sapia | South African Petroleum Industry Association

SAPIA Flange Management Guideline

DOCUMENT CONTROL

Date of Revision	Revision	Person	Version Number
Aug 2021	New		0
Aug 2023	Next		

LIST OF ABBREVIATIONS

AARH	Arithmetic Average Roughness Height
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
BAM	Bundesanstalt für Materialforschung und -prüfung
CAF	Compressed Asbestos Fibre
CR	Chloroprene
DIN	Deutsches Institut Für Normung
EO	Ethylene Oxide
FF	Flat-Face
HSSE	Health, Safety, Security and Environment
LJ	Lap Joint Flange
LR	Lens Ring Flange
MFD	Mechanical Flow Diagram
NPS	Nominal Pipe Size
OEM	Original Equipment Manufacturer
P&ID	Piping & Instrument Diagram
PPE	Personal Protective Equipment
PTFE	Polytetrafluoroethylene
QC	Quality Control
RF	Raised Face
RJ	Ring Joint
SAPIA	South African Petroleum Industry Association
SO	Slip on Flange
SS	Stainless Steel
TG	Tongue and Groove
UV	Ultraviolet
WN	Weld Neck flange

LIST OF FIGURES

TABLE OF CONTENTS

1. SAPIA FLANGE MANAGEMENT GUIDELINE

INTENT OF GUIDELINE

This best practice guideline is intended to guide SAPIA members on flange management to prevent loss of material from primary containment. This guideline does relieve the responsibility of the Members to ensure that all relevant HSSE risks assessments are conducted, comply with all legislative requirements, and implement appropriate measures to prevent loss of containment.

SCOPE OF USE

This guideline is intended for SAPIA members in South Africa (SA). Non-SAPIA members will require the permission of SAPIA on the use of this guideline and will do so solely at their own discretion without any liability to SAPIA or its members. This guideline is not a list of procedures.

EXCLUSIONS OF GUIDELINE

This guideline is not a legally binding document. It serves to share best practice to ensure that loss of material from primary containment and accidents be prevented. This guideline is also not exhaustive. Risk assessments at facilities may determine unique risks peculiar to specific sites which need to be considered.

2. INTRODUCTION

The purpose of this guideline is to define a best practice that will explain the assembling, disassembling and inspection of bolted flanged joints and quality management of flange joints in order to prevent loss of material from primary containment. This guideline deals with pipe and equipment connections that involved flanges and gaskets. The main purpose of a seal is to contain a fluid and protect the immediate environment from contamination.

3. SCOPE

This guideline deals with the management of flanges and gaskets. From it, you will get an overview of how this equipment works as well as an in-depth look into the related maintenance tasks.

The guideline contains the following module:

- Types of flanges.
- Types of gaskets.
- Practices for assembly of flanges.
- Inspection of flanged joints.

4. DEFINITIONS

Critical Flanges:
Generally defined as lines operating at a temperature higher than 300 ºC or below 15 ºC and lines with a 600# or higher ASME/ANSI flange rating. Critical flanges could also include:

- Known problem flanges.
- Flanges subjected to high temperature or pressure gradients during start-up or upset conditions.
- Flanges subject to temperature and pressure cycling
- Flanges which are opened and closed regularly.

Gasket:
Is a static seal that is used where there is no movement between two sealing faces or surfaces. A gasket is most used between two pipe flanges, at manholes and at circular parts that seal onto each other.

AARH:
It is used to measure the roughness (rather smoothness) of surfaces. 125 AARH means 3.2 micrometres will be the average height of the ups and downs of the surface.

5. TYPES OF FLANGES

Different types of pipe flanges are used in piping systems. The type of flange use will depend on the fluid, pressure and temperature rating, material of construction of the flange and the connecting equipment.

The different types of flanges, based on their facing, are discussed below.

5.1 Flat-face flange

Flat-face (FF) pipe flanges are used to connect to other flat-faced flanges. They are mainly used for connections to cast-iron equipment, valves and special equipment. An FF flange has a gasket surface on the same plane as the bolting circle face. An example is shown Figure 1.

Figure 1: The FF flange

5.2 Raised face (RF) flange

The most used flanges are raised face (RF) pipe flanges. In other words, Total flange thickness is the sum of the flange thickness and the raised-face thickness. On higher rating flanges, however, the raised-face thickness is not included in the flange thickness. Refer to the example in Figure 2.

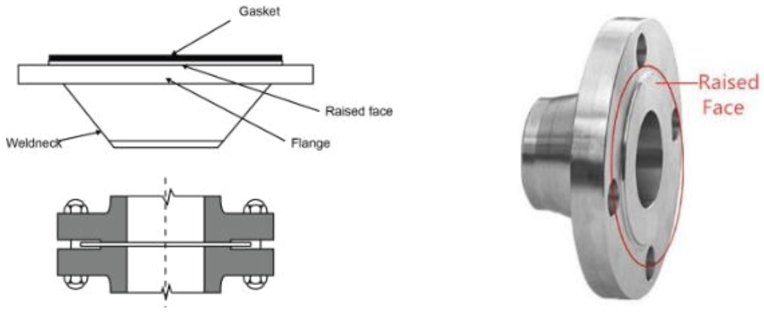


Figure 2: The RF flange

5.3 Tongue-and-groove flange

The tongue-and-groove (TG) pipe flange is the most reliable type of flange joint. This type of flange is, however, more costly than the other types of flanges see Figure 3.

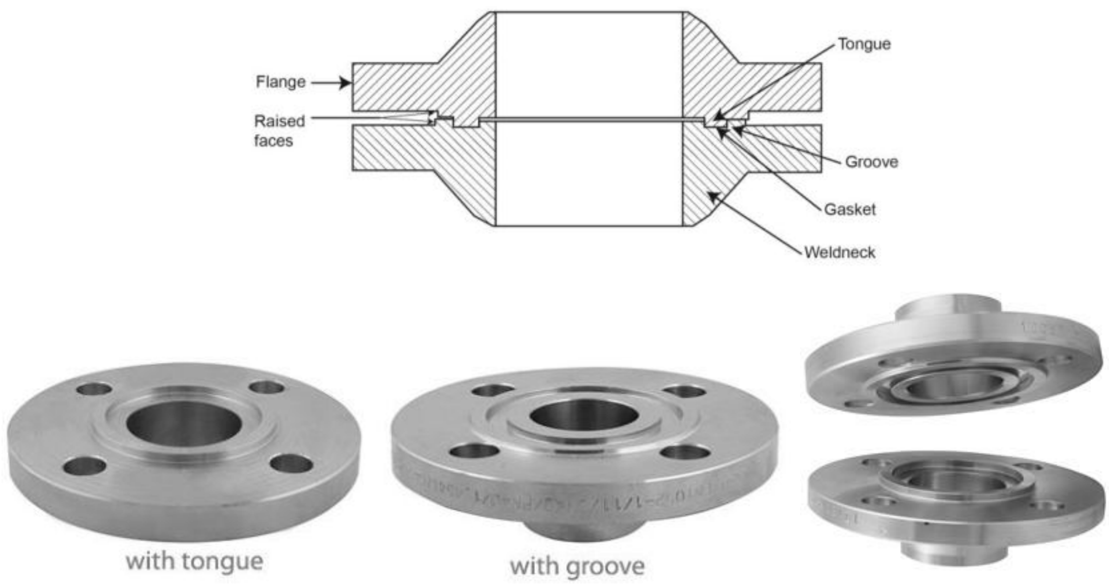


Figure 3: The TG flange

5.4 Ring-joint flange

This type of pipe flange is the most reliable type of flange joint, but it is also more costly than the other types of flanges. Ring-joint (RJ) flanges are generally used in high pressure a class 600# rating and higher and / or high temperature services above 427°C. It should be maybe advised that different type of RJ's is available namely Octagonal and Oval and different grooves in the Ring Joint Flanges, see Figure 4.

