FLANGE FACINGS

CONTENT

1. Introduction

When valves are connected to the pipeline with flanges, it must be defined which type of flange facing will be used. Both flanges, at the valve side and at the pipe side must be of the same type to ensure a proper sealing when installed.

Different types of flange faces are used as the contact surfaces to seat the sealing gasket material. ASME B16.5 and B16.47 define various types of flange facings, including the raised face, the large male and female facings which have identical dimensions to provide a relatively large contact area.

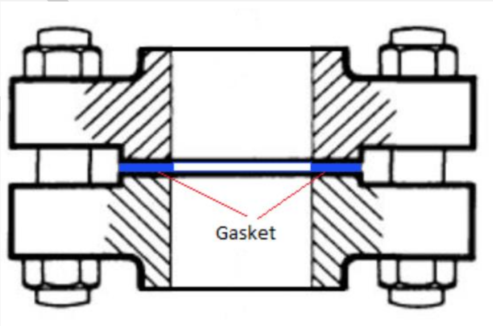
Other flange facings covered by these standards include the large and small tongue-and-groove facings, and the ring joint facing specifically for ring joint type metal gaskets.

2. Types of Flange facings

2.1 Raised Face (RF)

The Raised Face flange is the most common type used in process plant applications and is easily to identify. It is referred to as a raised face because the gasket surfaces are raised above the bolting circle face. This face type allows the use of a wide combination of gasket designs, including flat ring sheet types and metallic composites such as spiral wound and double jacketed types.

The purpose of a RF flange is to concentrate more pressure on a smaller gasket area and thereby increase the pressure containment capability of the joint. Diameter and height are in ASME B16.5 defined, by pressure class and diameter. Pressure rating of the flange determines the height of the raised face.

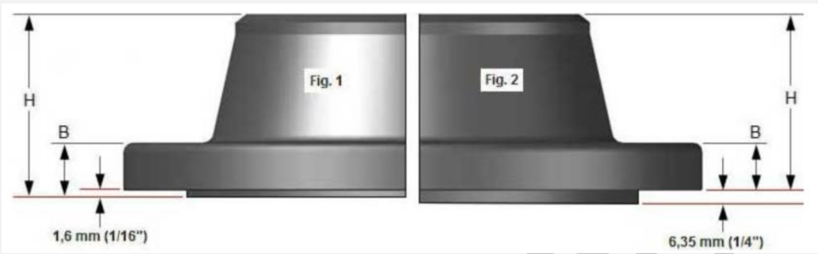


The typical flange face finish for ASME B16.5 RF flanges is 125 to 250 µin Ra (3 to 6 µm Ra).

Raised Face height

In pressure classes 150 and 300, the height of raised face is approximately 1.6 mm (1/16 inch). In these two pressure classes, almost all suppliers of flanges, show in their catalog or brochure, the H and B dimensions including the raised face height. ((Fig. 1))

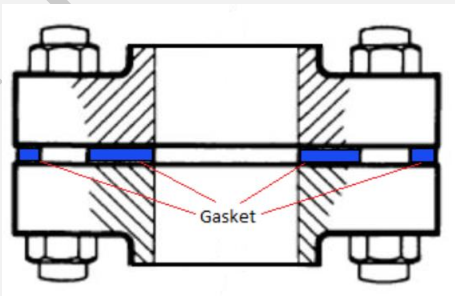
In pressure classes 400, 600, 900, 1500 and 2500, the height of raised face is approximately 6.4 mm (1/4 inch). In these pressure classes, most suppliers show the H and B dimensions excluding the raised face height. (Fig. 2)



2.2 Flat Face (FF)

The Flat Face flange has a gasket surface in the same plane as the bolting circle face. Applications using flat face flanges are frequently those in which the mating flange or flanged fitting is made from a casting.

