


Piping Component E-books for Oil & Gas Engineer

LEARN ABOUT PIPING COMPONENTS USED IN PROCESS PIPING

HardHat Engineer

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Index

Pipe

Piping covers very large part of any process plant. If you look at Oil Exploration platform, Refinery and Petrochemical complex one thing that catches the attention is a complex network of piping. Piping is used to transport various process materials from one equipment to another. But why?

Process Plant is a place where a series of activities performed in particular ordered to convert raw material into a useful product and interconnected pipe and pipe components are used to transport raw material, intermediated product and final product to the desired location. Piping components such Pipe, Elbow, Tee, Reducer, caps, flanges, gasket, and Valves are the basic building of Oil & Gas industries.

Let's learn about first building block of Oil & Gas Industries.

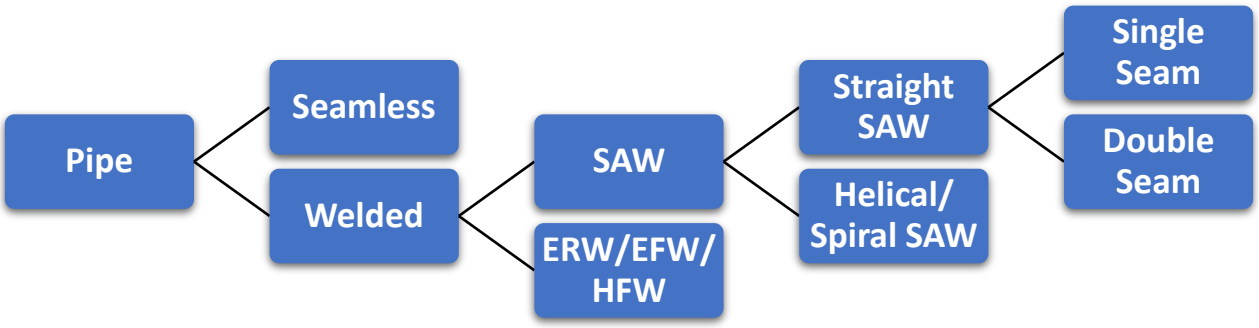
1. What is a pipe?

The pipe is a straight pressure tight cylindrical hollow, used in the piping system to transport liquid, gas and sometimes solids.

2. Types of Pipe

Different types of pipes used in different design conditions, considering technical and commercial parameters. For small & medium sizes requirement seamless pipe is more popular whereas for larger diameter welded pipes are more economical.

In the chart below, you can see the most commonly used types of pipe in Oil & Gas industries.



3. Manufacturing method of Pipe

Seamless pipe:

- Seamless pipe is Strongest amongst all pipes type as it has a Homogenous structure throughout pipe length.
- Seamless pipes are manufactured in a verity of size. However, there is a Restriction on the manufacturing of large diameter pipe. Seamless pipes are widely used in the manufacturing of pipe fittings such as bends, elbows, and tees.
    - Seamless pipes are manufactured by any of the following methods;
        - **Mandrel Mill Process** – In this method steel billet is heated to high temperature in the rotary furnish. A cylindrical hollow which is also known as mother hollow is produced with the help of a rotary piercer and set of roller arrangement that keeps the piercer at the center of the billet. Outside diameter of piercer is approximately that of the inside diameter of finished pipe. With the help, secondary roller arrangement outside diameter and thickness are achieved.
        - **Mannesmann Plug Mill Process** – Mannesmann was German engineer who has invented this method. The only difference between Plug mill process and Mandrel mill process is that in mandrel method inside diameter is achieved in single pass whereas in Mannesmann multi-stage reduction is possible.
        - **Forged Seamless Pipe** - In a Forging process, a heated billet is placed in forging die that has a diameter slightly larger than finished pipe. A hydraulic press of forging hammer with matching inside diameter is used to create cylindrical forging. Once this forging is done pipe is machined to achieve final dimension. Forging is used to manufactured large diameter seamless pipe that cannot be manufactured using traditional methods. Forged pipes are normally used for steam header
        - **Extrusion Processes** - In an extrusion method a heated billet is placed inside the die. A hydraulic ram pushes the billet against the piercing mandrel, material flows from the cylindrical cavity between die and mandrel. This action produces the pipe from the billet. Sometimes pipe manufactured produce pipe with a high thickness which is known as mother hollow. Many secondary pipes manufactured used this mother hollow to produce pipe with different dimensions.

Welded pipe:

- Welded Pipes are manufactured from Plate or continues Coil or strips. To manufactured welded pipe, first plate or coil is rolled in the circular section with the help of plate bending machine or by a roller in the case of continues process. Once the circular section is rolled from the plate, the pipe can be welded with or without filler material. Welded pipe can be manufactured in large size without any upper restriction. Welded pipe with

filler material can be used in the manufacturing of long radius bends and elbow. Welded pipes are cheaper with compared to the seamless pipe and also Weak due to the weld joint.

There are different welding methods used to weld the pipe.

- ERW- Electric Resistance Welding
- EFW- Electric Fusion Welding
- HFW- High-frequency welding
- SAW- Submerged Arc Welding (Long seam & Spiral Seam)

- In the ERW / EFW / HFW pipe process, first plate is formed in a cylindrical shape and the longitudinal edges of the cylinder formed are welded by flash-welding, low-frequency resistance-welding, high-frequency induction welding, or high-frequency resistance welding.
- In arc welding process, external filler metal (wire electrodes) are used to join the formed plates. SAW pipes can have a single longitudinal seam of double longitudinal seam depend on the size of the pipe. SAW pipe are also available in the spiral seam, which is continually rolled from the single plate coil. The production rate of spiral SAW pipe is very high as compared to Straight SAW pipe. However, Spiral SAW pipe are only used in low-pressure services such as water, non-critical process services etc.

4. Size & Dimension

Pipe Dimensions are covered in following Standard

ASME B36.10 – Welded and Seamless Wrought Steel Pipe (Carbon & Alloy Steel)
ASME B36.19 – Stainless Steel Pipe

Three different terms are commonly used to define the size of the pipe.

1. **NPS – Nominal Pipe Size**
   All American standard used NPS designation to define pipe size. This is a modern derivation of earlier IPS – Iron Pipe Size. NPS is not an OD or ID of the pipe it is in-between of the outer and the inner diameter of the pipe. For example, NPS 2 size pipe outside diameter is 60 mm or 2.375 inches. In general, NPS 12 and the smaller pipe has outside diameter greater than the size and for NPS 14 and above size pipe outside diameter is the same as the size in inches.

2. **NB – Nominal Bore**
   This is the European equivalent of NPS. In this standard pipe sizes are mentioned in millimeter

3. **DN – Diameter nominal**

This is the German equivalent of NPS. In this standard also, pipe sizes are mentioned in millimeter

In the table, you can see the correlation of size and OD.

NPS	½	¾	1	1 ½	2	3	4	6	8	10	12
NB/DN	15	20	25	40	50	80	100	150	200	250	300
OD in mm	21.3	26.7	33.4	48.3	60.3	88.9	114	168	219	273	324

Small Bore Vs Large / Big Bore Pipe

In the project, you will come across the terms such as small Bore & big bore / large bore. Pipes having size range ½" – 1 ½ " are termed as small bore. Pipes having size range 2" & above are termed as big bore.

Pipe Thickness - Schedule number

Pipe Thickness are expressed in Schedule number. What is Schedule No?

- A schedule number is an approximate value of the equation = 1000 *P/S*
  - *P* is the service pressure in (psi)
  - *S* is the allowable stress in (psi)
- Common schedule nos. are 5, 10, 20, 30, 40, 60, 80, 100, 120, 140, 160.
- Pipe Thickness are also expressed as STD, extra strong-XS, double extra strong-XXS.
- Higher the schedule no. higher the thickness of the pipe and smaller the inside diameter of the pipe as outside diameter of each pipe size is standardized.
- The thickness of stainless steel pipe is also expressed in Schedule number. Schedule no with S suffix is as per ASME B36.19, and it is used with stainless steel pipe. There is only four schedules are mentioned in ASME code which are 5S, 10S, 40S, 80S. So, please remember schedule no. 10 and 10S do not have the same thickness.
- Please note that carbon steel schedules equal stainless schedules for following
  - Up to NPS 12, all Sch 10 and Sch 10S wall thicknesses are the same.
  - Up to NPS 10, all Sch 40, Std Wt and Sch 40S wall thicknesses are the same.
  - Up to NPS 8, all Sch 80, XS and Sch 80S wall thicknesses are the same.

Pipe Length (Single Random Vs Double Random Pipe)

Pipe length is mentioned in either meter or in feet. During production pipe is not manufactured in same lengths and during construction of process plant, you required various lengths of pipe. To

address this issue standard has defined pipe lengths in single random and double random categories.

- Single random pipe comes in 4.8 m to 6.7 m in lengths with 5% of lengths in between 3.7 to 4.8 m
- Double random pipe has a minimum average of 10.7 m and a minimum length of 4.8 m with 5 % of lengths in between 4.8 m to 10.7 m

you can order Fixed length pipe also, but it may cost you more

Pipe Ends

Pipe comes in following 4 end types

1. Plain End – This kind of end used when socket type weld fittings are used.
2. Beveled End – This kind of end used when butt type weld fittings are used.
3. Threaded End – This kind of end used with threaded connections in piping system
4. Socket & Spigot – This type of end generally used in Ductile iron pipeline and non-metallic piping pipeline such as PVC, GRE/GRP.

5. Material

ASME B31.3 provides the list of material that can be used in Process Piping. in below table, you can see the most commonly used material types & their Grades.

Carbon steel **Used up to 425°c**	**Stainless steel** **Used for corrosive fluid**	**Low alloy steel** **Used for temp > (425°c)**	**Low temp carbon steel** **Used for temp < (-29°c)**
A53 Gr B A106 Gr B API 5L Gr B	A312 Gr TP304 A312 Gr TP316 A312 Gr TP321	A335 Gr P2 , P12, P11, P22, P5, P9	A333 Gr 6

Chemical Properties of these piping material are covered in their respective ASTM standard. ASTM Standard restrict the use of material produced by certain manufacturing process only. For example, ASTM A106 allow only killed steel that produces by the open-hearth, basic-oxygen, or electric furnace, with preferred separate degassing.

6. Heat Treatment (Hot Finished Vs Cold Finished)

Heat treatment of pipe depends on the way it is manufactured.

- **In the case of hot finished pipe**, no heat treatment is required. As during the manufacturing, Pipe temp. remain in the range of heat treatment temperature till the final size and thickness are achieved

- **In the case of Cold finished pipe**, heat treatment is required as per applicable ASTM standard. The cold finished pipe is either cold drawn or temperature is not in maintained in the standard specified range during the manufacturing.

