a negative pressure and very high temperature shall be located very close to the suction source. This is often directly below the tower or immediately outside the tower support column. Pumps located directly beneath the tower can be mounted on a special spring base.

14. What care shall be taken while doing layout for End section – Top discharge Horizontal type Centrifugal pump piping?

Answer: -

The following point shall be taken care of while doing layout for End section- Top discharge pump piping.

A. Clear access in between the valve handle and pump shall be ensured. The valve in suction line shall be installed with the stem in the horizontal position i.e. install valve in the vertical run of pipe.

B. Suction Strainer shall be located at grade to ease easy maintenance and removal for cleaning. The drain connection from strainer assembly shall have a break up flange immediately after the isolation valve and the drain line shall be routed in such way that the strainer can be removed with ease for maintenance.

C. Discharge piping shall be taken to grade for making valve accessible.

D. Do not route the suction and discharge piping above prim mover otherwise it may create hindrance while dismantling the same.

E. Small bore piping shall be routed in such a manner that tripping hazards are avoided.

F. Care shall be taken while routing discharge line not to block access to couplings. 0

G. Some examples of end suction- top discharge pump piping are shown in sketches 4, 5 & 6.

14. What are the different types of misalignment with regards to rotating machinery?

Answer: -

Different types of misalignment are:-

A.	Parallel or Radial Misalignment	:	The centre line of two shafts is parallel but do not lie on the same line. It is also called offset misalignment.
B.	Angular or Axial Misalignment	:	Condition which describes the angularity between the centerline of the two shafts. It can be corrected by rotating a shaft about the centre of the coupling face.
C.	Combined Angular and Parallel Misalignment	:	It occurs when the centerline of the two shafts is not lying along the common centerline and the one coupling face is not parallel to other coupling face in any of the plane, horizontal or vertical. It is the combination of the above two.

15. What are the pre- alignment checks to be carried out in aligning rotating machinery?

Answer:-

The pre- alignment checks involved in aligning rotating machinery are:-

A. Check the machine is properly secured to foundation.
B. Check for excessive run- out conditions i.e. Eccentric coupling bore, Bent Shaft.
C. Machine to base plate interface problems i.e. soft foot.
D. Ensure that no piping loads are coming on the machine.

17. What are the basic steps involved in aligning rotating machinery?

Answer:-

The basic steps involved in aligning rotating machinery are:-

A. Carry out pre-alignment checks as mentioned above.
B. Arrange all the necessary alignment tools & measuring tools.
C. Collect necessary data for the equipment to be aligned as:
- Any special tools needed to measure the alignment.
- Any data available on shaft movement from position of rest.
- Tolerance on alignment.

D. Inspect the coupling for any damage or worn out component.
E. Measure shaft or coupling hub run out.
F. Mount the alignment tools & measuring instruments, rotate the shaft.
G. Record one set data & determine the shaft positions with respect to each other. Compare the shaft positions with desired shaft positions. If shaft positions are within tolerance no further movement of machine is required.

18. What is soft foot as indicated in pre-alignment checks?

Answer:-

When rotating machinery is set in place on its base frame/ sole plate, one or more than one of the 'feet' may not make good contact at the 'foot points' on the frame. This is due to bowed/ warped frames, improper machining of feet.

19. What are the steps involved to detect & correct the soft foot problem?

Answer:-

A. Before installation of the machine on the base frame, ensure that all mounting pads on the base frame are flat enough. (Check with straight edge across the pads & no gap underside of the straight edge.) If pad is not flat enough, correction can be done by machining the frame.

B. Clean the mounting area & install the machine on the base frame.

C. Fully tightened all the mounting bolts. Place dial indicator at one of the feet near the bolthole with stem resting on frame. Loose all bolts one by one & observe the dial movement, if is not exceeding 0.05mm, no correction is required & no soft foot exists.

D. In case of higher movement of dial indicator, mark the feet. Check the gap between the feet & mounting pad. If there is gap & it is uniform then insert shim plate of thickness equal to the gap. If the gap is not uniform, it shall be corrected.

20. What is Blue matching with reference to the alignment of rotating machinery?

Answer:-

It is a type of check. By this method, the flatness of the mounting pad is checked. In this method blue colour (Blue mixed with oil) is applied with the help of brush on to surface of a glass of suitable size. The glass with the painted surface pointing towards the mounting pad is place on to the mounting pad and is rotated with little pressure. Now the glass is removed from the mounting pad. The surface of mounting pad which is slightly up is now clearly visible as the blue colour stick on these portions. Now these coloured surfaces shall be flattened by using rotating disc. Repeat the above procedure till 80% of the mounting pad surface gets coloured.

21. What are the Tools required for measuring the shaft centre line during alignment?

Answer:-

Following Tools are required for measuring the shaft centre line.