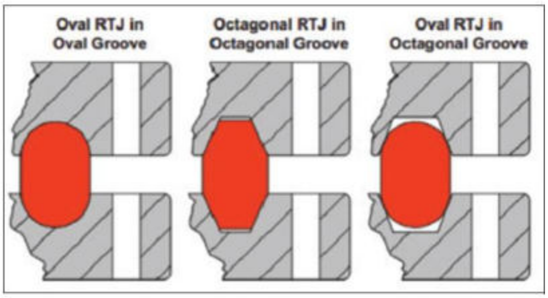


Figure 4: Different type of ring joint gaskets

Figure 5: The RJ flange

5.5 Lens-ring flange

Another example of a RJ flange is a lens-ring (LR) type flange (also known as a ring type), which is shown in Figure 6.

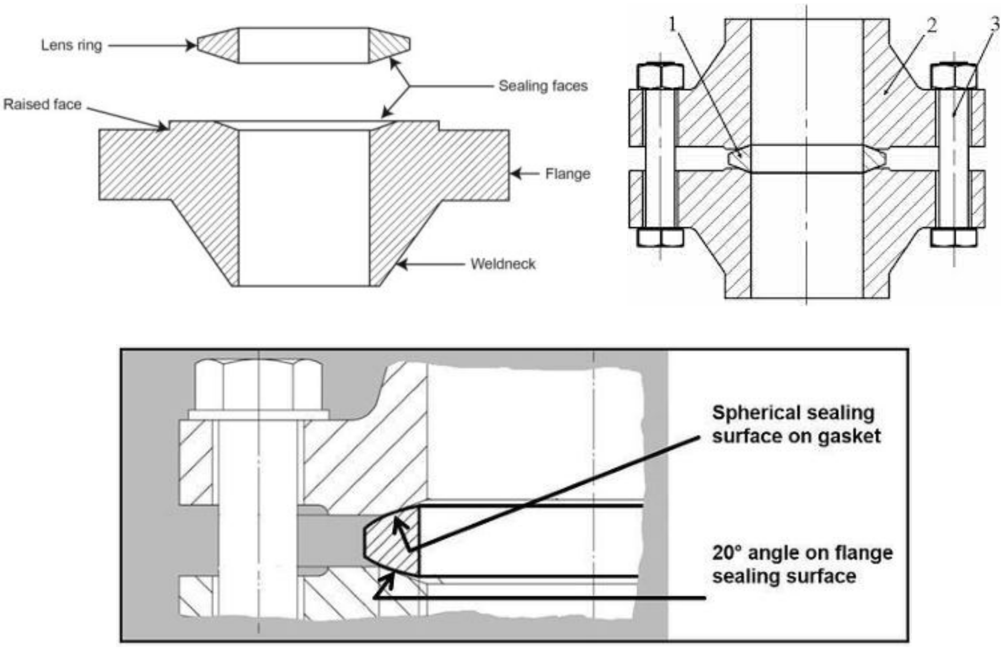


Figure 6: The LR flange

6. TYPES OF GASKETS

6.1 Non-metallic gasket

These types of gaskets are usually made from composite-sheet materials, which are used with FF flanges and low-pressure applications. Non-metallic gaskets are manufactured from non-asbestos material or compressed asbestos fibre (CAF). Types of non-asbestos material include aramid fibre, glass fibre, elastomer, Teflon (PTFE) and flexible graphite.

NOTE:
Gaskets made from asbestos are no longer in use in South Africa, since the usage of asbestos was banned many years ago. This means that these types of gaskets are not used.

Polytetrafluoroethylene or reinforced polytetrafluoroethylene (PTFE) is used in high-corrosive applications. In terms of non-metallic gaskets, full-face gasket types are suitable for use with FF flanges and flat-ring gasket types are suitable for use with RF flanges. An example of this type of gasket is shown in Figure 7.

Figure 7: Non-metallic gasket

6.2 Semi-metallic gasket

Semi-metallic gaskets are composites of metal and non-metallic materials. The metal used in these gaskets provides strength and resilience while the non-metallic part of the gasket provides adaptability and seal ability. The most used semi-metallic gaskets are spiral wound, metal jacketed, Kammprofile, and a variety of gaskets that use metal reinforced graphite.

Semi-metallic gaskets are designed for the widest range of operating conditions (temperature and pressure). Semi-metallic gaskets are also used on RF flanges, male and female flanges, and TG flanges.

Spiral-wound gaskets are used for high temperature and high-pressure applications. The main parts of a spiral-wound gasket are metallic windings and filler material. When selecting the material for windings you must check the following:

- Corrosive nature
- Fluid concentration
- Operating temperature
- Material cost

Commonly used materials for windings are stainless steels 304, 316, and 321. Other winding materials can also be used, depending on the application. The filler materials normally used is graphite.

For proper positioning, spiral-wound gaskets are provided with an outer-centring ring made up of carbon steel. In vacuum service applications, the gasket is provided with an inner ring. The material of the ring should be compatible with the process fluid. It is recommended that a spiral-wound gasket have a flange-face finish of 63–250 μm AARH.

6.3 Metallic gasket

A metallic gasket is made from a metal or a combination of metals that has been moulded to the required shape and size. The most common types of metallic gaskets are RJ gaskets and LR gaskets. Metallic gaskets are suitable for high-pressure and high-temperature applications. These gaskets also require a high-bolt load to seal

6.4 Spiral wound gaskets

A spiral wound gasket can be considered as a heavy-duty spring in a series with the bolts, nuts, washers, and flange. Its spring like structure enables the gasket to recover under variable loads. Figure 8Figure is an example of a spiral wound gasket.

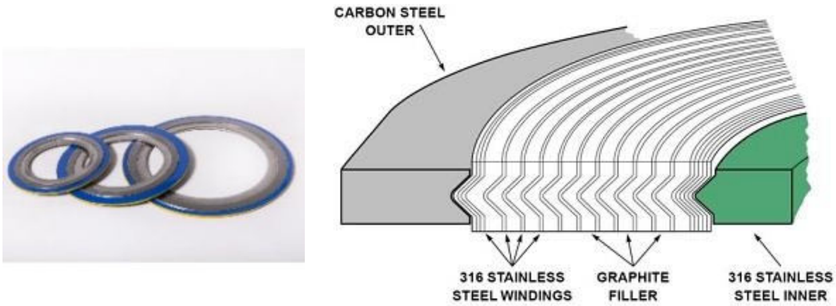


Figure 8: Spiral wound gasket

Upon compression, the soft graphite filler material flows into the flange imperfections and creates a tight seal see Figure 9.