Different heat treatment methods are used for different grade of the pipe material. These heat treatment methods are

- Normalizing
- Quenching
- Tempering
- Solution Annealing
- Stress relieving
- Or it is a Combination of above

7. Product analysis – Chemical & Mechanical Testing

Metallurgical Tests confirm the chemical requirements of pipe are as per the material standard.

- Metallurgical Tests are normally known as Micro and Macro testing.
- Micro Analysis or Chemical Analysis of
  - Raw material
  - Product
  - And Weld ensures that all the alloying elements are within the range as specified in the material standard.
- Macro Analysis for Weld will check proper fusion of weld material with pipe material.
- There are some Special tests also carried out on pipe material when it is going to be used in aggressive environments. These tests will ensure that pipe material is able to withstand in such aggressive environments also. Some of the tests are
  - Grain size (AS & SS)
  - IGC- Intergranular Corrosion Test(SS)
  - Ferrite (SS)
  - HIC- Hydrogen-induced Cracking
  - SSC- Sulfide Stress Corrosion Cracking

  These tests are performed when it is asked by the purchaser in his specification.

The mechanical / Destructive test confirms the mechanical requirements of pipe are as per the material standard.

In Destructive Testing- a sample from the pipe is cut to performed tests

- The tensile test is done to check yield and ultimate tensile of the pipe. If required by the purchaser or by standard high or low-temperature tensile test are also performed.
- Bend test / Guided bend test are used to check integrity of weld joint

- Flattening test examines ability of plastic deformation in pipe
- Impact test / Charpy V-Notch Test, check the ability of material to withstand under low-temperature conditions
- Creep test is done to check long term effect of temperature under constant load.

8. Inspection – Hydro test, NDT, Visual, Dimension Tolerance

To ensure product quality, during and after the production certain inspection and non-destructive testing are performed on the pipe body & weld. They will check whether any physical defects are present in the pipe / weld, which may affect its performance during the service. These testing are

- Flux leakage examination or Magnetic flaw detection
- Eddy current
- Ultrasonic – can be done on full body or only for weld seam
- Radiography (Only for Weld)
- Magnetic particle test for pipe ends & weld seam
- And Positive Material Identification.

Hydrostatic Test is carried out to

- Ensure that pipe is 100% leak proof
- It also ensures the ability to withstand pressure
- Hydro test pressure is calculated based on equation given in ASTM A530,

  P = 2St/D or S = PD/2t

  P = hydrostatic test pressure in psi or Mpa,
  S = pipe wall stress in psi or Mpa,
  t = specified nominal wall thickness, nominal wall thickness corresponding to specified ANSI schedule number, or 1.143 times the specified minimal wall thickness, in. [mm], and
  D = specified outside diameter, outside diameter corresponding to specified ANSI pipe size, or outside diameter calculated by adding 2t (as defined above) to the specified inside diameter, in. [mm].
- Holding time for the hydro test is minimum 5 sec as per ASTM A530. Pressure is monitored by the computerizing system.
- For welded pipe, the test pressure should be held for a time, sufficient to permit the inspector to examine the entire length of the welded seam
- Hydrostatic test can be waived under certain conditions as set in the ASTM standard

Visual Inspection

- Visual Inspection is one of the most effective inspection method used to check overall product quality. During the visual inspection, you will check for overall product finish. You will check

for surface imperfections such as mechanical marks, lamination, tears or any other visual imperfections and also check weld defects such as porosity, undercuts, uneven weld bead, and excess or under fill of weld material. Acceptance of these imperfections is as per applicable ASTM standard

Dimension inspection

- Dimension inspection of the pipe is carried out based on the Dimension Standard, final dimension of the pipe must confirm the following standard or it should be as specified in purchaser's specification.
- For Welded and Seamless Wrought Steel Pipe dimensional requirements are cover in ASME B36.10
- For Stainless Steel Pipe dimensional requirements are cover in ASME B36.19

During dimensional inspection, following to be confirmed with standard

- Diameter
- Length
- Thickness
- Straightness
- Ovality &
- Weight

Permissible Variations depends on manufacturing standard.

Tolerances for Outside Diameter Pipe

Nominal Pipe Size		Carbon Steel		Stainless Steel
NPS	DN	ASTM A53M	ASTM A106M	ASTM A999M
⅛ to 1½	6 to 40	±0.4 mm	±0.4 mm	+0.4 / -0.8 mm
Over 1½ to 4	Over 40 to 100	±1%	±0.8 mm	±0.8 mm
Over 4 to 8	Over 100 to 200	±1%	+1.6 / -0.8 mm	+1.6 / -0.8 mm
Over 8 to 18	Over 200 to 450	±1%	+2.4 / -0.8 mm	+2.4 / -0.8 mm
Over 18 to 26	Over 450 to 650	±1%	+3.2 / -0.8 mm	+3.2 / -0.8 mm
Over 26 to 34	Over 650 to 850	±1%	+4.0 / -0.8 mm	+4.0 / -0.8 mm
Over 34 to 48	Over 850 to 1200	±1%	+4.8 / -0.8 mm	+4.8 / -0.8 mm

Tolerances for Wall Thickness of Pipe

Nominal Pipe Size		Carbon Steel	Stainless Steel
NPS	DN	ASTM A53M & 106M	ASTM A312M
6 to 65	⅛ to 2½	-12.5% minimum	+20.0 / -12.5%
3 to 18, t/D ≤ 5% t/D > 5%	80 to 450, t/D ≤ 5% t/D > 5%	-12.5% minimum	+22.5 / -12.5% +15.0 / -12.5%
20 and over… ▪ welded ▪ seamless, t/D ≤ 5% ▪ seamless, t/D > 5%	500 and over… ▪ welded ▪ seamless, t/D ≤ 5% ▪ seamless, t/D > 5%	-12.5% minimum (maximum wall thickness limited only by mass)	 +17.5 / -12.5% +22.5 / -12.5% +15.0 / -12.5%
t = nominal wall thickness		D = ordered outside diameter	

Tolerances for Mass / weight of Pipe

The mass of all carbon steel pipe and seamless stainless steel pipe is limited to +10% and a minus limit that varies depending on size – refer to standards for more details.

Straightness

The carbon steel pipe standards require only that "the finished pipe shall be reasonably straight". ASTM A312M (in ASTM A999M) requires welded stainless steel pipe to be straight to within 3.2 mm over 3.0 m length. Generally, thumb rule is that 1 mm per meter is acceptable. However, most purchaser clearly specified a maximum acceptable limit for straightness.

9. Marking

Once the pipe is cleared all test and inspection, it is marked as per the standard requirements

- Following shall be marked on pipe
  - Manufacturer logo
  - ASTM material code
  - Material Grade
  - Size
  - Thickness- schedule no.
  - Length
  - Heat No
  - Special marking WR for weld repair or NH for the non-hydro tested pipe.
- These Marking can be done by paint or by Hard punching
- For stainless steel, pipe stenciling is also used
- Please note that
  - For carbon steel no hard punching below 6 mm thickness
  - For stainless steel no hard punching below 12 mm thickness

10. Packing

To prevent the damage during transportation, pipe ends are covered with a cap. Spider supports at the end of the pipe are also installed in Large diameter pipe to protect circularity of pipe.

11. Supplementary requirements

Supplementary requirements are optional requirements that purchaser has to specify along with purchase requisition. Mainly these requirements are related to additional testing of the product such as low-temperature tensile, transverse tensile, restriction on Carbon Equivalent etc.

Each standard lists these requirements at the end of the standard product requirements.

Refer Table for Supplementary requirements of ASTM A106 & ASTM A312,

ASTM A106	**ASTM A312**
Product Analysis	Product Analysis
Transverse Tension Test	Transverse Tension Test
Flattening Test, standard	Flattening Test
Flattening Test, Enhanced	Etching Tests
Metal Structure and Etching Test	Radiographic Examination
Carbon Equivalent	Stabilizing Heat Treatment
Heat Treated Test Specimens	Intergranular Corrosion Test
Internal Cleanliness–Government Orders	Minimum Wall Pipe
Requirements for Carbon Steel Pipe for Hydrofluoric Acid Alkylation Service	Weld Decay Test

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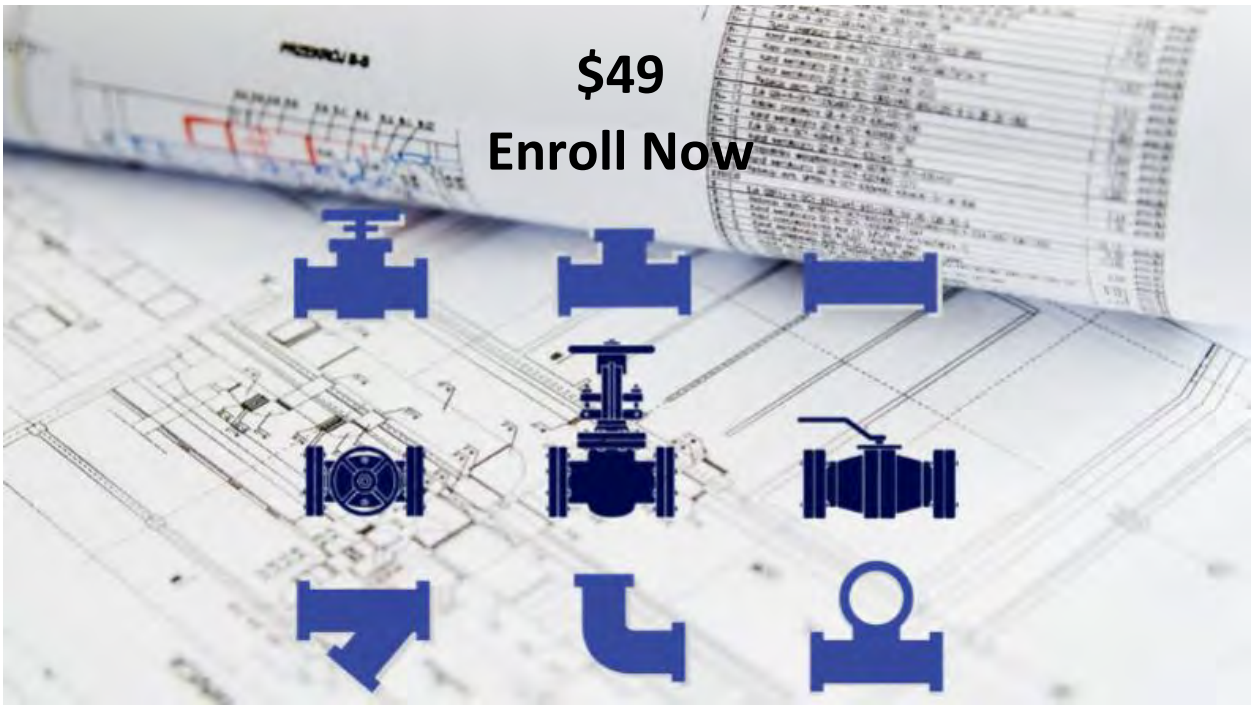

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Pipe Fittings

1. What are Pipe Fittings?

Fittings are Piping component which helps in Changes the direction of the flow such as elbows, tee. Changes the size of the pipe such as reducers, reducing tees. Connect to components together such as couplings and stop the flows such as Caps.