A. Straight edge.

B. Feeler Gauge.

C. Taper Gauge.

D. Measuring Tape & Ruler.

E. Alignment Bracket.

F. Vernier caliper.

G. Dial Indicator.

22. How the Dial Indicator reading is interpreted? Mention method of measurement by Dial indicator?

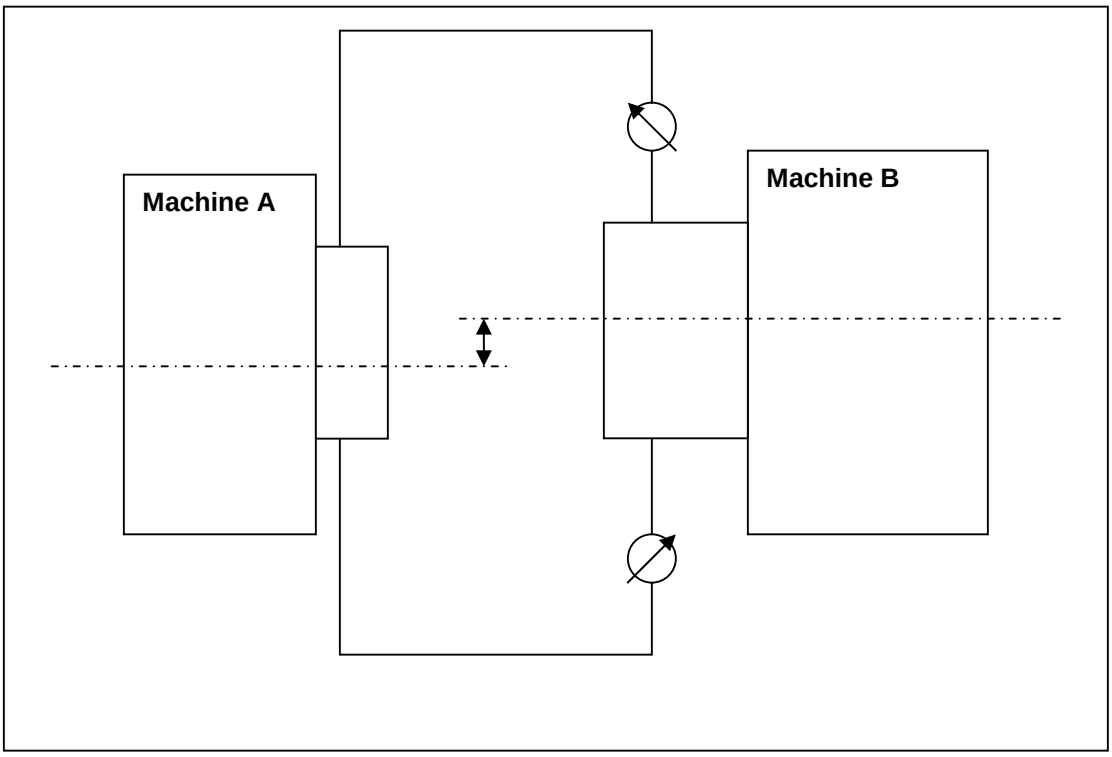
Answer:-

The inward movement is indicated by clockwise movement of indicator or in (+) direction. The outward movement is indicated by anti-clockwise movement or in (–) direction.
Different measurement methods are:-

A. Vertical Move : The figure shows how the vertical offset of 0.02mm of a shaft with respect to the other shaft will be displayed.

B. Sweep Reading : Sweeping reading is obtained by zeroing the dial at the top position on the coupling to be indicated. Slowly rotate the shaft so that the dial indicator is rotated by 360° in 90°increment. Obtain reading at top (T), bottom (B), right (R) and left (L). Refer figure.7

C. Horizontal move : The figure (7) displays how the alignment of two shaft having 0.02mm vertical offset and 0.02mm horizontal offset will look alike.



Machine A is 0.02 mm lower with respect to the machine A

22. What are the different alignment techniques adopted for aligning rotating machinery?

Answer:-

Following alignment techniques are adopted for aligning rotating machinery.

A. Straight edge & feeler gauge Method.
B. Shaft alignment using dial indicator.
  1.0 Face-rim method.
  1.1 Two indicator method.
  1.2 Three indicator method.