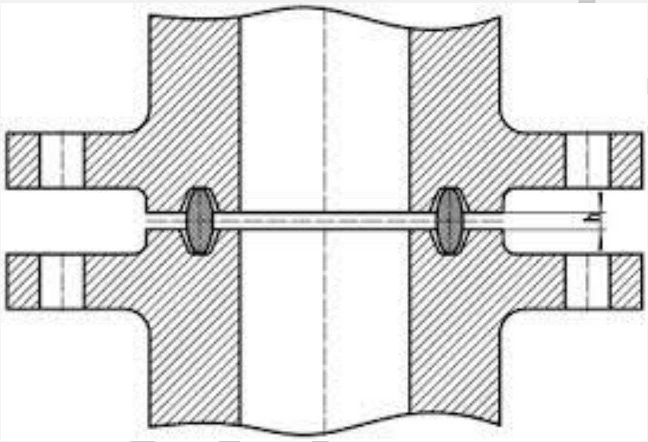
Flat face flanges are never to be bolted to a raised face flange. ASME B31.1 says that when connecting flat face cast iron flanges to carbon steel flanges, the raised face on the carbon steel flange must be removed, and that a full-face gasket is required. This is to keep the thin, cast iron flange from being sprung into the gap caused by the raised face of the carbon steel flange.



2.3 Ring-Type Joint (RTJ)

The Ring Type Joint flanges are typically used in high pressure (Class 600 and higher rating) and/or high temperature services above 427°C (800°F). They have grooves cut into their faces in which steel ring gaskets must be used. The flanges seal when tightened bolts compress the gasket between the flanges into the grooves, deforming the gasket to make intimate contact inside the grooves, creating a metal to metal seal.

An RTJ flange may have a raised face with a ring groove machined into it. This raised face does not serve as any part of the sealing means. For RTJ flanges that seal with ring gaskets, the raised faces of the connected and tightened flanges may contact each other. In this case the compressed gasket will not bear additional load beyond the bolt tension, vibration and movement cannot further crush the gasket and lessen the connecting tension.



2.4 Ring Type Joint gaskets

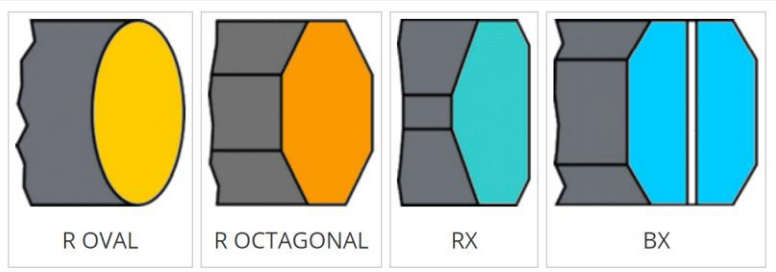
Ring Type Joint gaskets are metallic sealing rings, suitable for high-pressure and high-temperature applications. They are always applied to special, accompanying flanges which ensure good, reliable sealing with the correct choice of profiles and material.

Ring Type Joint gaskets are designed to seal by "initial line contact" or wedging action between the mating flange and the gasket. By applying pressure on the seal interface through bolt force, the "softer" metal of the gasket flows into the microfine structure of the harder flange material and creating a very tight and efficient seal.

Most applied type is style R ring that is manufactured in accordance with ASME B16.20 used with ASME B16.5 flanges, class 150 to 2500. Style 'R' ring type joints are manufactured in both oval and octagonal configurations.

The OCTAGONAL ring has a higher sealing efficiency than the oval and would be the preferred gasket. However, only the oval cross section can be used in the old type round bottom groove. The newer flat bottom groove design will accept either the oval or the octagonal cross section.

Style R ring type joints are designed to seal pressure up to 6,250 psi in accordance with ASME B16.5 pressure ratings and up to 5,000 psi.



The RX type is suitable for pressures up to 700 bar. RTJ is capable of sealing itself. The outer sealing surfaces make the first contact with the flanges. A higher system pressure causes a higher surface pressure. Type RX is interchangeable with the standard R-models.

The BX type is suitable for very high pressures up to 1500 bar. This ring joint is not interchangeable with other types and is only suited for API type BX flanges and grooves.

The sealing surfaces on the ring joint grooves must be smoothly finished to 63 Micro inches and be free of objectionable ridges, tool or chatter marks. They seal by an initial line contact or a wedging action as the compressive forces are applied. The hardness of the ring should always be less than the hardness of the flanges.