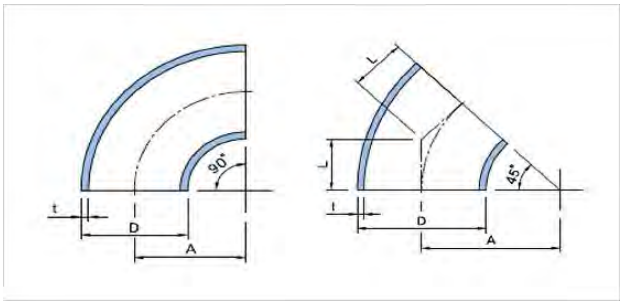
Elbow:

Elbow is used more than any other pipe fittings. It Provides flexibility to change the pipe direction. Elbow mainly available in two standard types 90° and 45°. However, it Can be cut to any other degree.

Elbows are available in two radius types, Short radius (1D) and Long radius (1.5D).

A Long Radius elbow is having the radius equivalent to 1.5 times the Diameter of the pipe and a Short Radius elbow is having the radius equivalent to the Diameter of the pipe.

- Long Radius A=1.5D
- Short Radius A=1D



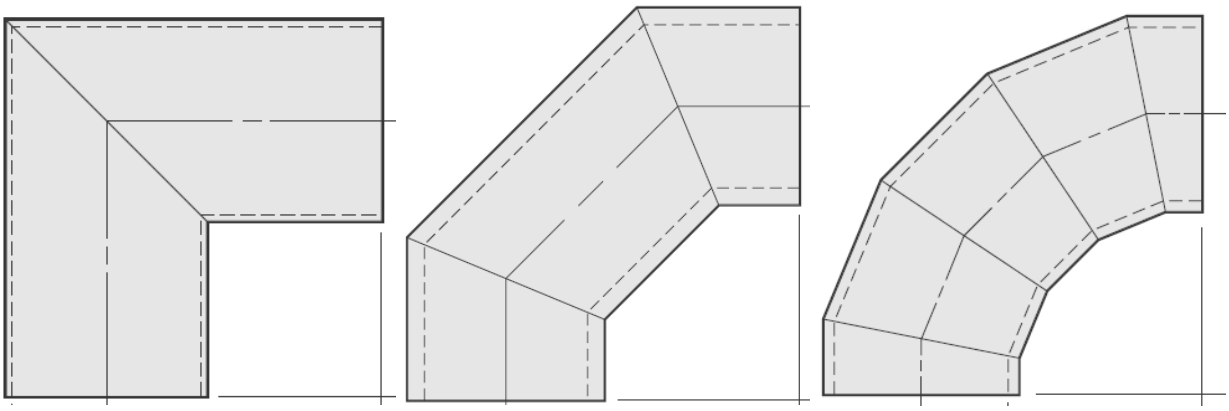
When fluids are transported to long distances or go frequent directional changes, short radius elbows are not recommended because of their greater friction loss, which may require installation of larger pump or compressor.

Reducing Elbow:

The 90 reducing elbow is designed to change direction as well as reduce the length of flow within a piping system. The reducing elbow eliminates one fitting and reduces the welding by more than one-third. Also, the gradual reduction in diameter throughout the arc of the reducing elbow provides lower resistance to flow and reduces the effect of stream turbulence and potential internal erosion. These features prevent sizeable pressure drops in the line.

Miter bend:

Miter bends are not standard fittings they are fabricated from pipes. Usually they are preferred for size 10” & above because large size elbow is expensive. Use of miter bend is restricted to low pressure water line. Miter bend can be fabricated in 2, 3, & 5 pieces.



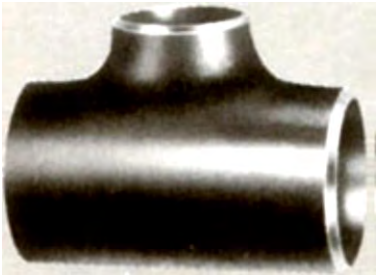
Returns:

Retuning elbows are used to make 180º change in direction. Available in short & long pattern. Mainly used in heating coil, heat exchanger etc.

Tee:

There are different types of Tee used in piping,

- Equal/Straight Tee– in this type of tee Diameter of Branch is same as the Diameter of the Run Pipe
- In Reducing Tee – Diameter of the Branch size is smaller than the Diameter of the Run Pipe

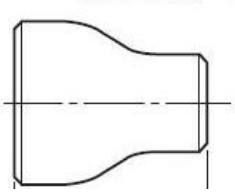


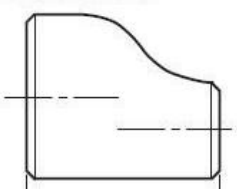
Cross:

Cross are also known as four-way fittings. A cross has one inlet and three outlets (or vice versa). Generally, crosses are not used in process piping to transport fluid. But forged crosses are common in fire water sprinkler line.

Reducer:

There are two types of reducer used in piping Concentric & Eccentric.





- In Concentric reducer, center of the both the ends are on same axis. It maintains the center line elevation of pipe line.
- Whereas in Eccentric reducer, center of the both the ends are on different axis as shown in image. It maintains BOP (bottom of pipe) elevation of pipe line.

$$Offset = \frac{(Larger\ ID - Smaller\ ID)}{2}$$

Swage:

Swage is like reducers used to connect butt welded pipes to smaller screwed or socket welded pipes. Like reducers they are concentric & eccentric type. They are covered under the regulatory code BS – 3799.

Pipe caps:

Pipe caps are used at the dead end of the piping system. It is also used in piping headers for future connections

Stub ends:

Stub ends are used with lap joint flange. In this type of flange, stub is butt welded with pipe, whereas flange is freely move over the stub end.

Union:

Union is used to connect small bore pipes. It can be socket end or threaded end

Half Coupling & Full Coupling:

Half Coupling generally used for branching or for vessel connections. It can be threaded or socket type.

Full Coupling Generally used for connecting pipes or items with either threaded or socket ends.

2. Pipe Fitting Dimensions

Wrought Fittings Size & Thickness are always in line with connecting pipe dimension.

- Fittings are sized with respect to pipe size. In Nominal pipe size (NPS) & also as a Diameter nominal (DN)
- Thicknesses are marked in schedule no. Fitting are generally have a higher thickness than pipe to avoid any rejection due to thickness reduction during manufacturing. To avoid mismatch of fittings ID to pipe ID, manufacturer bevel the inside edge of fittings.

Forged Fittings are classified based on its pressure-temperature class

- Socket weld & Threaded end fittings are available from NPS 1/8” to 4” size
- Forged Fittings are available in following pressure-temperature ratings class
  - 2000 (Only Threaded Fittings)
  - 3000 & 6000 (for both types)
  - 9000 (Only Socket weld Fittings)

3. Fitting Materials

Fittings are always connected with pipe hence, Chemical and Mechanical property of these material to match with pipe material

- Fittings are manufactured in different material grade to match pipe material such as carbon steel, alloy steel, stainless steel and exotic material such as titanium, copper alloy etc.
- ASME B16.9 &16.28 provides list of material used to manufactured wrought fittings
- ASME B16.34 Provides list of material used to manufactured forged fittings as per ASME B16.11
    - ASME B16.9 is standard for - Factory-Made Wrought Buttwelding Fittings & ASME B16.28 is standard for - Butt-Welded Short Radius Elbows & Returns Bends
    - ASME B16.11 is standard for - Forged steel socket welding & threaded fittings which refer another ASME standard for material which is standard for ASME B16.34 Flanged, Threaded, And Welding End Valves

Material grade shall be prefix with WP if fittings are made as per ASME B16.9 & B16.28

- Commonly used material grades for wrought fittings are listed hear
- For Carbon Steel :- ASTM A234Gr.WPA/B, ASTM A420 Gr.WPL6
- For Alloy Steel :- ASTM A234 WP1 /WP5 /WP7 /WP9 /WP11 /WP12 /WP22
- And for Stainless Steel :- ASTM A403 WP304 /WP304L /WP304H /WP316 / WP316L/ WP321/ WP347

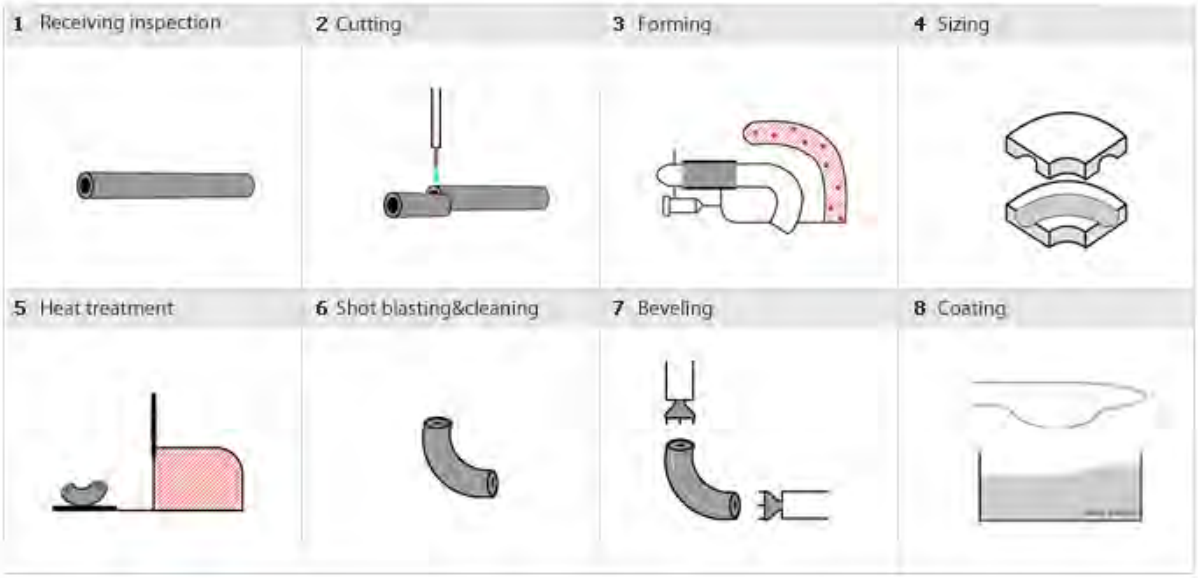
4. Pipe Fittings Manufacturing

Fittings are manufactured from Seamless Pipe and from Welded Pipe with filler material (ERW & EFW pipes cannot be used to manufactured fittings). large diameter fittings are manufactured from Plate.
To manufactured wrought fitting various methods are used, these are all different type of Hot and cold forming process. These methods are