  2.0 Reverse indicator method.
  2.1 Face- Face- Distance method.
C. Laser Alignment method.

23. Describe 'Face-OD method using Two Dial Indicator?

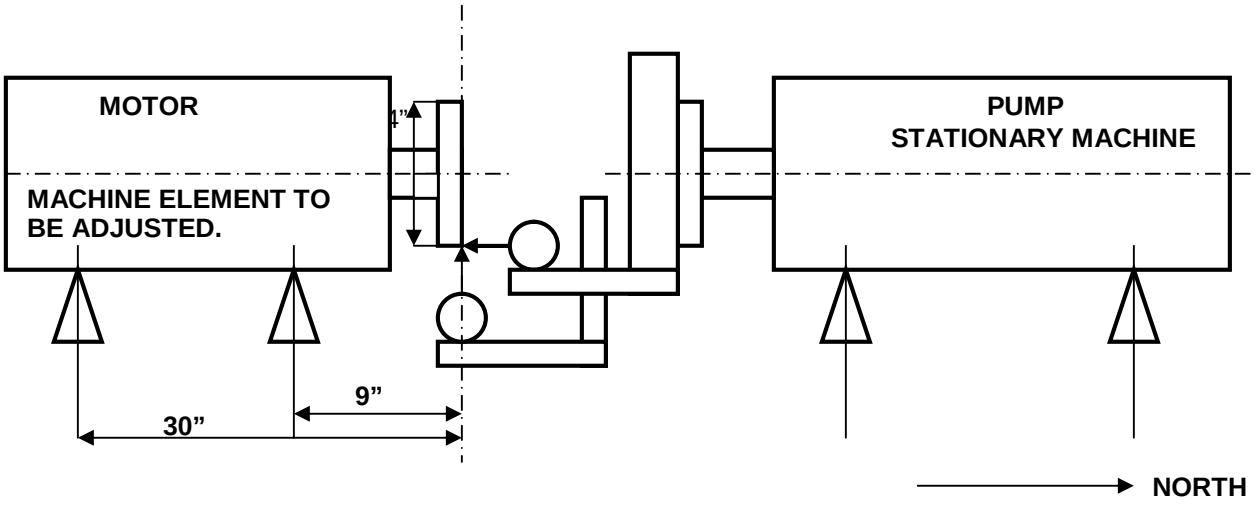
Answer:-

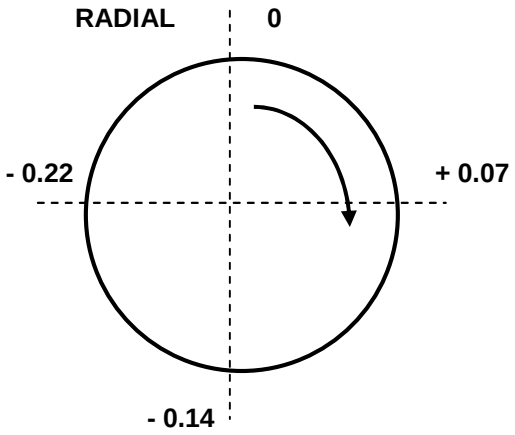
It is the most widely used method for alignment. In this method a bracket is attached to one of the shaft and extends near the coupling hub on the other shaft. Dial indicators are attached to the bracket with the stem of one indicator resting on OD or rim of opposite coupling hub & other stem resting on face of same coupling hub. Offset of the shaft or parallel misalignment is determined by the OD reading whereas angularity is determined by 'face' reading. Normally both the shafts are rotated together to eliminate errors due to face and rim irregularities.

24. Write the procedure for recording the indicator reading and its interpretation by Two indicator method?

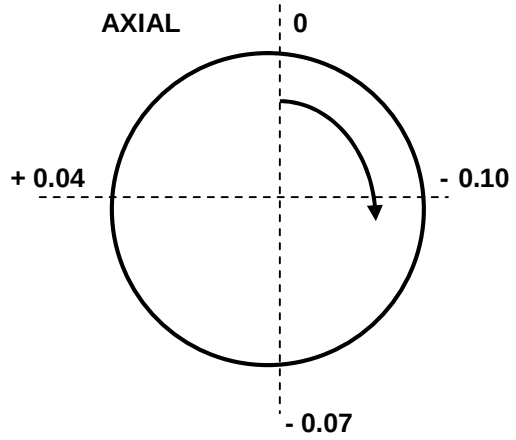
Answer:-

A. Dial Indicator with the pointer indicating zero to be mounted on the bracket first.
B. Rotate both the shafts simultaneously in clockwise direction.
C. Note the reading in top, bottom, left and right position of the shaft.
D. Interpret the final reading and do the required adjustment.