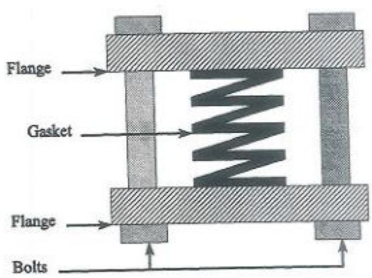


Figure 9: Tight seal in gasket

The metallic spirals hold the filler and give both resilience and blow out protection to the gasket see Figure 10.

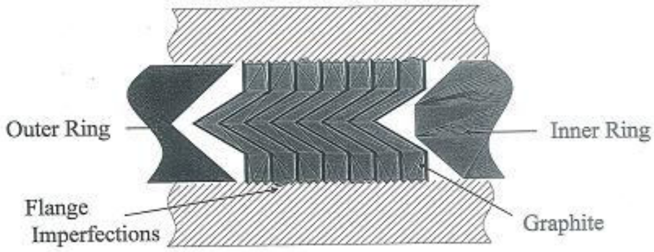


Figure 10: Metallic spirals of gasket

6.5 Serrated metal gasket

The serrated metal gasket is a composite gasket which uses a serrated metal core and a soft gasket facing. Serrated metal gaskets provide improved sealing at reduced bolt loads. They are ideal for pitted, worn, or uneven flanges faces.

Although graphite is the most common facing material, other materials can be used. Serrated gaskets can be manufactured from a wide range of core materials.

Serrated metal gasket composition.
The Maxi profile is a composite gasket with a serrated metal core and a soft facing material see Figure 11.

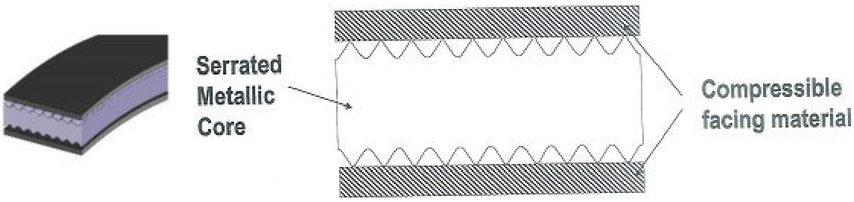


Figure 11: Serrated metal gasket

6.6 Corrugated metal gasket

The corrugated metal gasket is a high-performance gasket for standard flange or heat exchanger applications. It has a high seal ability and conformity where low bolt loads are available. It is also economical and has a graphite purity of 98%. However, it is fragile. An example of this gasket is shown in Figure 12.

Figure 12: Corrugated metal gasket

7. Gasket materials

7.1 Raw materials

This section discusses features, advantages, and disadvantages of the most used materials found in the most popular compressed gasketing constructions. It is important to know the various properties of the individual constituents in order to have a better understanding of the features and benefits of the final gasketing constructions.

The following information is categorised by the generic term commonly used to describe the different materials included within each group.

- Basic elastomers or rubbers
- Fibres (natural and manmade)
- Fillers
- Reinforcements (metal inserts)

These materials are used for several reasons. Rubber, for example, is used because it can be deformed but not reduced in volume, it can be stretched, and it can prevent the passage of gases. In addition to this, fillers are used because they can be any material added to another material either to improve quality or to reduce cost and sometimes both. Fillers can be very important ingredients for improving physical properties and chemical resistance, therefore, resulting in more efficient and effective sealing constructions.

Fillers can take the form of powders, however, quite frequently, fibre can be used as fillers. Combinations of fibres and powders can also be used. The metal reinforcement offers safety and increased life expectancy in cycling conditions. As the gasket cures and becomes brittle the metal helps hold the material together under changing loads. It will also aid in the prevention of catastrophic failure i.e. blow out. As lift off occurs the metal will prevent pieces of the gasket from being blown out which allows the flange to re-seat itself on the gasket as the inline pressure decreases.

Generally, metal reinforced materials have higher maximum gasket stress so they can be assembled at higher loads.

a. Rubber

Natural and synthetic rubbers are used in gaskets. Rubber is the most suitable material to use for gaskets, as it can be compressed and/or stretched. The elasticity of the material ensures that facial contact is maintained across a wide range of loads. Rubber's various characteristics make it suitable for a wide range of conditions.

The suitability of rubber for a gasket is indicated by the durometer hardness. Duro numbers range from 35 to 95. A rubber material with a low duro number is suitable for light-bolt pressure and flanges. Rubber materials with higher duro numbers are used for higher loads and smoother flange surfaces.

b. PTFE based materials

PTFE (Polytetrafluoroethylene) has two properties that make it highly desirable as a gasket material:

- Outstanding chemical resistance
- Thermally stable to 260°C, some manufacturers advice that the gasket should not be use in applications above 250°C.

Under the influence of temperature and load, PTFE will creep resulting in rapid loss of gasket stress and loss of friction between the gasket and flange can cause over compression.

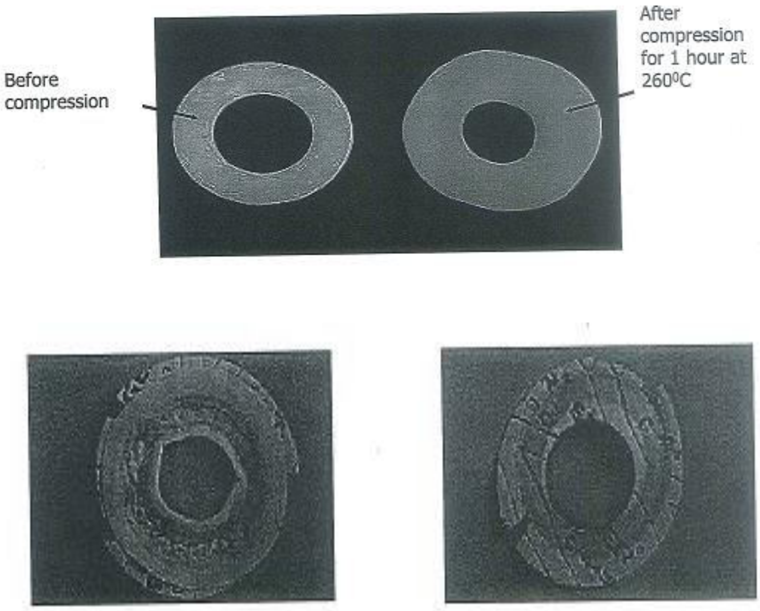


Figure 13: Over compression on PTFE material

PTFE can be modified to improve its strength and reduce creep, by filling it, and to increase porosity by expanding it.

Filled PTFE materials offer several advantages, broadening their usage beyond aggressive duties:

- Thermally stable to 260°C and virtually chemically inert (chemical plants can standardise on one gasket material)
- No impurities
- Easy to handle and install
- Outstanding seal ability
- Electrically insulating

An example of filled PTFE is shown in Figure 9Figure.

Figure 14: Filled PTFE

c. Flexible graphite

Originally introduced as a problem solver, flexible graphite is now the most widely used non-asbestos sealing material for the following reasons:

- Excellent thermal stability
- Unaffected by most chemicals
- Excellent adaptability to flange surfaces even at low gasket stresses.
- Low creep relaxation even at high temperatures
- Fragile

d. Metal

Gaskets containing metal are generally used for services that require high pressures and/or high temperatures. When you want to determine which gasket to use, you should decide based on the pressure, temperature and corrosion resistance required. A metal gasket is usually a ring that fits into two semi-circular grooves.