- Hot forming or Extrusion Method
- Hydraulic Bulge method – Cold forming
- UO or Single weld seam Method
- Monaka or Double weld seam Method
- Deep Drawing Method for caps
- Flare Method for Stub ends

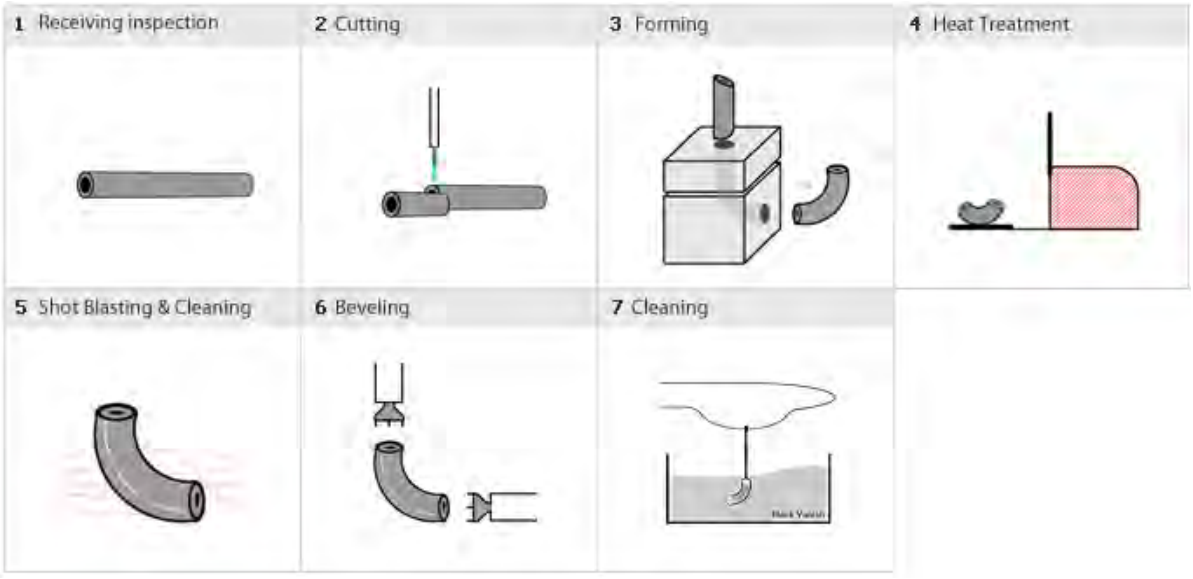
ELBOWS: Mandrel method (Hot Forming)

- One of the most common manufacturing methods for manufacturing Elbows from pipe is mandrel method which is kind of hot forming methods.
- In this method pipe is cut in pieces and push with the help of hydraulic ram. Induction heating coil heat the pipe and, it is pushed over a die called "mandrel" which allows the pipe to expand and bend simultaneously.
- This method can be used to manufacture a wide range of diameter of elbows.



Extrusion Method

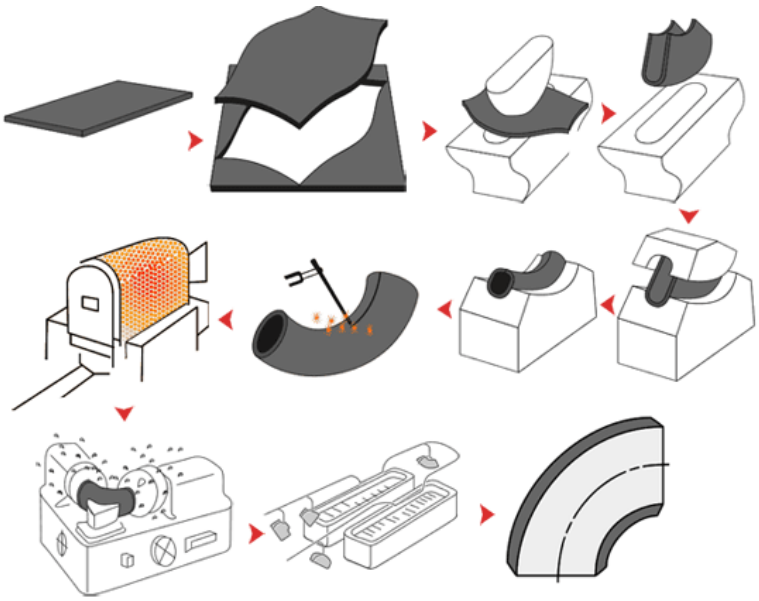
In cold Extrusion method, a pipe with the same diameter as finished product, is pushed through a die and formed into its desired shape. Usually applied to stainless steel small to medium sizes elbows.



UO Method

UO method is used to manufacture medium size of elbow, tee and reducers. Plate is cut out into a specially designed shape, it is formed first into a U-shape using a die and then into an O-shape or tubular form

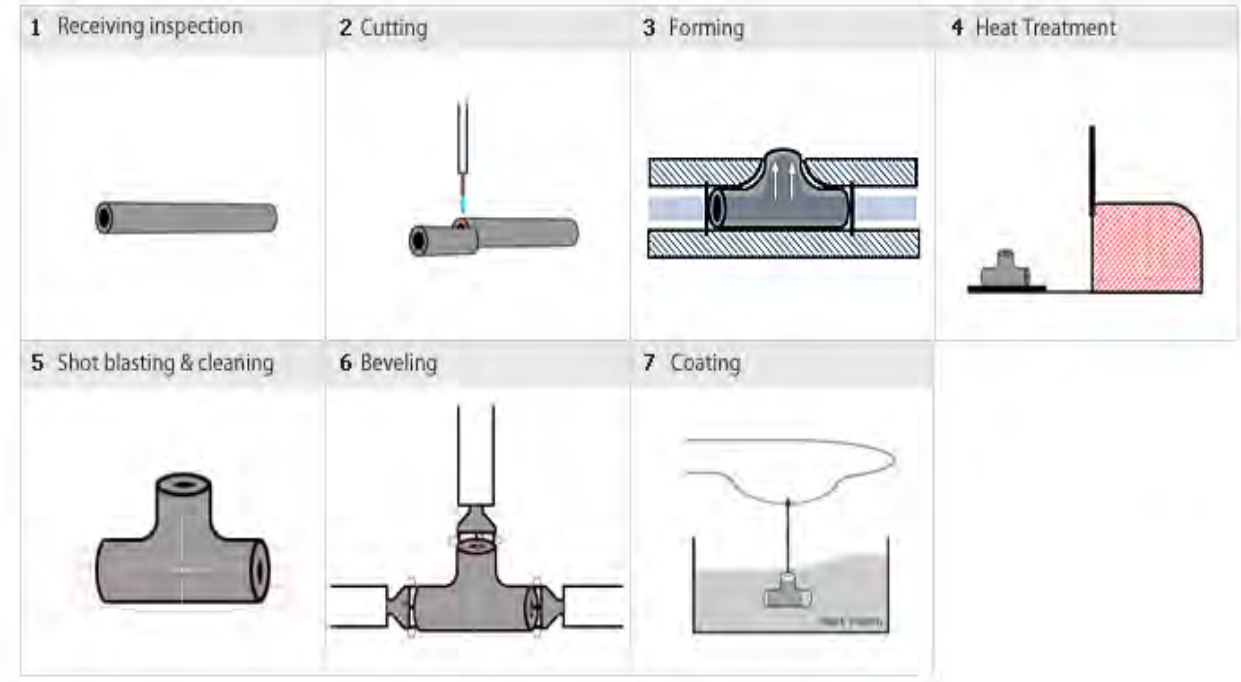
using another die, that is why this method is known as UO method. Once the fittings formed in tumbler shaped it is welded from inside and outside of the closing seam. A cut plate is 1st from in U shape and then in O shape.



Hot Forming Method

In a Hot Forming Die Bending method a Pipe is heated to forming temperature & formed in die with specific shape, this process may be repeated as needed to obtain the required shape, size and wall thickness. Usually applied to thick-wall items that cannot be bent on a mandrel die

Hydraulic Bulge method



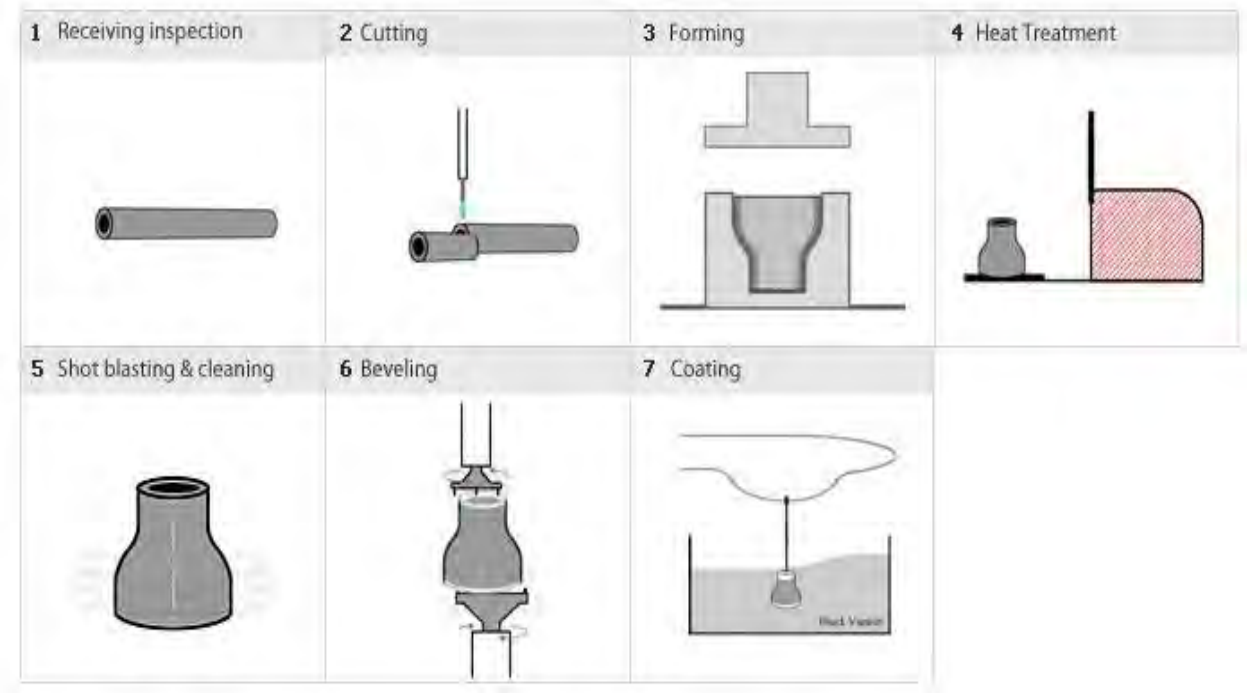
Hydraulic Bulge method is used to manufacture Tee. Cut piece of Pipe is placed in hydraulic die and liquid is fill inside the pipe, Hydraulic pressure pushes out the branch, in the fixed opening in the die. This method gives good surface finish. However, higher thickness Tee cannot be manufactured by this method.