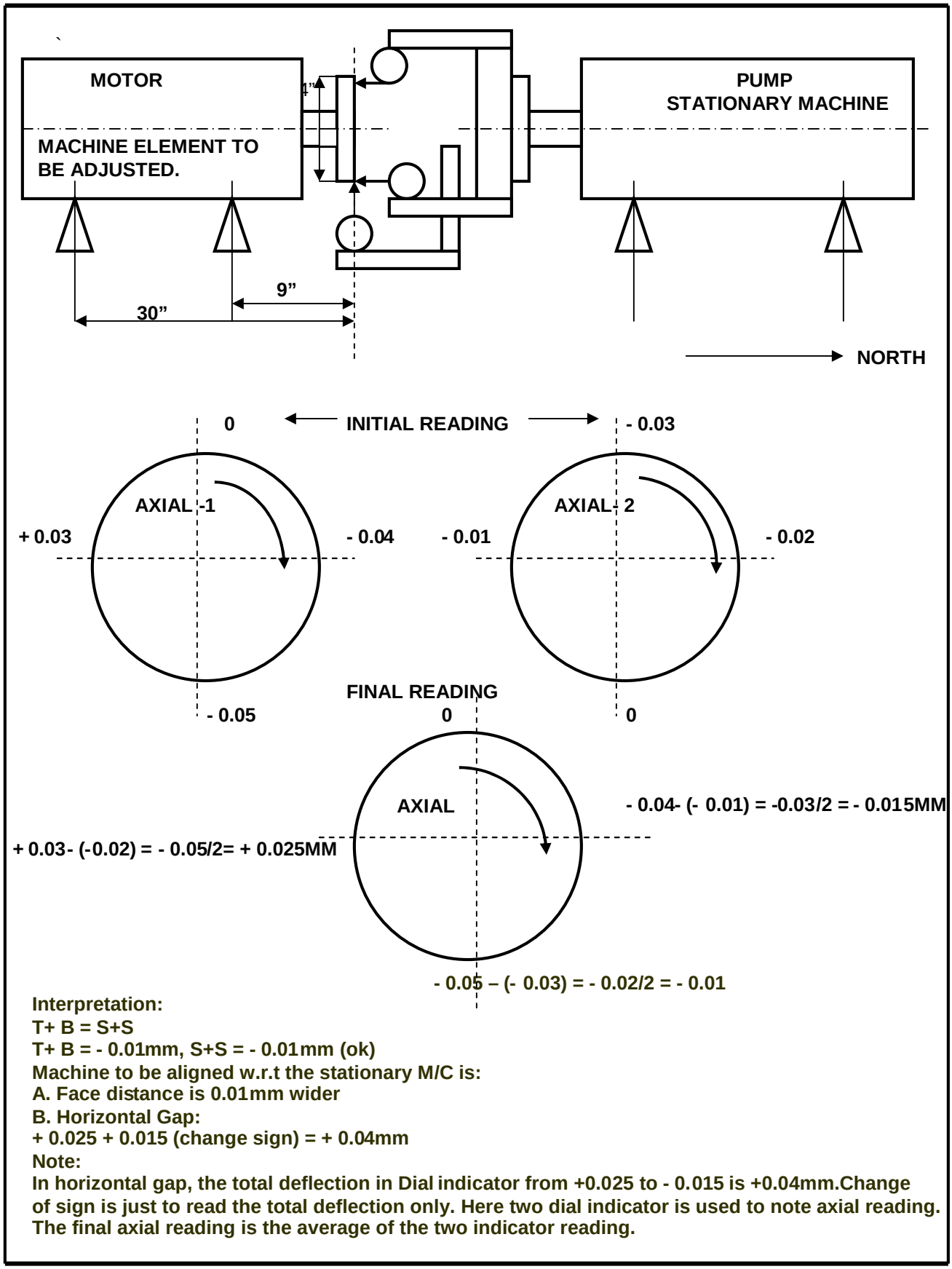


Interpretation:
T+ B = S+S
T+ B = - 0.14mm, S+S = - 0.15mm (ok)
Machine to be aligned w.r.t the stationary M/C is:
A. Higher = - 0.14+ 0.03 (sag) = - 0.11/2 = 0.055mm
B. Horizontal Offset:
- 0.22- 0.07 (change sign) = -0.29/2 = - 0.145mm.
Note:
In horizontal offset, the total deflection in Dial indicator from +0.07 to - 0.22 is -0.11mm.Change of sign is just to read the total deflection only.



Interpretation:
T+ B = S+S
T+ B = - 0.07mm, S+S = - 0.06mm (ok)
Machine to be aligned w.r.t the stationary M/C is:
A. Face distance is 0.07mm wider.
B. Horizontal Gap:
+ 0.04 + 0.10 (change sign) = + 0.14mm
Note:
In horizontal gap, the total deflection in Dial indicator from +0.04 to - 0.10 is +0.14mm.Change of sign is just to read the total deflection only.

25. Write the procedure for recording the indicator reading and its interpretation by Three indicator method?



Interpretation:
T+ B = S+S
T+ B = - 0.01mm, S+S = - 0.01mm (ok)
Machine to be aligned w.r.t the stationary M/C is:
A. Face distance is 0.01mm wider
B. Horizontal Gap:
+ 0.025 + 0.015 (change sign) = + 0.04mm
Note:
In horizontal gap, the total deflection in Dial indicator from +0.025 to - 0.015 is +0.04mm.Change of sign is just to read the total deflection only. Here two dial indicator is used to note axial reading. The final axial reading is the average of the two indicator reading.

Question Related to Norms & Assumptions For Piping & Structural Work:-

1. Write the estimation for welding consumables for piping work (Groove& Fillet welding)?

Answer:-

WELDING CONSUMABLE ESTIMATION FOR PIPING WORK WITH SINGLE V HAVING INCLUDED ANGLE OF 75 DEGREES

WALL THICKENSS (MM)	GROOVE AREA (SQ.MM)	WELD METAL WEIGHT gm/inch dia	ELECTRODE/FILLER WIRE CONSUMPTION (where root welding by E6010 -consumption of E6010 will be 30 gm/inch dia) gm/inch dia			
			SINGLE	SINGLE	COMBINATIONAL	
			GTAW	SMAW	GTAW	SMAW
4	23	15	20	26	0	0
5	33	21	28	37	19	11
6	46	29	38	51	19	25
7	59	38	50	67	19	41
8	75	48	63	84	19	59
9	91	58	77	102	19	76
10	110	70	92	123	19	98
11	130	83	110	146	19	120
12	151	97	128	171	19	145
13	174	111	147	195	19	170
14	198	127	168	224	19	198
15	224	143	189	252	19	226
16	252	161	213	283	19	258
17	281	180	238	317	19	291
18	311	199	263	350	19	325
19	343	220	290	387	19	362
20	377	241	318	424	19	398
21	412	264	348	465	19	439
22	449	287	379	505	19	479