8. Different joints for flanges and gasket

8.1 Confined joint

In this type of joint, the gasket cannot push through to any side. The gasket can also not be blown out from the side of the flange at high pressure. The confined joint is suitable for non-metal gaskets with a wide contact area and a low-bolt pressure. An example of this joint is shown in Figure 15.

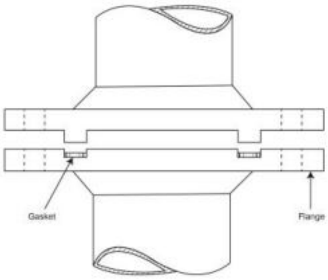


Figure 15: Confined joint

8.2 Non-confined joint

A gasket in a non-confined joint tends to distort if the bolt pressure gets too high. The gasket can also be blown out if the pressure on the inside of the gasket becomes too high. This type of joint is suitable for low-to-medium pressures and operating conditions. Refer to the example in Figure 16.

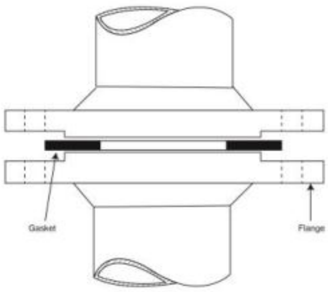


Figure 16: Non-confined joint

8.3 Partially confined joint

In this type of joint, the gasket can only move in one direction. As a result, the gasket is protected against gasket blow-out. This type of joint is generally used for soft gaskets and in situations where a gasket is usually opened and closed regularly. This type of joint is also used on domes and moveable pipe plates. You can see this type of joint in Figure 17Figure.

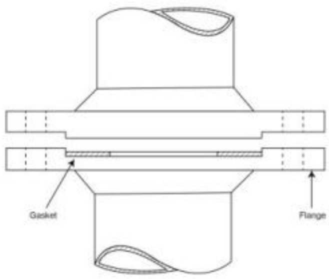


Figure 17: Partially confined joint

8.4 Self-confined joint

Blow-out cannot occur with this type of joint. Most gaskets containing metal are used in this type of joint, except for gaskets containing soft metal. This is because soft metal gaskets react in the same way as non-metal gaskets under pressure and temperature. An example of a self-confined joint is shown in Figure 18.

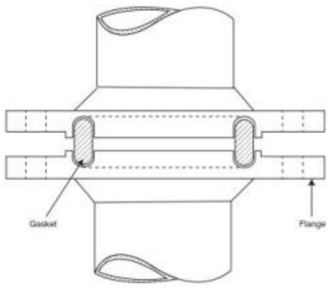


Figure 18: Self-confined joint

8.5 Self-energised joint

When this type of joint is first energised, it is not dependent on bolt pressure. Pressure on the gasket is caused by the pressure exercised (applied) by the product that is being sealed off. It is very important to remember that when the pressure rises, the pressure exercised on the bolts is reduced. make sure that the bolts are tightened accordingly. Look at the example shown in Figure 19Figure.

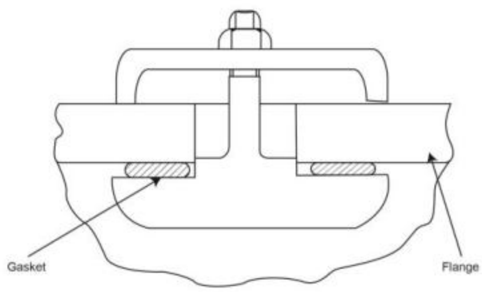


Figure 19: Self-energised joint

9. FLANGE AND BOLTING COMPONENTS

A flange and gasket structure are made of the following components and can be seen in figure 19:

- Flanges
- Packing
- Bolts
- Nuts

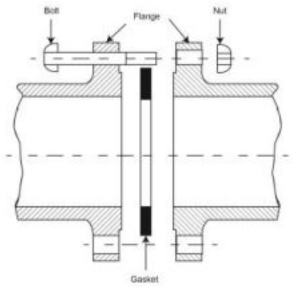


Figure 20: Components of a flange and gasket structure

9.1 Bolting and flange connections

- Bolting material shall be in accordance with the relevant line class.

- Bolts can be shortened and often are cut from threaded bar

- The exposed bolting length after a completed flange connection shall be equal on both sides. On both sides at least three full thread shall be exposed, but no more than five threads.

- Controlled bolt tightening methods shall be employed in the following services:
  - Design temperature above 600 °C.
  - Critical factory headers with design temperature above 400 °C.
  - Class 900 and above with design temperature above 400 °C.
  - Any other high-risk services as identified in a Hazop study.
  - Systems with high temperature fluctuations, such as regeneration systems.

- Examples of control bolt tightening but not limited to:
  - Torque Wrench
  - Hytorc
  - Bolt Tensioning

- Controlled tightening shall include:
  - Calculation of bolt load, including the load required for seating, and design conditions, and the external forces and moments applied to the joint;
  - Cleanliness and use of a suitable lubricant and apply correct bolt torque;
  - Sequencing of the tightening to an acceptable practice; and

- Traceability of finished joints and making it tamper proof. Refer to ASME PCC-1 for guidelines.

- Controlled Tightening of Bolts. Ideally all critical flange connections should have the bolts tightened in a controlled manner, preferably by means of measured bolt stretching or alternatively with torque wrenches.

9.2 Primary causes of flange leakage

a. Uneven Bolt Stress
Flanges fastened unevenly may cause some bolts to be nearly loose while others are so heavily loaded that they locally crush the gasket. This causes leaks, particularly in high temperature service, where the heavily loaded bolts tend to relax (or may even fracture) with subsequent loosening of the joint.

b. Improper Flange Alignment
As with unevenly fastened joints, improper alignment, especially lack of parallelism between flange faces, can cause uneven gasket compression, local crushing and subsequent leakage. Proper centreline alignment of flanges is important to assure even compression of the gasket.

c. Excessive Forces in the Piping System
This can occur because of improper piping flexibility design, or by excessive application of force to attain flange alignment. Improper or lack of restraints or supports, will also cause high flange bending moments and forces.

d. Improper Centring of Gasket
A gasket, which is misaligned, installed so that its centreline does not coincide with the flange centreline, will be unevenly compressed, or not fully compressed across the gasket seating surface thereby increasing the possibility of subsequent leakage.

Spiral wound gaskets are provided with a centring ring to the inner bolt circle to facilitate centring of the gasket. Even so, the gasket should be centred with respect to the bolt circle. Compressed Fibre gaskets should, be cut so that the outside diameter extends to the inner bolt circle.

e. Dirty or Damaged Flange Faces
- These are obvious causes for leakage since damage or dirt, including scale can create a leakage path along the flange face. Damage includes scratches; protrusions such as weld spatter; and distortion or warpage of the flange.