Hot Extrusion Method for Tee Manufacturing

Tees with large diameters, heavy wall thickness and /or special material with challenging workability that cannot be manufactured using the hydraulic bulge method are manufactured using hot Extrusion Method. In hot Extrusion Method, Normally Bigger diameter pipe is used than the finished product size, the branch outlet is extruded from the pipe with help of extrusion tool. Other dimensions of body and branched can also be adjusted by pressing the die if required.

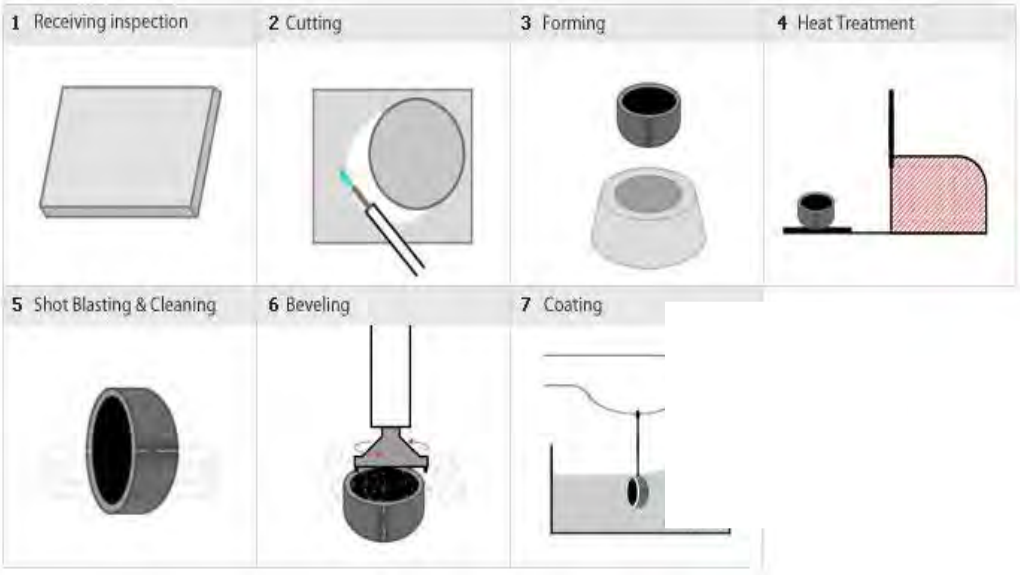
Outer Die Method

Most common method for manufacturing Reducers is Outer Die method. Pipe is cut and pressed in the outer die; compressing the one end of pipe into a smaller size. This method is useful for manufacturing of small to medium size of reducers.



Deep Drawing Method

CAPS are manufactured by Deep Drawing method. In this method Plate is cut out in a circle and formed by deep drawing die.



Flaring Method

Stub Ends or Lap Joints Flange are manufactured by flaring method. Pipe end is flare or spared out to form flange face as shown in picture. Stub ends are also manufactured by forging in which forge block are machined to final dimension.

5. Fitting heat Treatment

Hot finished pipe fittings do not require heat treatment, however for Cold finished pipe fittings Heat treatment is required as per applicable ASTM standard.

- Common Heat Treatment for Fittings are
- Normalizing
- Quenching
- Tempering
- Solution Annealing
- Stress reliving
- And Combination of above

6. Hydrotest for Pipe Fittings

- Hydrostatic Test Not required for pipe fittings unless specifically requested by purchaser
- Code mandate that fittings shall be able to withstand under pressure required by applicable Piping Code.
- Most purchasers mandate, that a hydro tested pipe shell be used to manufacture fittings.

Proof Test

To qualified the design of the pipe fitting, manufacturer performed a various test including burst test to ensure that design will meet the all the standard & code requirements. In this test, a pipe & fittings are welded and a dummy pipe spool is prepared. This pipe spool is then pressurized to pre define calculated burst test pressure. If the fittings withstand the test, all the future product manufactured using that design will consider safe to use.

Lap joint stub ends are exempt from the proof test because they are used with flange assembly and design considering applicable pressure- temperature ratings.

7. Non Destructive testing

Based on type of fittings any of the following Non Destructive testing are performed on finished fittings to ensure soundness of product.

- Ultrasonic
- Radiography (Only for Weld)
- Magnetic particle test
- Liquid penetrant test
- And Positive Material Identification

8. Destructive Testing

Destructive Testing are performed to check of the strength of the body and weld of the product.

- Proof test is also known as type test or burst test. Manufacturer use this test to qualify fitting design. Fittings are welded with pipe and pressurize up to burst pressure calculated by design or till the fittings burst. This is one time test to qualify the fitting design. Other destructive test are
- Tensile test
- Impact test / Charpy V-Notch Test
- And hardness test

9. Metallurgical Tests

Metallurgical Tests are performed on fittings body and weld to confirm standard requirements

- Micro Analysis or Chemical Analysis of
  - Raw material
  - Product
  - Weld
- Macro Analysis
  - Weld

10. Special Tests

- Special tests are carried out on fittings to confirm its ability to with stand in corrosive environments. These tests are
  - IGC- Intergranular Corrosion Test(SS)
  - Ferrite (SS)
  - HIC- Hydrogen-induced Cracking
  - And SSC- Sulfide Stress Corrosion Cracking
  - Grain size (AS & SS) of material are checked to confirm micro structure.

11. Visual Inspection

Visual Inspection are conducted on fittings to check any surface imperfections.

Both fittings body and weld are checked for any visible surface imperfections such as dents, die marks, porosity, undercuts etc.

Acceptance as per applicable standard

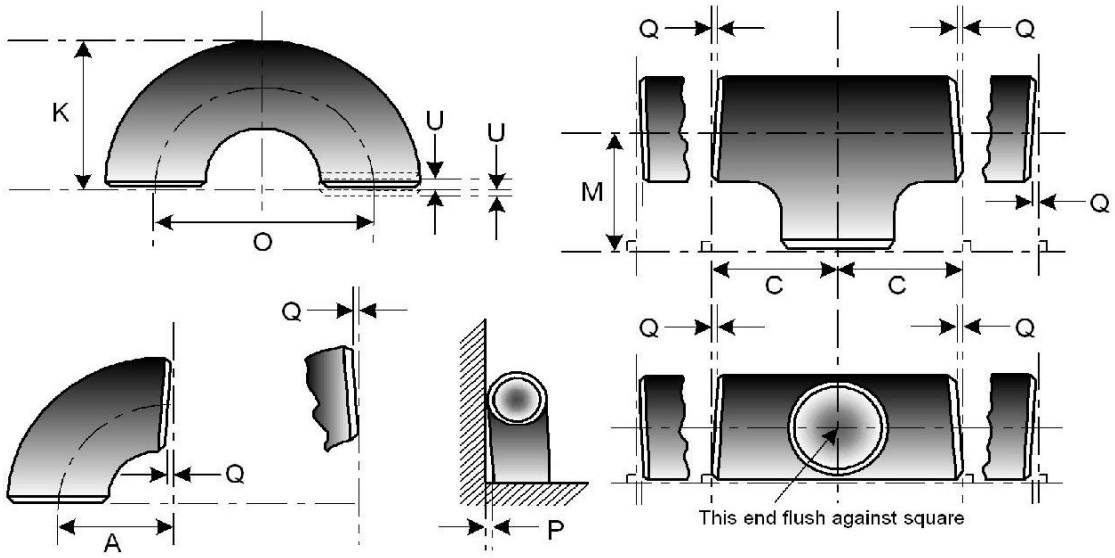
12. Dimension Inspection

Dimension of the fittings must meet the standard requirements.

- For Wrought Product (WP) Dimension are covered in
  - ASME B16.9- Factory-made Wrought Butt-welding Fittings for size NPS ½ through NPS 48 and
  - B16.28- for Wrought Steel Butt-Welding Short Radius Elbows and Returns for size NPS ½ through NPS 24

- For Forged Fittings Dimension are covered in ASME B16.11- Forged Steel Fittings, Socket Welding and Threaded

- Following to be confirm during inspection
  - Diameter
  - Length
  - Thickness schedule no
  - Straightness & perpendicularity of the fittings ends
  - Degree of elbows & bends
  - And Concentricity of reducer



Nominal Pipe Size	All Fittings			Elbows and Tees	180 Deg Return Bends			Reducers	Caps
NPS	O.D. at Bevel (1), (2)	I.D. at End (1), (3), (4)	Wall Thickness (3)	Centre-to-End Dimension A,B,C,M	Centre-to-Centre O	Back-to-Face K	Alignment of Ends U	Overall Length H	Overall Length E
1/2 to 21/2	+0.06 -0.03	0.03	Not less than 87.5% of nominal thickness	0.06	0.25	0.25	0.03	0.06	0.12
3 to 31/2	0.06	0.06		0.06	0.25	0.25	0.03	0.06	0.12
4	0.06	0.06		0.06	0.25	0.25	0.03	0.06	0.12
5 to 8	+0.09 -0.06	0.06		0.06	0.25	0.25	0.03	0.06	0.25
10 to 18	+0.16 -0.12	0.12		0.09	0.38	0.25	0.06	0.09	0.25
20 to 24	+0.25 -0.19	0.19		0.09	0.38	0.25	0.06	0.09	0.25
26 to 30	+0.25 -0.19	0.19		0.12	...	...	...	0.19	0.38
32 to 48	+0.25 -0.19	0.19		0.19	...	...	...	0.19	0.38

Nominal Pipe Size NPS	Angularity Tolerances	
	Off Angle Q	Off Plane P
1/2 to 4	0.03	0.06
5 to 8	0.06	0.12
10 to 12	0.09	0.19
14 to 16	0.09	0.25
18 to 24	0.12	0.38
26 to 30	0.19	0.38
32 to 42	0.19	0.50
44 to 48	0.18	0.75

All dimensions are given in inches. Tolerances are equal plus and minus except as noted.