WELDING CONSUMABLE ESTIMATION FOR PIPING WORK WITH SINGLE V HAVING INCLUDED ANGLE OF 75 DEGREES

WALL THICKNESS (MM)	GROOVE AREA (SQ. MM)	WELD METAL WEIGHT (gm/inch dia)	ELECTRODE/FILLER WIRE CONSUMPTION (gm/inch dia)			
			SINGLE	SINGLE	COMBINATIONAL	
			GTAW	SMAW	GTAW	SMAW
23	464	297	392	523	19	497
24	479	307	405	540	19	515
25	495	317	418	558	19	532
26	512	327	432	576	19	550
27	529	339	447	597	19	571
28	547	350	462	616	19	590
29	566	362	478	637	19	611
30	586	375	495	660	19	634
31	607	388	512	683	19	657
32	628	402	531	708	19	682
33	650	416	549	732	19	706
34	673	431	569	759	19	733
35	697	446	589	785	19	759
36	722	462	610	813	19	787
37	747	478	631	841	19	816
38	773	495	653	871	19	846
39	800	512	676	901	19	875
40	828	530	700	933	19	907
41	857	548	723	964	19	939
42	886	567	748	998	19	972
43	916	586	774	1031	19	1006
44	947	606	800	1067	19	1041
45	979	627	828	1104	19	1078
46	1012	647	854	1139	19	1113
47	1045	669	883	1177	19	1152
48	1079	691	912	1216	19	1190
49	1114	713	941	1255	19	1229
50	1150	736	972	1295	19	1270
51	1187	759	1002	1336	19	1310
52	1224	783	1034	1378	19	1352
53	1262	808	1067	1422	19	1396
54	1301	833	1100	1466	19	1440
55	1341	858	1133	1510	19	1484
56	1382	884	1167	1556	19	1530
57	1423	911	1203	1603	19	1578
58	1465	938	1238	1651	19	1625
59	1508	965	1274	1698	19	1673
60	1552	993	1311	1748	19	1722
61	1597	1022	1349	1799	19	1773
62	1642	1051	1387	1850	19	1824
63	1688	1080	1426	1901	19	1875
64	1735	1111	1467	1955	19	1930
65	1783	1141	1506	2008	19	1982

WELDING CONSUMABLE ESTIMATION FOR FILLET WELDING

FILLET SIZE	FILLET AREA	WELD METAL WEIGHT	ELECTRODE/FILLER WIRE CONSUMPTION gm/meter			
MM	SQ MM	gm/ meter	SINGLE	SINGLE	COMBINATIONAL	
			GTAW	SMAW	GTAW	SMAW
2	8	64	84	113	0	0
3	13	100	132	176	0	0
4	18	144	190	253	132	77
5	25	196	259	345	132	169
6	32	256	338	451	132	275
7	41	324	428	570	132	394
8	50	400	528	704	132	528
9	61	484	639	852	132	676
10	72	576	760	1014	132	838
11	85	676	892	1190	132	1014
12	98	784	1035	1380	132	1204
13	113	900	1188	1584	132	1408
14	128	1024	1352	1802	132	1626
15	145	1156	1526	2035	132	1859
16	162	1296	1711	2281	132	2105
17	181	1444	1906	2541	132	2365
18	200	1600	2112	2816	132	2640
19	221	1764	2328	3105	132	2929
20	242	1936	2556	3407	132	3231
21	265	2116	2793	3724	132	3548
22	288	2304	3041	4055	132	3879
23	313	2500	3300	4400	132	4224
24	338	2704	3569	4759	132	4583
25	365	2916	3849	5132	132	4956
26	392	3136	4140	5519	132	5343
27	421	3364	4440	5921	132	5745
28	450	3600	4752	6336	132	6160
29	481	3844	5074	6765	132	6589
30	512	4096	5407	7209	132	7033
31	545	4356	5750	7667	132	7491
32	578	4624	6104	8138	132	7962
33	613	4900	6468	8624	132	8448
34	648	5184	6843	9124	132	8948
35	685	5476	7228	9638	132	9462
36	722	5776	7624	10166	132	9990
37	761	6084	8031	10708	132	10532
38	800	6400	8448	11264	132	11088
39	841	6742	8899	11866	132	11690
40	882	7056	9314	12419	132	12243

WELDING CONSUMABLE ESTIMATION FOR FILLET WELDING

FILLET SIZE	FILLET AREA	WELD METAL WEIGHT	ELECTRODE/FILLER WIRE CONSUMPTION			
MM	SQ MM	gm/ meter	gm/meter			
41	925	7396	9763	13017	132	12841
42	968	7744	10222	13629	132	13453
43	1013	8100	10692	14256	132	14080
44	1058	8464	11172	14897	132	14721
45	1105	8836	11664	15551	132	15375
46	1152	9216	12165	16220	132	16044
47	1201	9604	12677	16903	132	16727
48	1250	10000	13200	17600	132	17424
49	1301	10404	13733	18311	132	18135
50	1352	10816	14277	19036	132	18860

2. What are the consumption norms for grinding/cut-off wheel?

Answer:-

For piping work:-
A. Grinding wheel for fabrication : 0.035 Numbers/ inch dia.
B. Grinding Wheel for joint grinding for UT : 0.012 Numbers/ inch dia.