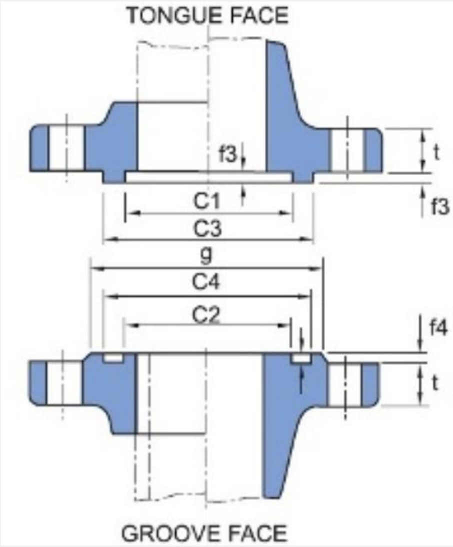
2.5. Tongue-and-Groove (T&G)

The Tongue and Groove faces of this flange must be matched. One flange face has a raised ring (Tongue) machined onto the flange face while the mating flange has a matching depression (Groove) machined into its face.

Tongue-and-groove facings are standardized in both large and small types. They differ from male-and-female in that the inside diameters of the tongue-and-groove do not extend into the flange base, thus retaining the gasket on its inner and outer diameter. These are commonly found on pump covers and valve bonnets.

Tongue-and-groove joints also have an advantage in that they are self-aligning and act as a reservoir for the adhesive. The scarf joint keeps the axis of loading in line with the joint and does not require a major machining operation.

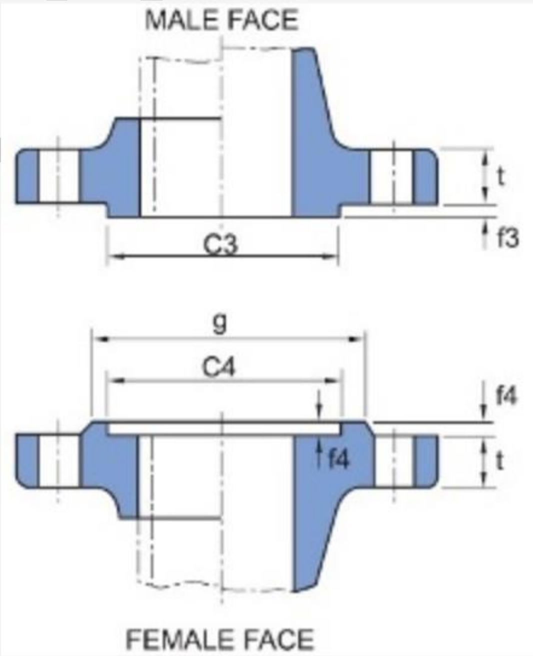
General flange faces such as the RTJ, T&G and the F&M shall never be bolted together. The reason for this is that the contact surfaces do not match and there is no gasket that has one type on one side and another type on the other side.



2.6. Male-and-Female (M&F)

With this type the flanges also must be matched. One flange face has an area that extends beyond the normal flange face (Male). The other flange or mating flange has a matching depression (Female) machined into its face.

The female face is 3/16-inch deep, the male face is1/4-inch high, and both are smooth finished. The outer diameter of the female face acts to locate and retain the gasket. In principle 2 versions are available: The Small M&F Flanges and the Large M&F Flanges. Custom male and female facings are commonly found on the Heat Exchanger shell to channel and cover flanges.



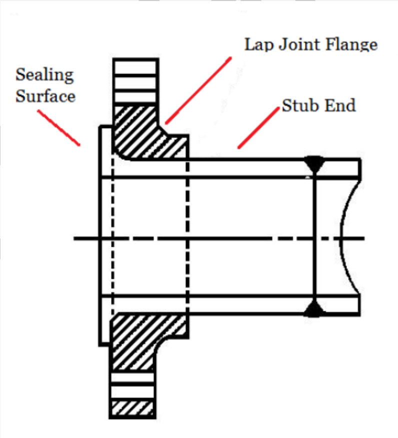
2.7 Advantages and Disadvantages of T&G and M&F flange faces

ADVANTAGES
Better sealing properties, more precise location and exact compression at sealing material, utilization of other, more suitable sealing and specialized sealing material (O-rings).