(1) Out-of-round is the sum of absolute values of plus and minus tolerance.

(2) This tolerance may not apply in localized areas of formed fittings where increased wall thickness is required to meet design requirements of ASME B16.9.

(3) The inside diameter and the nominal wall thicknesses at ends are to be specified by the purchaser.

(4) Unless otherwise specified by the purchaser, these tolerances apply to the nominal inside diameter, which equals the difference between the nominal outside diameter and twice the nominal wall thickness.

13. Pipe Fitting Marking

Following shall be marked on Fittings

- Manufacturer logo
- ASTM material code
- Material Grade
- Size, for tee size of branch & run pipe and for reducer size of both end
- Thickness (Schedule No) for both the ends if they are connected to different thickness pipe
- Heat No
- Compliance - for standard fittings –WP, for Special fittings S58, S8, SPLD etc.

Marking can be done by painting or by Hard punching. For stainless steel stenciling can be used. For carbon steel no hard punching below 6 mm thickness and for stainless steel no hard punching below 12 mm thickness

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Pipe Flanges

1. Flange

The flange is second most used joining method after welding. Flanges are used when joints need dismantling. It Provides flexibility for maintenance. Flange Connects the pipe with various equipment and valves. Breakup flanges are added in the pipeline system if regular maintenance in required during plant operation.

A flanged joint is composed of three separate and independent although interrelated components; the flanges, the gaskets, and the bolting; which are assembled by yet another influence, the fitter. Special controls are required in the selection and application of all these elements to attain a joint, which has acceptable leak tightness.

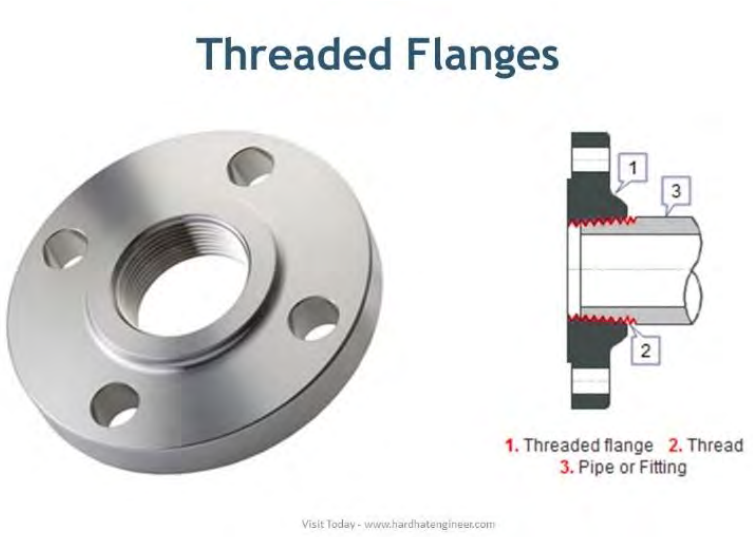
However, it is not advisable to used flange connection in underground piping when it supposed to be buried. The flange is also a most common source of leak and fire in a process plant. There are variety of flanges available to suit the requirements. Flanged can be classified in several alternate ways as follows:

1. Based on Types of Connection
2. Based on Flange facing Types
3. Based on Pressure Temperature Ratings
4. Based on Material Types

2. Flange Types

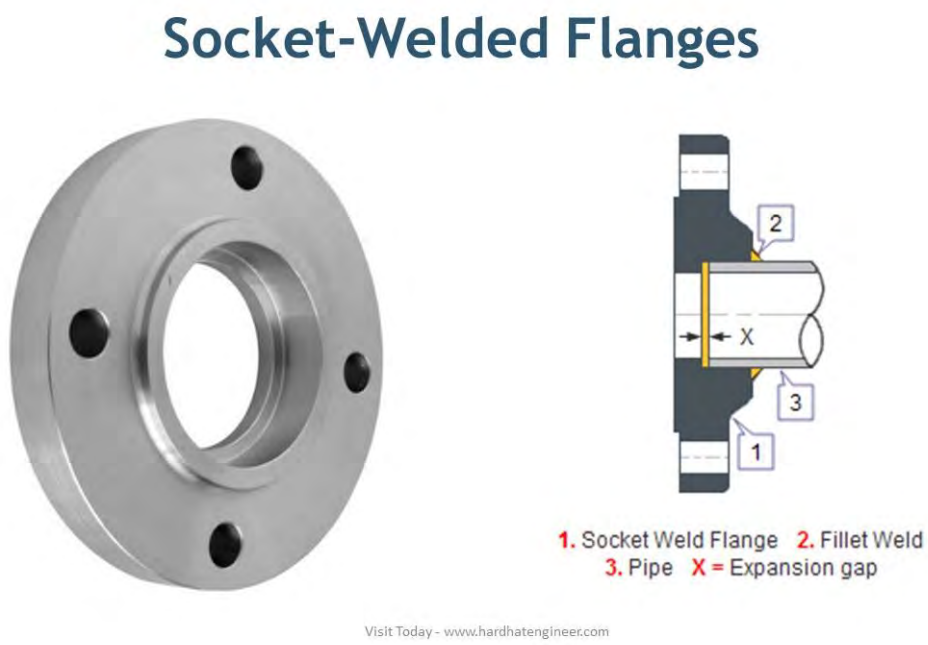
Threaded Flanges

Threaded Flanges are also known as screwed flange, and it is having a thread inside the flange bore which fits on the pipe with matching male thread on the pipe. This type of joint connection is Speedy and simple but not suitable for high presser and temperature applications. Threaded Flanges are mostly used in utility services such as air and water.



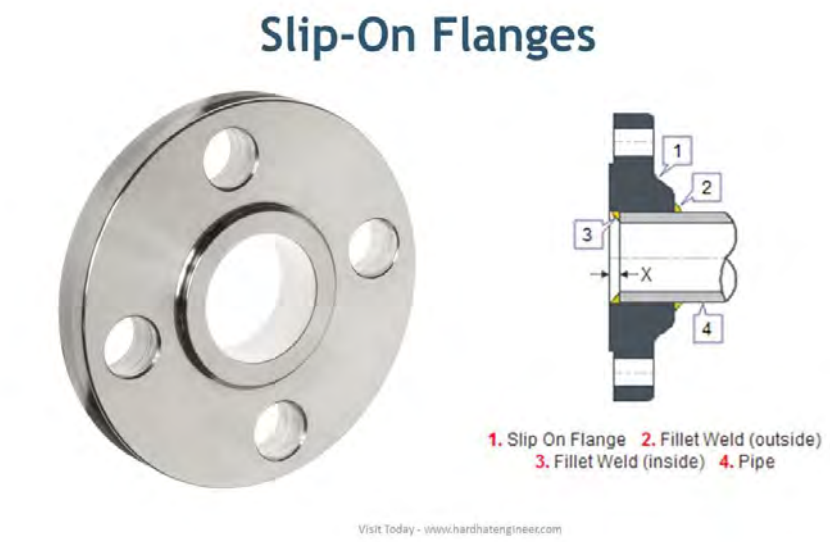
Socket-Weld Flanges

Socket-Weld Flanges has a female socket in which pipe is fitted. Fillet welding is done from outside on the pipe. Generally, it is used in small bore piping and only suitable for low pressure and temperature application.



Slip-On Flanges

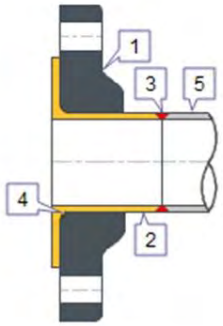
Slip-On flange has a hole with matching outside diameter of pipe from which pipe can pass. The flange is placed on pipe and fillet welded from both inside and outside. Slip-On Flange is suitable for low pressure and temperature application. This type of flange is available in large size also to connect big bore piping with storage tank nozzles. Normally, these flanges are of forged construction and are provided with the hub. Sometimes, these flanges are fabricated from plates and are not provided with the hub.



Lap Joint Flanges

Lap flange is having two components, a stub end, and a loose backing flange. Stub end is butt welded to the pipe and Backing flange freely move over the pipe. The backing flange can be of different material than stub material and normally of the carbon steel to save the cost. Lap flange is used where frequent dismantling is required, and space is constrained.

Lap Joint Flanges

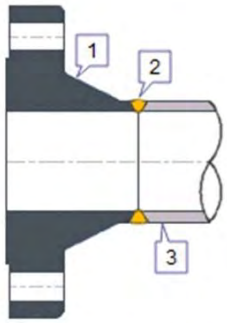


1. Lap Joint Flange 2. Stubend
3. Buttweld 4. Radius (R)
5. Pipe or Fitting

Weld Neck Flanges

Weld neck flange are most widely used flanged in process piping. It gives the highest level of joint integrity due to Butt-welded with a pipe. These types of flanges are used in high pressure and temperature application. Weld neck flanges are Bulky & costly with respect to other types of flange.

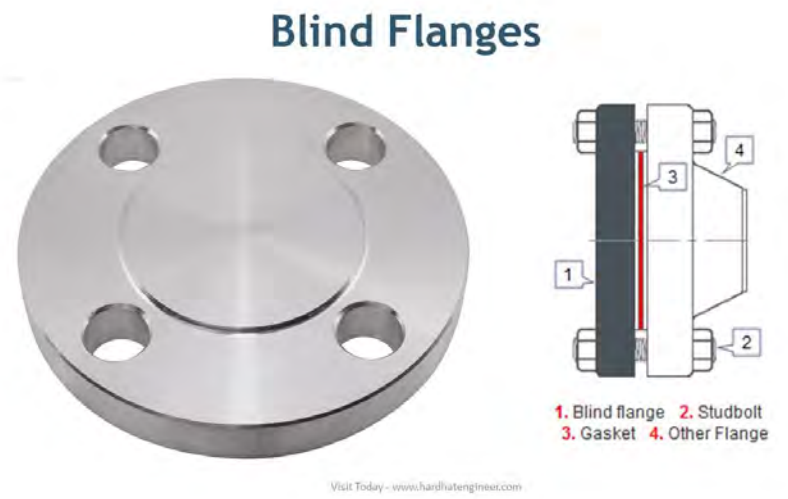
Weld Neck Flanges



1. Welding Neck flange 2. Buttweld
3. Pipe or Fitting

Blind Flanges

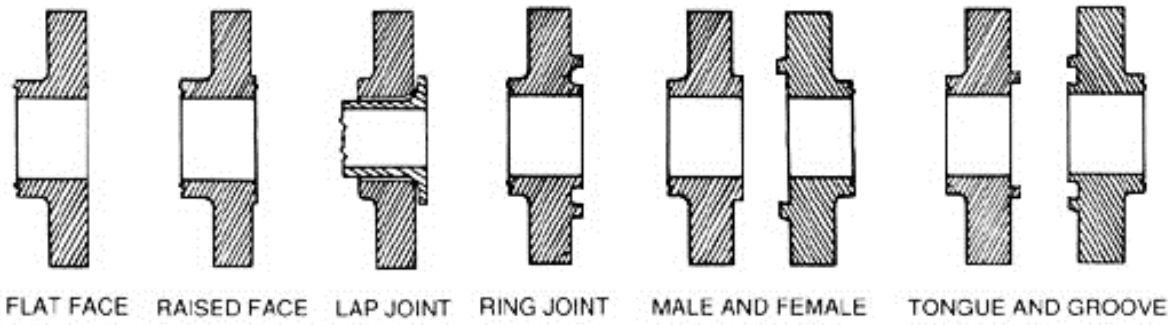
The blind flange is a blank disc with bolt hole. These types of flanges are used with another type of flange to isolate the piping system or to terminate the piping as an end. Blind flanges are also used as a manhole cover in the vessel.