For structural work:-
A. Grinding Wheel AG 7 (7"*7MM) : 0.75 Numbers/ MT.
B. Grinding Wheel AG 5 (5"*5MM) : 0.25 Numbers/ MT.

For support fabrication at shop:-
A. Grinding Wheel : 2 Numbers/ MT.

3. What are the consumption norms for Dissolved Acetylene and Oxygen?

Answer:-

For piping work:-
A. Dissolved Acetylene (D.A.) : 0.0140 Cu-M/ inch dia.
B. Oxygen (O_2) : 0.0510 Cu-M/ inch dia.

For structural work:-
A. Dissolved Acetylene (D.A.) : 2.2 Cu-M/ inch dia.
B. Oxygen (O_2) : 8.0 Cu-M/ inch dia.

For support fabrication at shop:-
A. Dissolved Acetylene (D.A.) : 3.5 Cu-M/ inch dia.
B. Oxygen (O_2) : 12 Cu-M/ inch dia.

4. What are the manpower deployment norms for structural steel work?

Answer:-

For fabrication of 1 MT of structural steel per day, the manpower required is as:-

A. Welder : 02
B. Fitter : 02
C. Gas cutter : 01
D. Grinders : 01
E. Riggers : 02
F. Helpers & others : 02

For erection of 1 MT of structural steel per day, the manpower required is as:-

A. Welder : 0.75
B. Fitter : 01
C. Gas cutter : 01
D. Grinders : 0.5
E. Riggers : 03
F. Helpers & others : 02

5. What are the manpower deployment norms for piping erection work?

Answer:-

Normally, 90 to 120 IM is erected per day per gang. One gang comprises the following:

A. Welder : 01
B. Fitter : 01
C. Gas cutter : 0.5
D. Grinders : 0.5
E. Riggers : 04
F. Helpers & others : 02

6. What is the productivity of the welder for plant piping and for off-site piping?

Answer:-

PIPE SIZE	FOR PLANT PIPING	FOR OFF-SITE PIPING
Upto Dia. 1 ½ “	10 ID/welder/day	12 ID/welder/day
Dia. 2” to 12”	16 ID/welder/day	18 ID/welder/day.
Dia. 8” to 12”	18 ID/welder/day	20 ID/welder/day
Dia.14” & above	20 ID/welder/day	22 ID/welder/day

7. How many pipe joints for plant piping & for offsite piping are assumed?

Answer:-

PIPE SIZE	FOR PLANT PIPING	FOR OFF-SITE PIPING
Upto Dia. 1 ½ “	1JT/MTR.	1JT/2MTRS.
Dia. 2” to 6”	1JT/1.5MTR	1JT/4MTRS
Dia. 8” to 12”	1JT/2MTR	1JT/4MTRS
Dia.14” & above	1JT/2.5MTR	1JT/4MTRS