- Ring type joint flange grooves heavily scaled due to lack of protection during stress relieving or storage

- As a rule, flange faces should be machined if the following more common defects exist, refer to ASME PCC-1-2019:

- Flange joint face cut, gouged, scratched to a depth equal to the depth of the serrations, extending two thirds (2/3rds) across the width of the face.
- Incorrect surface finish / gramophone finish for the type of gasket being used.
- Heavy corrosion of the jointing face especially if this results in loss of serrations.

- As a rule, flanges should be replaced if the following defects exist:

    - Flange distortion (rotation) beyond allowable limits due to historic overtightening. This is quite visible when the flange outer diameter closes between two flanges upon tightening.
    - Restored Flange dimensions after machining is lower than the design requirements.

f. Human Error

- Loose and/or missing bolts, wrong size/material of bolts, half nuts.

- Two gaskets installed/ Missing gaskets, Wrong gaskets

- Incorrect size/type/rating of gasket installed, e.g. 150# ANSI in 300# ANSI and 600# ANSI flanges

g. Bolt maintenance

- A bolt replacement strategy should be considered pending the following factors:

    - Age.
    - Repetitive use.
    - Condition from visual inspections.
    - Bolt stress requirements for flange sealing using special torque procedures.
    - Service i.e. cyclic operating conditions.
    - Product type.
    - Possible consequences in the event of a leak.

- Bolts should be serviced by cleaning the threads and applying lubrication before re-use (Type of lubrication used must be factored in when performing bold load calculations for torque applications)

- Bolt material selection should be confirmed for each application as specified by the design drawings.

9.3 Additional troubleshooting

a. Joint-friendly commissioning and operating procedures
These measures are aimed at minimising thermal and pressure shocks of critical

flanged joints. The objective should be to ensure that temperature and pressure gradients experienced are as gradual as can be tolerated by the process. Typically, gradients should not exceed 50°C per hour to allow all parts of the system to expand/contract in unison.

Sudden and steep pressure and temperature fluctuations should similarly be avoided as far as reasonably practical to avoid sudden relaxation of bolt stresses.

Operations personnel are to inform Reliability personnel when such events have taken place to ensure that critical flanges in these systems are checked for potential leaks soonest.

b. Improved flange / piping layout design
Where other mitigation measures prove to be ineffective and a design change is unavoidable, this should carried out by means of the management of change procedure.

c. Improved gasket design
Gasket changes that deviate from the design specification, shall only be done in accordance of the management of change procedure.

d. Special Types of Studs and/or Nuts
Special types of stud bolts and nuts such as "super-bolts", special spring washers etc. shall only be used after following the management of change procedure.

e. Leak Testing
Prior to bringing a unit or process system online all joints should be leak tested for leakage. This can be done by taping the joints with masking tape, piercing the tape with a small hole (pin prick). The pipe circuit should then be pressurised with nitrogen and a leak test carried out on each gasket by checking, at the hole made in the tape covering the flanges, with a soapy water mixture to ensure that no bubbles are formed. If bubbles formed, flange to be pulled up or gasket replaced.

f. Hammer Test
It is prudent as part of flange assembly QC to conduct a hammer test on all fastened bolts – the "ring" emitted when the stud/bolt is lightly tapped by a small hammer (spark free) should make the same "ringing" sound on all fastened bolts. Uniformly bolt loads will produce a uniform "ring" whilst a loose bolt will not. It should be noted that this is a "quick and nasty" test and is subject to interpretation and should not be an alternative to correctly tensioned bolting.

9.4 Flange leakage control

The following mitigations can be considered to reduce the consequences of a leaking or gasket failure:

- Provision of snuffing steam to dilute any gases that may escape.

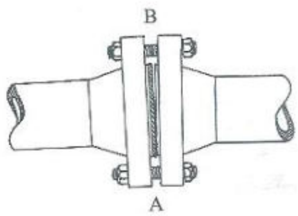
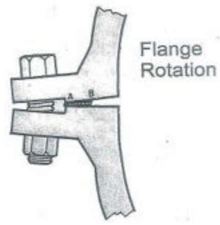
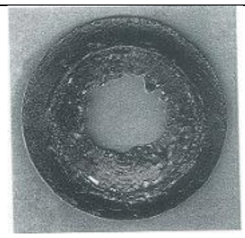
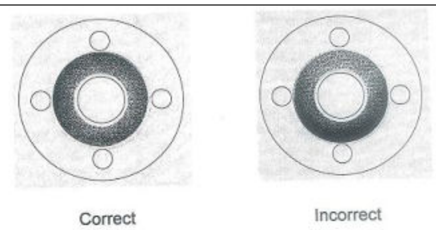
- Provision of a standby person/ fire brigade with fire equipment in cases where the risk is high during commissioning / start-up.

- Re-tightening, hot bolting or re-torqueing. (Must be done under controlled conditions as per procedure after completing a through Risk Assessment.)
- Online leak sealing devices.

Since every critical flanged joint is unique, each one of these shall be treated uniquely and shall have its own specific works instruction drawing from the typical measures described above.

9.5 Fault finding

This section discusses the things that can go wrong with gaskets and flanges.

Problem	Cause	Image
Flange misalignment	Flange misalignment generally results from over-compression of the gasket at A and under compression of the gasket at B. It also results from high stresses in pipes	
Flange rotation	The outer edges of the flange are pulled toward each other as the bolts are tightened. The inner diameter of the gasket can be partially unloaded by this process. Thermal expansion and/or contained pressure can also cause flange rotation.	
Over-compression of gasket material	Over compression occurs when the load bearing limit of the material is exceeded. The gasket extrudes and exhibits a sharp decrease in thickness. Loss of gasket stress leads to joint leakage.	
Gasket misalignment	The tightening sequence on gasket loading.	

10. GASKET INSTALLATION AND INSPECTION PROCEDURES

10.1 Prior to Gasket Installation

a. Gaskets

- Determine the pipeline class designation from the P&ID, MFD and/or Isometric. Check that the flange rating, facing, bolting, gasket size, material and type and are as specified by the pipeline class.
- Dissimilar metals should not be used for ring joints and flanges to avoid galvanic corrosion.
- Ensure that the correct colour coding of the gasket to be installed.
- Gasket size is a common error. Inside diameter of gasket should coincide with or be more than pipe inside diameter. No gasket material should protrude into the product stream, for oxygen service this is extremely important as this could cause ignition.
- The outside diameter of the compressed fibre gasket and of the centring ring for spiral wound gaskets should extend to the inner face of the bolts. If this criterion is not met the gasket is usually the wrong size or pressure rating and won't centralize in the flange. Too small gasket could cause misalignment and/or crushing of the gasket seating area leading to a leaking flange joint.
- Oxygen service requires special gaskets.
- Check new gasket condition. Only new gaskets should be used. Damaged gaskets, including loose spiral windings and damage across the spiral wound sealing surface and or score marks on ring-joints should be rejected. Ensure gasket is dry and remains dry for and during installation.
- Inspect removed gasket as it will show evidence of the condition of flange faces, flange alignment and bolt torque (incomplete compression etc.).
- In accordance with ASME B16.20, Inner Rings are Mandatory for the following flange designations:
    - Class 900 – NPS 24 and larger
    - Class 1500 – NPS 12 and larger
    - Class 2500 – NPS 4 and larger
    - All PTFE filled gaskets
- Check condition of flange faces, that flanges faces are clean of any protective coating, paint, rust, etc.

b. Flange Face Finish and Flange Alignment
Scratches, score marks, dirt, scale and protrusions. All flange joint faces must be thoroughly cleaned prior to new gasket installation and bolt up. Generally accepted surface finishes according ASME PCC-1 are as follows:

Gasket Type	Surface Finish
Soft Cut, thickness ≤ 1.5mm	Ra 3.2 – 6.4 microns
Soft Cut, thickness >1.5mm	Ra 3.2 – 12.5 microns
Spiral Wound	Ra 3.2 – 6.4 microns
Metallic Jacketed	Ra 2.5 microns (max.)
Solid Metal Ring Joint	Ra 1.6 microns (max.)