3. Flange Facing Types

Based on Flange facing Types, it can be further classified as

- Flat Face (FF)
- Raised Face (RF)
- Ring Joint (RTJ)
- Tongue and groove (T&G)
- And Male and Female types



Flat Face

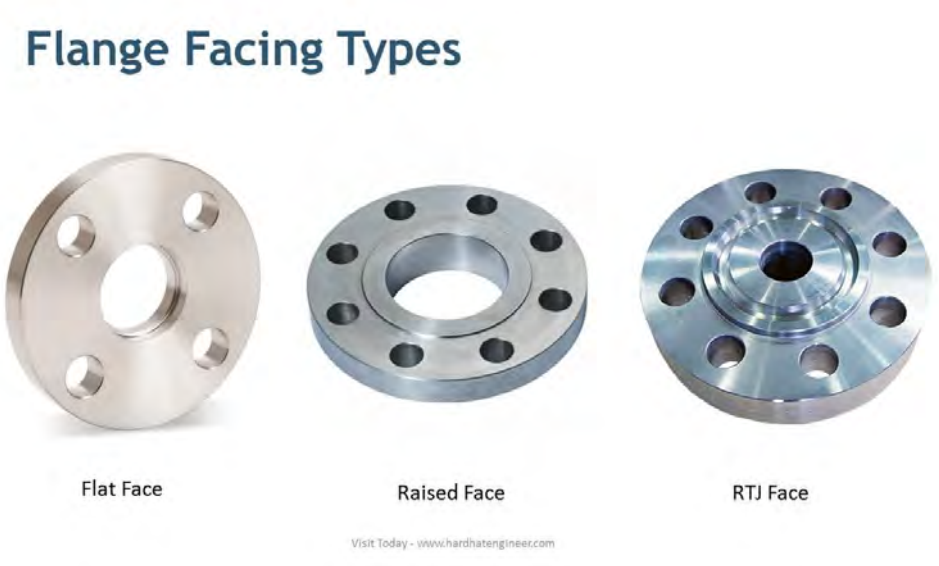
As name suggest, flat face flange has a flat face. Flat face flanges are used when the counter flanges are flat face. This condition occurs mainly on connection to Cast Iron equipments, valves and specialties. Full face gasket is used when flat face flange is used.

Raised Face

Raised face flange has small portion around the bore is raised from the face. The gasket seat on this raised face. The height of the raised face depends on the flange pressure temperature rating that is known as a class of the flange. For 150# & 300# height of the raised face is 1/6" and above 300# it is 1/4". The inside bore circle type of gasket is used with raised face flange.

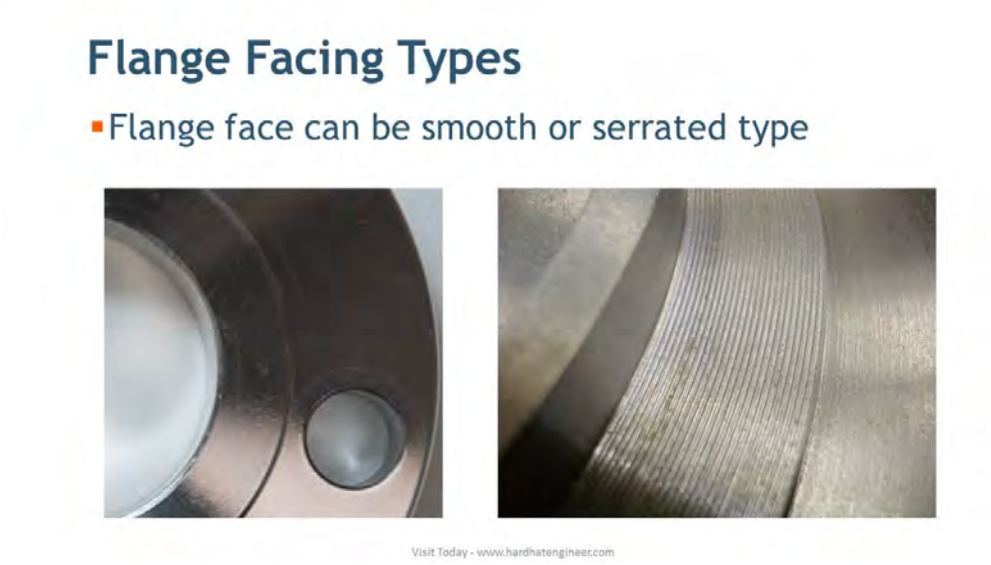
RTJ Face

Ring joint type face flange has a specially designed grove in which metal gasket seat. This type of flange is used in high pressure and temperature services.



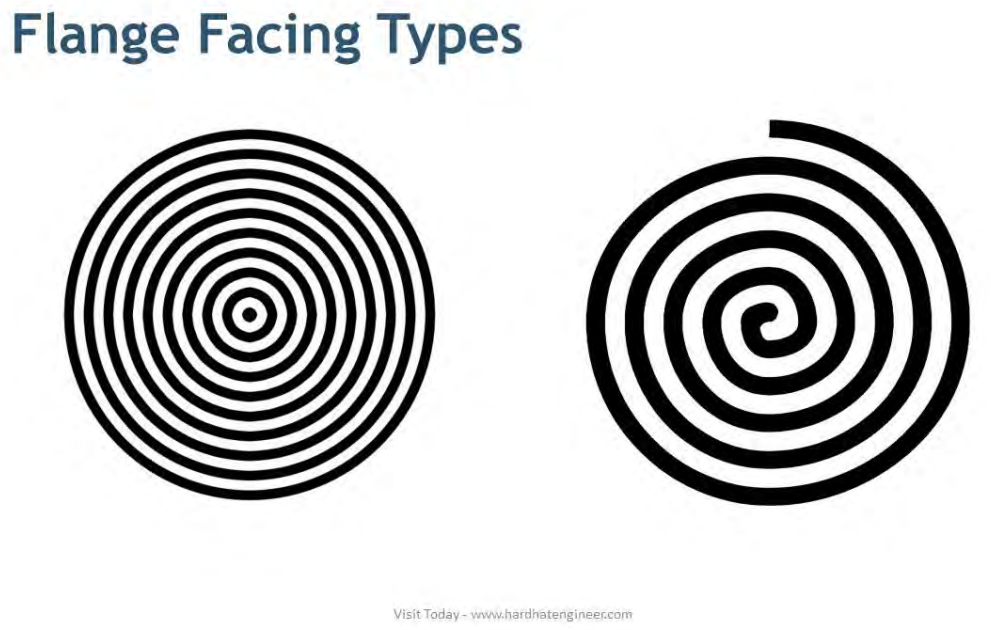
Serration on the Flange Face

The flange face has small grooves as you can see in the image. This machining is known as a serration. Flange face can be smooth or serrated type. Which type of face to use is depends on the type of the gasket and service of the fluid.

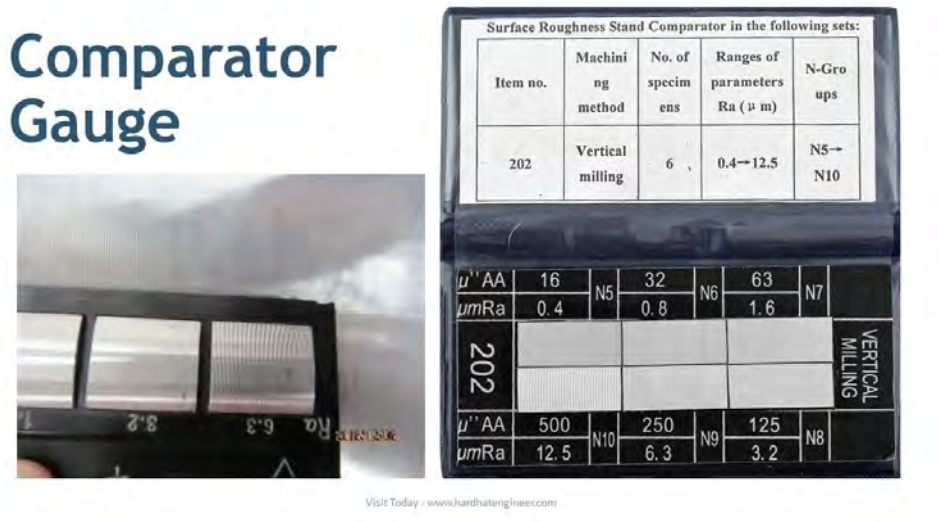


Smooth finish is used with metallic gasket whereas serrated finish is used with non-metallic gasket. Soft material of gaskets is set in this serration and prevent liquid or gas from passing from flange joint.

Serration can be spiral or concentric rings as you can see in the slide. Concentric rings type finishing is used when fluid is of very low density. If you use spiral type finish with very low density fluid, it may find leakage path through the spiral cavity.



Serration of flange face is specified in RMS (Root Mean Square) or AARH (Arithmetic Average Rough Height), the most common value of serrated face is 120-250 AARH. Comparator gauge is used to check serration of the flange. In the image, you can see the how gauge is used to verify the value of serration.



4. Flange Pressure-Temperature Class (Service Rating)

Flange are classified as per their pressure-temperature ratings which are designated as 150#, 300#, 400#, 600#, 900#, 1500# and 2500#. Large diameter flanges that is 24" to 60" are available up to 900# class. Pressure-temperature ratings are maximum allowable working gage pressures in the bar & the temperatures in degrees Celsius.

Higher the rating, heavier the flange and can withstand higher pressure and temperature. When the temperature goes up, the pressure goes down, and vice versa. Please note that different material has different pressure ratings.