DISADVANTAGES
Commercial availability and cost. Normal raised faced is far more common and ready available both regarding Valves, flanges and sealing material. Another complexity is that some rigid rules must be applied to the piping design. When specifying the valves, it must be defined to be male or female at each side.

2.8 Lap joint flange

A lap joint flange has a flat face, which is not used to seal the flanged joint but simply hosts the back of a stub end. The sealing surface is actually on the stub end itself and may be either flat face or raised face.

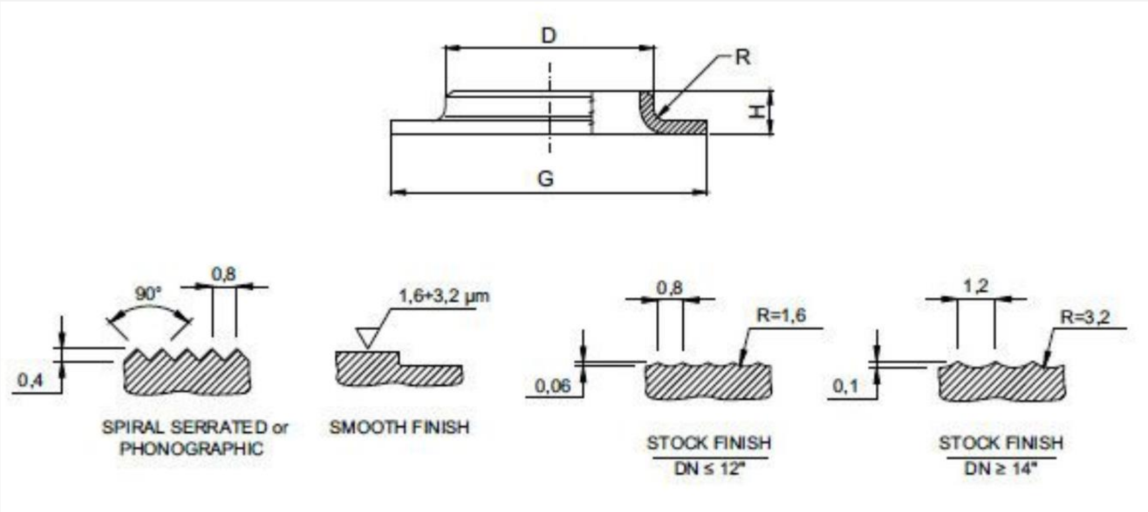


3. FLANGE FACE FINISH

To ensure that a flange mates with the gasket and the companion flange perfectly, some roughness is required on the flange surface area (RF and FF flange finish only). The type of roughness on the flange face surface defines the type of “flange face finish”.

Common types are stock, concentric serrated, spiral serrated and smooth flange finish.

Steel flanges are available with four basic face finish, however, the common objective of any type of flange face finish is to create the desired roughness on the face of a flange to ensure a strong match between the flange, the gasket, and the mating flange and thus provide a high-quality seal.



3.1 FACE FINISH TYPES

The most common flange face finish types are:

3.1.1 Stock finish

The stock finish is the most widespread type of finish as it suits many applications. The pressure embeds the soft face of the gasket into the flange finish and results in the formation of a good seal due to the friction existing between the contacting parts.
As the mating flanges are bolted together, gaskets get “squeezed” into the flange face surface and create a very tight seal.
A stock finish face is manufactured using a phonographic spiral groove featuring a 1.6mm radius round-nose tool with a depth of 0.15mm and a feed-rate of 0.8mm per revolution. The resulting “Ra” value (AARH) for the surface ranges from 125µinch to 500 µinch (125 µm to 12.5 µm).

3.1.2 Spiral serrated

Spiral serrated finish is a phonographic spiral groove type that differs from the stock finish as the groove is crafted by a 90 degrees tool (instead of a round nosed one) that creates a “V” geometry with a 45-degree serration angle.
A serrated finish, concentric or spiral, has from 30 to 55 grooves per inch and roughness between 125 to 250 µinch.