The finish of the gasket contact faces shall be judged by visual comparison with the Ra standards (see ASME B46.1) and not by instruments having a stylus and electronic amplification.

Except for solid metal ring joint gaskets, a defined range is specified for surface finishes. A finish coarser than that specified would require a higher initial compression load to cause the filler to flow into the surface irregularities. If the finish is too smooth this will result in a movement of the seal section over the flange face and increase the probability of premature failure.

NOTE:
Prior to 1996 the ANSI B16.5 (Pipe Valves and Flange Fittings) Standard allowed for a raised face surface finish of namely Ra 3.2 – 12.5 um.

Deep scratches, heavy corrosion or dents will require re-facing or lapping. A generally accepted standard for scratches is not greater than one third of gasket seating width and not deeper than the depth of the grooves. Repairs to flange faces should be done in accordance with ASME PCC-2, Article 305.

According to ASME PCC-1, 2019 Table 2 allowable defect sizes (Pits, Dents, Scratches and Gouges) are as follows:

Defect Size (Expressed as a proportion of the gasket sealing width)	Allowable Defect Depth (Hard-Faced Gaskets)	Allowable Defect Depth (Soft- Faced Gaskets)
Less than ¼	< 0.76 mm	< 1.27 mm
Between ¼ and ½	< 0.25 mm	< 0.76 mm
Between ½ and ¾	Not allowed	< 0.13 mm
Greater than ¾	Not allowed	Not allowed

Use a straight edge to check for flange facing flatness. Reject warped flanges or repair/machine in accordance with ASME PCC-2 (Article 305).

Check alignment of mating flanges. Avoid use of force or hard pull-up to achieve alignment. Acceptable alignment tolerances as per ASME PCC-1-2019, measured when flanges are at rest, are as follow:

Lateral Alignment	**Max 1.5 mm**
Parallel Alignment	Max of 0.8 mm difference between the narrowest and widest gaps
Rotational Alignment	Max 3.0 mm
Excessive Spacing	Not more than twice the thickness of the gasket

Inspect the bolt holes of the flange and the flange bearing surface for any galling / wear – repair if necessary and use hardened washers to act as bearing surface in future. (Reference ASME PCC-1-2019)

c. Gasket Installation

- Care must be taken during transportation and handling of gaskets, especially the spiral wound types. Extra care must be taken when using graphite filled spiral wound gaskets due to the very soft nature of the filler.

- Visually inspect the gasket for:
  - Correct gasket type as per line class specification.
  - Check size and rating on outer ring against that on flanges.
  - Check windings for damage.
  - Check gasket for damage.
  - Check the colour coding of gasket edge for correctness. Spiral Wound Gaskets shall be installed so that the colours are visible between bolts and orientated toward a platform / walkway / access way for easy of identification.

  Do not use:
  - Seal compound on gaskets or flange faces.
  - Masking tape to keep gasket in place.
  - Oil or grease gasket or flange sealing faces.
  - Rather use a multipurpose spray glue.

- Inspect flanges gasket seating area for cleanliness and damage. Insert gasket, making sure it is properly centred. Gaskets correctly cut will fit inside the bolt circle and will centre automatically

- Insert remaining bolts and re-check flange alignment. Do not pull up hard on individual bolts in a manner causing uneven compression of gasket.

- The flange management checklist must be completed for all critical lines/flanges prior to flange assembly.

11. PROCEDURE FOR BOLTED FLANGE ASSEMBLY

The following covers the bolting up of a flange joint and it is assumed that the following steps have been completed:

- Flanges, faces and gaskets have been inspected.
- The correct gasket has been selected as per the line class specification and is inserted and centred evenly within the inner bolt circle.
- The bolts and nuts are as per the line class specification of the correct material and they have been lubricated and are in good condition.
- The bolts have been inserted and are finger tight.
- Flange management checklist completed for all critical lines/flanges.

11.1 Wrench and Hammer

- "Hand" tighten bolts with a short wrench using the "criss-cross" pattern shown in Appendix 2. Do not pull up hard on individual bolts in a manner causing uneven compression of gasket.
- Tighten bolts a second time, again using "criss-cross" pattern with wrench and a light hammer. Use of feeler gauge is mandatory for the first tightening sequence on oval ring metal gaskets.
- Continue tightening gradually in "criss-cross" pattern using a heavier hammer, until all bolts are completely drawn tight, this may take two or three additional rounds with the "criss-cross" pattern. For bolts larger than a 25 mm diameter, a final round or two with an even heavier hammer following the "criss-cross" pattern is necessary in order to reach the correct bolt tension.
- After following the "criss-cross" sequence a final tightening should be performed in a clockwise bolt-to-bolt sequence to assure all bolts have been evenly stressed.

Notes:

- *Never draw up tight on one or two bolts only. This will cause local crushing of the gasket or pinching or flange distortion, which will result in leaks. Always tighten up gradually, using the "criss-cross" pattern. After each round of tightening, the alignment should be checked by measuring the distance between flanges. A feeler gauge should be used when tightening spiral wound and ring joint gaskets.*
- *The question of how tight is "enough" could be defined as follows: the bolts should be gradually and evenly tightened with wrench and hammer until the hammer begins to "bounce" with a distinct ring. This takes patience and practice but will permit tightening to the required bolt stress level.*

11.2 Impact Wrench

Impact type wrenches are available and should be used, where practicable. They must be considered a labour-saving device to run nuts on and off, since they are not entirely reliable as a means of achieving even bolt tension. However, evenness of bolt load, can be at least as good as that achieved with a wrench and hammer.

11.3 Mechanical/Hydraulic Tensioning Devices

The use of mechanical or hydraulic tensioning devices is especially recommended for bolting up large flange joints. These devices save labour and will facilitate attaining very even bolt loading. They should be used to make up large flanges where bolt spacing permits fitting of the tensioner heads. Bolt extensions beyond the nut are to be protected by metal caps or other approved means to protect threads against galling and seizure due to corrosion.

Specific torque values are to be determined on an ad hoc basis by the bolt torqueing service provider who shall submit torqueing datasheet for review and approval prior to commencing the work. Torqueing service provider to provided joint torque certificate as well as quality control datasheet for all flange joints tightened.

11.4 Hot Bolting

Hot bolting is sometimes specified to recover initial bolt loading lost due to thermal expansion. This should not really be necessary if the studs are correctly tensioned and there is no mismatch between the thermal coefficients of expansion for the flange and bolting material.

The following guidelines should be followed to ensure that hot bolting is done with the utmost care and in a manner as safely as possible:

- A comprehensive risk assessment is done prior to doing hot bolting, it is recommended to decrease the pressure and temperature when attempting hot bolting. Hot bolting should not be done at operating conditions.