5. Flange Material

Flanges are manufactured from

- Carbon steel
- Low alloy steel
- Stainless steel
- Or Combination of Exotic materials (Stub) and other backing materials

List of materials used to manufacture flanges is covered in ASME B16.5 & B16.47.

- ASME B16.5 -Pipe Flanges and Flanged Fittings NPS ½" to 24"
- ASME B16.47 -Large Diameter Steel Flanges NPS 26" to 60"

Commonly used Forged material grads are

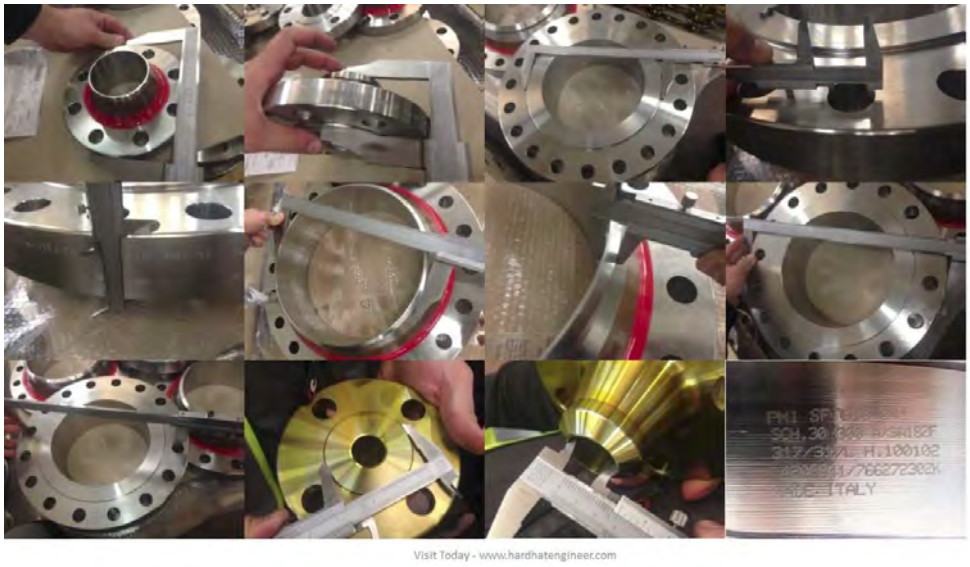
•Carbon Steel: - ASTM A105, ASTM A350 LF1/2, ASTM A181
•Alloy Steel: - ASTM A182F1 /F2 /F5 /F7 /F9 /F11 /F12 /F22
•Stainless Steel: - ASTM A182F6 /F304 /F304L /F316 /F316L/ F321/F347/F348

6. Flange Inspection

Following to be confirmed during inspection of flange

−Outer & Inner Diameter of body
−Bolt Circle & Bolt hole Diameter
−Hub Diameter & thickness of weld end
−Length of the Hub
−Straightness and alignment of the bolt hole

Permissible tolerances are given in B16.5 and B16.47 standard.



7. Marking

Following shall be marked on flange body

- Manufacturer logo
- ASTM material code
- Material Grade
- Service rating (Pressure-temperature Class)
- Size
- Thickness (Schedule)
- Heat No

- And Special marking if any QT (Quenched and tempered) or W (Repair by welding)

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Gasket

What is Gasket?

A Gasket is sealing material placed between connecting Flanges to create a static seal, which will Maintain the leak-proof sealing in all operating conditions

Gasket Selection Criteria

- Type of Gasket to be used in given fluid service is depends on the parameters such as
- Temperature
- Pressure
- Corrosion resistance
- Types of fluid
- Robustness
- Availability
- And Cost

Types of Gasket Used in Piping

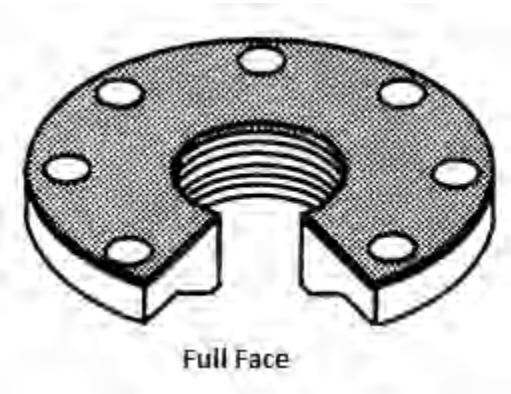
There are three types of gasket used in process piping. Non-Metallic, Metallic and Composite.

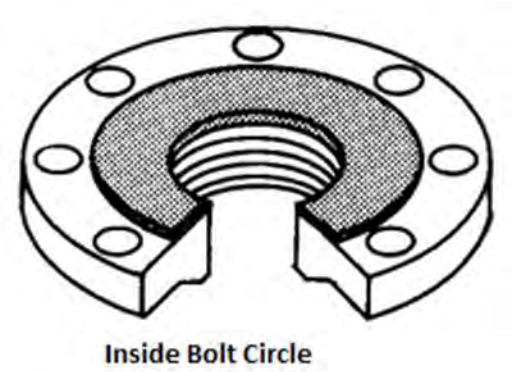
Non-Metal Gasket

- Most common materials used for this type of gaskets are Rubber, Teflon and Compressed Non-Asbestos Fiber (CNAF)
- These gaskets are also known as a Soft gasket. It can be full face or inside bolt circle type. Next slide will cover what is the full face and inside bolt circle means.
- Non-Metallic gaskets can easily compress with low tension bolting
- These types of gaskets are used with low-pressure class flanged such as 150 or 300 Class and in low-temperature services
- They are not used in hydrocarbon services
- Non-Metallic gaskets are Cheapest and easily available

You can see in the right-side image, which shows full-face gasket and left side is inside bolt circle gasket. The image also shows CNAF & PTFE gaskets.

Full face gasket can only be used with FF flange and normally used for temporary connection of utility lines.

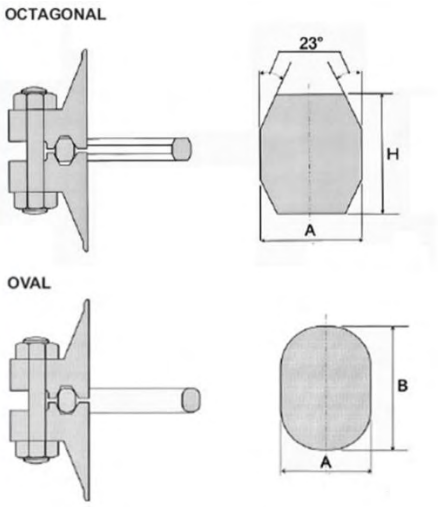




Metal Gasket

- Metal gaskets are manufactured from material such as Soft iron, Low Carbon steel, Stainless Steel, Monel and Inconel
- These gaskets are also known as ring gasket or RTJ gaskets
- Metallic gaskets are used in high-pressure class flanges, normally above 900 Class, they can also be used for high-temperature services.
- High tension bolting is required when we used metallic gaskets.
- They are Very robust & Most costly

There are two types of the metallic gasket are frequently used with RTJ flange. Octagonal and Oval. you can see the difference in their cross-section view.



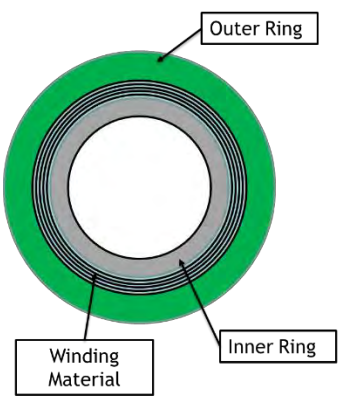
Composite Gasket

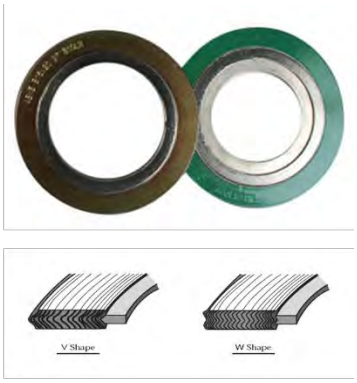
- Composite gaskets are Combination of metal and non-metal material. Different types of combination of materials are possible based on service requirement.
- Spiral wound, Metal Jacketed, and Kamprofile gasket are well known in composite gasket category. They can be Used in wide range of pressure and temperature services
- Composite gaskets are Cost effective with compare to metal gaskets but Careful handling is required.

Spiral Wound Gasket

The most widely used Composite type gasket is a Spiral Wound Gasket. It is suitable for wide range of pressure and temperature class. Normally Graphite or PTFE used as filler material & Stainless steel or other exotic material is used as winding material.

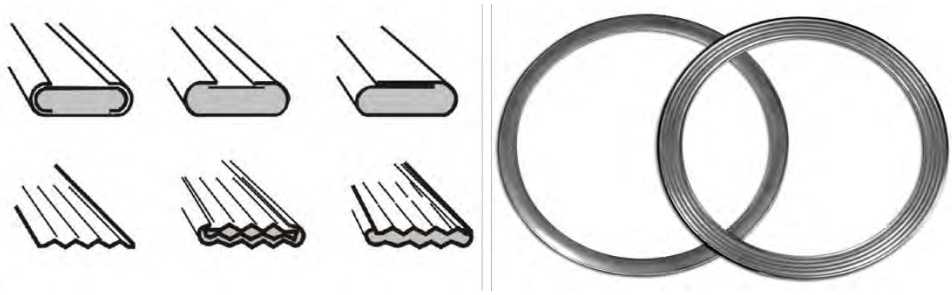
There are three components in spiral wound gasket. Inner & Outer ring, filler material, and winding material. However, sometimes an inner ring is not used. You can see in the image spiral wound gasket with and without inner ring. The inner ring is used to provide additional support to the winding material. The winding is an alternative layer of filler material and winding material. The filler material is a soft material such as graphite and PTFE and winding material is a thin sheet of metal. Winding can be a V-type or W type as shown in the image.





Metal Jacketed Gasket

In Metal Jacketed Gasket Soft filler material is enclosed in a thin sheet of metal jacket. There are different ways to cover filler material as shown in the image. Metal jacketed gaskets are commonly used in heat exchangers & valve.



Kamm/ Cam profile Gasket

Kamm/ Cam profile Gasket is having solid Metalcore with concentric grooves. Filler material, either graphite or PTFE is layered on this grooved metal ring. It is Costlier than Spiral wound gasket but provides better blowout resistance and easy to handle even in large diameters. Sometimes due to high pressure and temperature winding of spiral wound gasket disintegrate, if the winding quality is poor, that is called blowout of the gasket.

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