8. What are the consumption norms for Electrodes & Filler wire?
Answer:-

Consumption Norms for Welding Electrode & Filler Wires

DESCRIPTION OF JOB	UOM	Weld metal weight gms/ UOM	ELECTRODE CONSUMPTION (gms/UOM.)						TUNGSTEN ELECTRODE CONSUMPTION (EA/UOM)	TUNGSTEN ELECTRODE CONSUMPTION (EA/UOM)	Remarks
			SINGLE	SINGLE	COMBINATION		COMBINATION				
			GTAW	SMAW	GTAW	SMAW	SMAW	FCAW			
									Full GTAW	Root GTAW	
Piping-Shop welding											
CS-NIBR ---											
T < 10 mm (FULL TIG)	ID	48	63	-	-	-	-	-	0.06336		
10 mm < = t < 12 mm(Full Tig))	ID	83	110	-	-	-	-	-	0.10956		
12 mm < = t < 15 mm(Full Tig)	ID	127	168	-	-	-	-	-	0.16764		
t < 10 mm (TIG+SMAW)	ID	48	-	-	19	59	-	-		0.019	
10 mm < = t < 12 mm(Tig+SMAW)	ID	83	-	-	19	121	-	-		0.019	
12 mm < = t < 15 mm(Tig+SMAW)	ID	127	-	-	19	198	-	-		0.019	
t < 10 mm (BY SMAW/SSFCAW)	ID	48	-	84	-	-	26	49	NA		
10 mm < = t < 12 mm(BY SMAW/SSFCAW)	ID	83	-	146	-	-	26	100	NA		
12 mm < = t < 15 mm(BY SMAW/SSFCAW)	ID	127	-	224	-	-	26	165	NA		
15 mm < = t < 19 mm(BY SMAW/SSFCAW	ID	180	-	317	-	-	26	243	NA		
19 mm < = t < 24mm(BY SMAW/SSFCAW	ID	287	-	505	-	-	26	400	NA		
24 mm < = t < 30 mm(BY SMAW/SSFCAW)	ID	339	-	597	-	-	26	477	NA		
30 mm < = t < 37 mm(BY SMAW/SSFCAW)	ID	431	-	759	-	-	26	612	NA		
CS-IBR ---											
t < 10 mm (FULL TIG)	ID	48	63	-	-	-	-	-	0.06336	NA	
10 mm < = t < 12 mm(Full Tig))	ID	83	110	-	-	-	-	-	0.10956	NA	
12 mm < = t < 15 mm(Full Tig)	ID	127	168	-	-	-	-	-	0.16764	NA	
t < 10 mm (TIG+SMAW)	ID	48	-	-	19	59	-	-	NA	0.019	
t < 10 mm (BY SMAW/SSFCAW)	ID	48	-	84	-	-	26	49	NA	NA	
10 mm < = t < 12 mm(BY SMAW/SSFCAW)	ID	83	-	146	-	-	26	100	NA	NA	
12 mm < = t < 15 mm(BY SMAW/SSFCAW)	ID	127	-	224	-	-	26	165	NA	NA	
15 mm < = t < 19 mm(BY SMAW/SSFCAW	ID	180	-	317	-	-	26	243	NA	NA	
19 mm < = t < 24mm(BY SMAW/SSFCAW	ID	287	-	505	-	-	26	400	NA	NA	
24 mm < = t < 30 mm(BY SMAW/SSFCAW)	ID	339	-	597	-	-	26	477	NA	NA	
30 mm < = t < 37 mm(BY SMAW/SSFCAW)	ID	431	-	759	-	-	26	612	NA	NA	
LTCS :											
t < 10 mm	ID	48	63	84	19	59	-	-	0.06336	0.019	
10 mm < = t < 12 mm	ID	83	110	146	19	121	-	-	0.10956	0.019	
12 mm < = t < 15 mm	ID	127	168	224	19	198	-	-	0.16764	0.019	
15 mm < = t < 19 mm	ID	180	238	317	19	291	-	-	0.2376	0.019	
19 mm < = t < 24mm	ID	287	379	505	19	480	-	-	0.37884	0.019	
24 mm < = t < 30 mm	ID	339	447	597	19	571	-	-	0.44748	0.019	
30 mm < = t < 37 mm	ID	431	569	759	19	733	-	-	0.56892	0.019	
SS-NIBR											
t < 10 mm	ID	48	63	84	19	59	-	-	0.06336	0.019	
10 mm < = t < 12 mm	ID	83	110	146	19	121	-	-	0.10956	0.019	
12 mm < = t < 15 mm	ID	127	168	224	19	198	-	-	0.16764	0.019	
15 mm < = t < 19 mm	ID	180	238	317	19	291	-	-	0.2376	0.019	
19 mm < = t < 24mm	ID	287	379	505	19	480	-	-	0.37884	0.019	
24 mm < = t < 30 mm	ID	339	447	597	19	571	-	-	0.44748	0.019	
30 mm < = t < 37 mm	ID	431	569	759	19	733	-	-	0.56892	0.019	
AS-NIBR											
t < 10 mm	ID	48	63	84	19	59	-	-	0.06336	0.019	
10 mm < = t < 12 mm	ID	83	110	146	19	121	-	-	0.10956	0.019	
12 mm < = t < 15 mm	ID	127	168	224	19	198	-	-	0.16764	0.019	
15 mm < = t < 19 mm	ID	180	238	317	19	291	-	-	0.2376	0.019	
19 mm < = t < 24mm	ID	287	379	505	19	480	-	-	0.37884	0.019	
24 mm < = t < 30 mm	ID	339	447	597	19	571	-	-	0.44748	0.019	
30 mm < = t < 37 mm	ID	431	569	759	19	733	-	-	0.56892	0.019	
AS-IBR											
t < 10 mm	ID	48	63	84	19	59	-	-	0.06336	0.019	
10 mm < = t < 12 mm	ID	83	110	146	19	121	-	-	0.10956	0.019	
12 mm < = t < 15 mm	ID	127	168	224	19	198	-	-	0.16764	0.019	
15 mm < = t < 19 mm	ID	180	238	317	19	291	-	-	0.2376	0.019	
19 mm < = t < 24mm	ID	287	379	505	19	480	-	-	0.37884	0.019	
24 mm < = t < 30 mm	ID	339	447	597	19	571	-	-	0.44748	0.019	
30 mm < = t < 37 mm	ID	431	569	759	19	733	-	-	0.56892	0.019	