- It must be done under permit conditions as per permit to work procedure.

- The specific works instruction for the critical flanges should be attached to the permit to work.

- Where practical and possible, non-percussion hydraulic bolt tensioning devices shall be used to do the tightening to minimise shock loads. Where this is not possible, pneumatic impact wrenches shall be used. Only if this proves not to be practical, shall hammers be used. Where hammers are used, non-sparking hammers only shall be used (copper or synthetic), excluding non-flammable environments where sparking may have no adverse consequences.

- Where hydraulic or pneumatic equipment is used, stud bolts shall be tightened at the prescribed torque value for the size of bolt.

- Bolts should first be tightened in the typical criss-cross pattern to ensure that flanges are tightened evenly.

- Final tightening shall be done in a bolt to bolt sequence to assure that all bolts are evenly stressed.

- Requirements for hot bolting must be specified in the mechanical checklist prior to clearance for operation. These requirements for specific critical flanges shall also be included in the start-up procedures for the unit.

- It must be appreciated that hot bolting can be considered dangerous as the material properties of the studs, bolts and flanges are reduced by temperature. Furthermore, care should be taken that the bolts are not overstressed. If a flange is leaking due to over-tightening, hot bolting could aggravate the situation.

- Flogging of flanges by means of spanner and hammer should only be considered as a last resort after due consideration with an approved safety authorisation and after completing a thorough risk assessment.

- Consideration of online leak sealing to be considered as mitigation for leaking flanges if leak doesn’t damage gasket seating surface, cut flange or bolts. Reference ASME PCC-2 Article 3.6.

12. PROCEDURE FOR UNBOLTING FLANGE ASSEMBLY

- Before starting to unbolt the flange, assembly ensure that:
  - Safety authorisation and risk assessment has been completed.
  - Equipment has been made safe for maintenance actions.
  - A permit to work has been issued for the maintenance action to be carried out.
  - The process system is isolated. Take care in case of seepage or bypassing valves has allowed pressure to build up again.

  Remember to consider all the safety aspects:
  - Are you or others in the line of fire?
  - What if the flange is still under pressure?
  - What if there is still gas or fluid in the line?
  - What if the piping springs up on release?
  - What if the load swings in my direction?

There is an enormous amount of elastic energy stored in a fastened flange. In effect, the joint is a spring which has been held and compressed by the fasteners. As the bolts are removed one by one, the stored energy of the joint may begin to load the remaining bolts. This can have the effect of distorting the flange and may damage the flange surfaces.

Use the reverse of the procedure which you used to tighten them:

- Where hydraulic or pneumatic equipment are used, stud bolts shall be tightened at the prescribed torque value for the size of bolt.

- Put penetrating oil on the bolted joint threads prior to commencing with unbolting.

- Use a criss-cross bolt untightening procedure.

- Use several passes - partially loosen each bolt before further loosening any of them

- Gradually slacken the nuts by running them back along the bolts but do not remove them.

- Break flanges away from personal body standing position.

- Only when the fasteners are sufficiently loose to verify that the seal has been broken should the nuts be removed.

- Handle and store the flange and fastener components carefully to avoid damage or being misplaced.

- You may need to scrape out remnants of the gasket which have stuck to the flange surfaces - in which case use a tool such as a scraper or wire brush –

be careful of carbon contamination of stainless-steel flanges and faces which is softer than the flange material.

- If there is difficulty in releasing the joint, caused by galling of nuts and bolts, there are several approaches which can be used:

  - Use a nut-splitter.
  - Use a penetrating oil solution, clean it afterwards.
  - Weld a nut to the end of the stud and use this as a “head” to get a good grip on the bolt.
  - Use a double nut, lock nut, if threads allow.
  - As a last resort, saw off the fasteners, drill them out, cut off with oxy-acetylene torch while taking care to not cause damage to the flange.

13. LIKELIHOOD OF A LEAK

The likelihood of a leak at a flanged joint is typically increased in the following circumstances:

- When a flange is known from experience to be a problem flange in terms of past leakage during operation.
- Flanges operating at high pressures and extreme temperatures, both high and low temperatures are more prone to leaks.
- When steep temperature or pressure gradients can be experienced over short periods of time.
- The larger the flange diameter the higher the likelihood of a potential leak.
- The frequency at which a flanged joint is opened and closed, increases the probability of the flange leaking.
- Uncommon flange designs increase the likelihood of leaks.
- Factors such as plant upsets, temperature and pressure cycling, and vibration will increase the probability of a leak.
- Overstressing of specifically stainless-steel flanges can occur when B7 or B16 bolts are used and are then over-tightened.

The consequence of a leak on a flanged joint is typically a function of the following factors that should be considered:

- Flange diameter and line pressure will influence the size of a leak that will occur.

- The combination of flow medium and temperature will increase the severity of a leak, flammable and explosive products at high temperature are typical hazardous conditions.

- How will the leaking flange affect production, safety of plant and personnel and/or environment.

14. FIRST BREAK PROCEDURE FOR PROCESS SYSTEMS

Refer to the company line first break procedure. A guideline for first line break is captured in appendix 4.

15. GASKET STORAGE AND HANDLING

Although many gasket materials can be used safely after storage for many years, the performance of some gaskets may be compromised due to ageing. Chemical degradation will occur over time as some gaskets are exposed to temperature, humidity, ozone (generated from high voltage electrical sources) and UV exposure.

Compressed elastomer-based sheets, as well as finished gaskets, should not be stored for long periods of time. The elastomer used as a binder can age causing degradation of physical characteristics, important to sealing performance. Even aging at ambient temperatures for long periods will have a distinct effect on properties of certain types of gasket materials. This occurs over time primarily because of the chemical degradation of the rubber binder. Figure 21 shows a typical curve of a decrease in compressed elastomer-based fiber gasket material compressibility as a function of time at 25°C.

Primarily, aging is a concern for materials bonded with most elastomers. In general, these gaskets should not be used after about 4 years from the date of manufacture. Those materials with elastomeric binders will inevitably deteriorate over time and even more quickly at higher ambient temperatures. Degradation is also accelerated by intense sunlight and naturally occurring ozone. All these factors can cause extensive physical damage to the gasket material which will typically result in leakage over time.

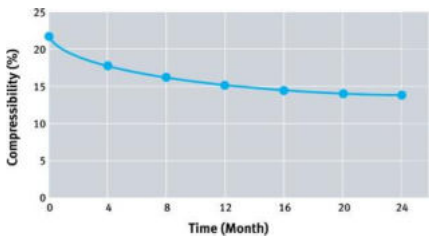


Figure 21: Compressibility Change after Aging

Since the mechanical properties of the gasket material play an important role in performance, it is important to control those conditions that accelerate deterioration from aging. The natural aging of the compressed non-asbestos gasket will depend upon the material composition, degree of rubber cure and the way the gasket was fabricated. It is important that the manufacturer recommendations for storage and handling be followed to ensure the longest shelf life for the material.

For metallic gaskets, performance degradation is of little concern; however, it may influence semi-metallic gaskets specifically, those which are combined with elastomer- bound materials and which may incorporate adhesives to bond substrates. Since homogeneous flexible graphite and PTFE materials contain no binders and are generally considered inert, sheets and gaskets of these materials have virtually an indefinite shelf life.