3.1.3 Concentric serrated

The concentric serrated flange finish features concentric grooves instead of spirals.
The grooves are crafted by the same 90-degree tool used for the spiral serrated finish, but the serrations have an even design on the face of the flange. To have concentric grooves, the tool has a feed rate of 0.039mm per revolution and a depth of 0.079mm.

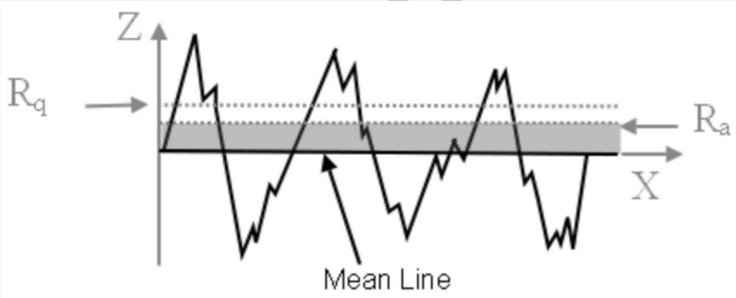
3.1.4 Smooth finish
Flanges with a smooth finish do not show visible tool markings at naked eye.
This type of flange finish is used with metal-facing gaskets such as the jacketed type.
As per the stock finish, this is achieved by having the contact surface machined with a continuous spiral groove generated by a 0.8mm radius round-nosed tool at a feed rate of 0.3mm per revolution with a depth of 0.05mm (that creates a roughness between Ra 3.2 and 6.3 micrometers, i.e. 125 – 250 micro inches).

3.1.5 Coldwater finish
The cold-water finishes appear shiny to the naked eye and very smooth. The AARH value for these surfaces' ranges between 85 µinch to 100 µinch. They are used with metal to metal seals (no gasket).

4. Roughness of sealing surfaces

Roughness parameters are defined in the ISO 4287:1997 standard

4.1 Roughness amplitude parameters



4.1.1 Ra
Arithmetical mean deviation of the assessed profile
The average arithmetic roughness height values are very important during the selection of flanges and gasket materials. Higher the "Ra" values depict a rougher surface, while lower values represent the smoother surface.
Every material possesses a surface roughness and sometimes surfaces are finished deliberately to have a specific roughness (small or bigger).
It is the average height of the irregularities on the metal surface, from the mean line as shown in the following figure.

4.1.2 Rq

Root mean squared (also called RMS) is the root mean square average of the profile heights over the evaluation length.

ASME/ANSI defined specific roughness standards for the flanges, as the flange face finish plays a pivotal role in gasket's reliability and service life.
According to the ASME/ANSI specifications, the serrated, spiral serrated, and concentric flange face finish should have an average roughness of 125 µinch to 250 µinch (3.2 µm to 6.3 µm).
The tool used to imprint a rough finish on the flange should have a radius of 0.06 inch (1.5mm) or larger. The groove density on the flange face should be from 45 grooves per inch to 55 grooves per inch (1.8 grooves/ mm. to 2.2 grooves/ mm.).
These are the standards for semi-metallic and nonmetallic gaskets. If the average roughness of flange face is not according to the described standards, the contacting surfaces would not properly seal and the flanged joint may wear after some time working under pressure (resulting in loss of bolt joint tightness and a possible leakage).
The soft nonmetallic materials such as PTFE may be used for more comfortable facing and better creep resistance.

4.1.3 Allowed imperfections

The sealing performance of the flanges' gaskets depends on the Ra value, the flange dimensions and the pressure of the stud bolts. According to ASME, the adjacent imperfections should be separated by a distance of at least 4 times the maximum radial projection.

The radial projection can be evaluated by subtracting the inner radius from the outer radius.
The serrations shall be at the same level, and the protrusion above them is not permitted. It can cause the adjacent serrations to lose hold of the gasket material and may result in wears and leakages.

4.2 Roughness depth

4.2.1 Rzi

The Single Roughness Depth (Rzi) is the vertical distance between the highest peak and the deepest valley within a sampling length.

4.2.2 Rz

The Mean Roughness Depth (Rz) is the arithmetic mean value of the single roughness depths of consecutive sampling lengths.

4.2.3 Rmax

The Maximum Roughness Depth (Rmax) is the largest single roughness depth within the evaluation length.

The units of Rz are micrometers or micro inches.