Consumption Norms for Welding Electrode & Filler Wires

Item Code	DESCRIPTION OF JOB	UOM	Weld metal weight gms/ UOM	ELECTRODE CONSUMPTION (gms/UOM.)						TUNGSTEN ELECTRODE CONSUMPTION (EA/UOM)	TUNGSTEN ELECTRODE CONSUMPTION (EA/UOM)	Remarks
				SINGLE	SINGLE	COMBINATION		COMBINATION				
				GTAW	SMAW	GTAW	SMAW	SMAW	FCAW			
										Full GTAW	Root GTAW	
	U/G piping ---											
2121806	U/G piping CS T<10 mm	ID	48	63	84	19	59			0.06336	0.019	
	Fillet welding ---											
2012501	CS Fillet of Size 6 mm	Mtr	256	338	451	132	275	-	-	0.33792	0.132	
2012502	CS Fillet of size 8 mm	Mtr	400	528	704	132	528	-	-	0.528	0.132	
2012503	CS fillet of size 10 mm	Mtr	576	760	1014	132	838	-	-	0.76032	0.132	
2012504	CS fillet of size 12 mm	Mtr	784	1035	1380	132	1204	-	-	1.03488	0.132	
2012505	CS fillet of size 14 mm	Mtr	1024	1352	1802	132	1626	-	-	1.35168	0.132	
2012506	CS fillet of size 16 mm	Mtr	1296	1711	2281	132	2105	-	-	1.71072	0.132	
2012508	CS fillet of size 20 mm	Mtr	1936	2556	3407	132	3231	-	-	2.55552	0.132	
2012400	**Erection of Structure**											
2012425	Erection of Structure from ground level to 10M height	MT	NA	NA	600	NA	NA	NA	NA	NA	NA	
2012426	Erection of Structure from ground level to 10M to 20M height	MT	NA	NA	600	NA	NA	NA	NA	NA	NA	
2012427	Erection of Structure from ground level to 20M to 30 M height	MT	NA	NA	600	NA	NA	NA	NA	NA	NA	
2012500	**Modification of Structure in erected position**											
2012502	CS fillet size 8mm	Mtr	400	NA	704	NA	NA	NA	NA	NA	NA	
2012503	CS fillet size 10mm	Mtr	576	NA	1013.76	NA	NA	NA	NA	NA	NA	
2080804	Steam Tracing in ISBL Racks	Mtr	NA	37	NA	NA	NA	NA	NA	NA	0.037	
2160700	**Fabrication of pipe supports**											
2160701	CS Material	MT	NA			NA	NA	20000	NA	NA	NA	
2160800	**Erection of Pipe Supports**											
2160801	CS Material	MT	NA			NA	NA	1000	NA	NA	NA	
2011700	**Strengthening of rolled steel section by welding plates**											
2011701	Fillet of 6mm size	Mtr	256	NA	451	NA	NA	176	229.32	NA	NA	
2011702	Fillet of 8mm size	Mtr	400	NA	704	NA	NA	176	441	NA	NA	
2012100	**Fabrication of Structure**											
2012144	Fabrication of Light Steel Shapes (Wt. 25 Kg or less/RM or Plate upto 10mm thk).	MT	NA	NA	20000	NA	NA	NA	NA	NA	NA	
2012145	Fabrication of Medium Steel Shapes (Wt. Above 25 Kg upto and including 75 Kg/RM or Plate above 10mm thk upto 20mm thk)..	MT	NA	NA	16000	NA	NA	NA	NA	NA	NA	
2012146	Fabrication of Heavy Steel Shapes (Wt. Above 75 Kg upto and including 150 Kg/RM or Plate above 25mm thk upto 50mm thk)..	MT	NA	NA	14000	NA	NA	NA	NA	NA	NA	
2012147	Fabrication of Extra Heavy Steel Shapes (Wt. Above 150 Kg /RM or Plate above 50mm thk)..	MT	NA	NA	12000	NA	NA	NA	NA	NA	NA	
2012151	Welding of Nuts for fireproofing	SQM	NA	NA	26	NA	NA	NA	NA	NA	NA	
2012154	Fabrication of channel boxes	MT	NA	NA	16000	NA	NA	NA	NA	NA	NA	
2013806	Handrailing & Standards	Lin Mtr	NA	NA	125	NA	NA	NA	NA	NA	NA	
2013807	Ladders and Cages	Lin Mtr	NA	NA	125	NA	NA	NA	NA	NA	NA	

Note

1. For erection of structure, 0.6 Kg (i.e. 5% of average MT wise consumption) electrode consumption have been considered. This is in addition to the consumption against item code available for the modification of erected structure.
2. For steam tracing, equivalent to 100 mm weld, 6mm fillet per meter has been considered.
3. For welding of nuts for fire proofing, 5 nuts/Sq Feet with single welding 3mm fillet, 4mm length has been considered.
4. For handrailing, ladders & Cages erection, consumption norms has been converted to linear meter considering 25Kg/Meter weight. 50% has been considered for field welding.
5. Where root welding is carried out by E6010, consumption of E6010 shall be 30 gm/Inch Dia