General guidance from most gasket manufacturers is to store gaskets and gasket materials in a cool, dry location away from heat, excessive humidity, direct sunlight, and chemicals. The optimum storage conditions are defined as 4°C to 27°C with 40% to 75% relative humidity, in a room with no windows and non-UV or low-UV producing lights, minimal dust and no chemical storage or high voltage electrical sources nearby.

15.1 Overall storage recommendations:

- Store in a cool, dry place, away from direct sunlight, UV light, water, oil, chemicals, and chemical vapours.

- Do not expose gaskets to excessive heat and humidity or extreme fluctuations of heat and humidity

- Keep gaskets clean and free from mechanical damage for maximum protection, store in sealed poly bags.

- Avoid accumulation of dust and particulate on gasket faces and edges which may cause compatibility issues with the fluid being sealed.

- Store most sheet materials flat where practical and wrapped and/or covered.

- Store non-metallic (soft) gaskets flat in stacks and avoid hanging them as they may deform.

- For spiral wound gaskets, store them in their original packaging with spacer clips intact. Commonly, gaskets up to 150mm (6”) are stacked in 5 or 10 pieces per bundle and gaskets between 150mm (6”) and 500mm (20”) are stacked in 2 or 5 pieces per bundle using plastic spacer clips to avoid damage to the sealing elements.

- For large diameter spiral wound gaskets (>500mm (20”)), keep them on their mounting board and in original packaging.

- For metallic gaskets, high humidity and moisture can cause oxidation. Typically, these gaskets are treated to prevent oxidation. Consult your gasket manufacturer.

The effect of storage and ageing will depend upon the material. Consequently, always consult the manufacturer for advice about storage of specific products.

Gaskets and their packaging should always be handled with care in order to avoid deterioration and damage and extra care should be taken when handling large gaskets greater than 500mm (20”) in diameter. Whenever gaskets are being transported; individually or in groups; it is preferred that they be kept flat, however, when this is not practical, always make sure that the gasket(s) are adequately supported to avoid any distortion. Typically, transporting gaskets in their original packaging will provide the best protection against distortion until they are ready to be installed.

For individual gaskets; sizes up to 800mm (32”) in diameter, can often be handled by one individual. However, it is recommended to use additional people for larger size gaskets in order to properly support the gasket and avoid twisting, distortion and breakage.

Gasket Size	**Number**
800 - 1000mm (32” - 40”)	3 people
1000 - 2000mm (40” - 80”)	4 people
2000mm (80”) and larger	6 - 8 people

When handling spiral wound gaskets, wear gloves and do not hold the gasket by the outer ring only. Failure to adequately support the sealing element and/or inner ring may cause it to dislodge from the outer ring under its own weight, or through flexing and become damaged. Always ensure to support all the components of spiral wound gaskets through to final installation. It is recommended to keep the mounting board in place for large diameter gaskets until the gasket is situated between the flanges.

Proper handling of gaskets will ensure its integrity is withheld through the transportation and installation stages. Special sizes and gasket configurations usually require special handling on their own. Always consult the manufacturer for recommendations and best practices for your unique conditions.

16. UNIQUE APPLICATIONS / SPECIALTY EQUIPMENT

As with most industrial products, there are many unique applications and pieces of specialty equipment. They often have their own product, material, and specification requirements. Though it is impossible to consider all the unique applications and specialty equipment, several common ones are briefly discussed below in order to highlight their specific gasketing requirements.

16.1 Oxygen Service

All organic and inorganic materials react with both gaseous and liquid oxygen at certain pressures and temperatures. This can cause serious fires and/or explosions. Because of this inherent danger, it is important to select gasket materials which have been tested and certified for use under these severe conditions. There are many sub-handling requirements for all products in oxygen service, but most applications require the base gasket material to be BAM certified. ASTM publishes two guides (G63, G94) which establish a system for evaluating non-metallic and metallic materials for oxygen service. Several materials commonly used as gaskets in oxygen service, such as PTFE, graphite, and sponge chloroprene (CR) elastomer. The best practice is to use the least reactive material available with the highest oxygen indices.

16.2 Chlorine Service

Chlorine is an aggressive oxidizer that reacts with many metals and organic materials. Service conditions, including contact with dry or wet chlorine, must be considered when assessing proper gasket selection.

16.3 Ethylene Oxide

Ethylene Oxide (EO) is considered very reactive and must be given special attention when selecting proper sealing products. The reactive process is referred to as polymerization and occurs naturally with many products. EO rapidly attacks and breaks down many of the organic polymers and elastomers used to make gaskets and one of the most important points to consider is the rate of deterioration of any selected material. It has been found that the preferred gasket type is a spiral wound gasket with 304SS outer/inner rings, 304SS windings and pure (98% min.) flexible graphite filler.

16.4 Fire Safe Requirements

In many refinery and power plants there is the requirement for gaskets to be rated as “fire safe”. It is common that most metallic and semi-metallic gaskets are accepted as being “fire rated”. There are non-metallic gasketing products such as flexible graphite gaskets which have passed fire tests. In addition, there are a few compressed elastomer-based fiber and PTFE gaskets that have also passed fire tests.

16.5 Clean/Ultra-Pure Water

Due to the requirement of this industry for ultra-clean equipment (piping, valves, fittings and gaskets), most gaskets can be used in these pure water applications providing they have been cleaned to some specific level as required by the end-user. In many circumstances cleaning procedures like those for oxygen service can be employed and will meet the local requirements, however, always consult with the manufacturer and verify that the gasket supplier's cleaning procedures meets end-user requirements. Typically, end-users will perform additional cleaning procedures before placing equipment in service.

16.6 Heat Exchangers

Shell and tube heat exchangers pose a unique challenge, due to the relatively low allowable gasket stress designed into the equipment, combined with the temperature cycles and temperature changes, creating a condition called radial shear, from chamber to chamber. Research indicates that there can be a net loss of 20% or more in initial bolt load during the increase in operational temperature of the joint. Care needs to be exercised when making gasket changes in these types of systems.

Many shell and tube heat exchangers come from the factory equipped (OEM) with metal jacketed gaskets, mostly for costs, which usually do not give optimum performance over an extended period. Kammprofile, expanded PTFE and flexible graphite gaskets, can be suitable alternatives to these OEM gaskets.

Kammprofile gaskets, stainless steel serrated cores with flexible graphite covering layers, offer significantly lower required seating stress, resiliency to temperature fluctuations and radial shear inherent in the application. With the varying designs of shell and tube heat exchangers and required partition bars, it is important to communicate measurements and drawings to your gasket manufacturer in order to ensure precision alignment with your equipment.

PTFE gaskets can be a gasketing option for heat exchanger design that does not require a metal component to the gasket. PTFE gaskets offer the benefit of conformability and chemical compatibility. Heat exchanger gaskets can be cut from PTFE sheets.

Often in the field, heat exchanger surfaces get damaged, causing difficulty in sealing the metal gasket specified in the original heat exchanger design. When heat exchanger surface re-surfacing is not possible during an outage, graphite joint sealant and PTFE can be an effective repair method.

Appendix 1: ASME B16.20 Colour code chart

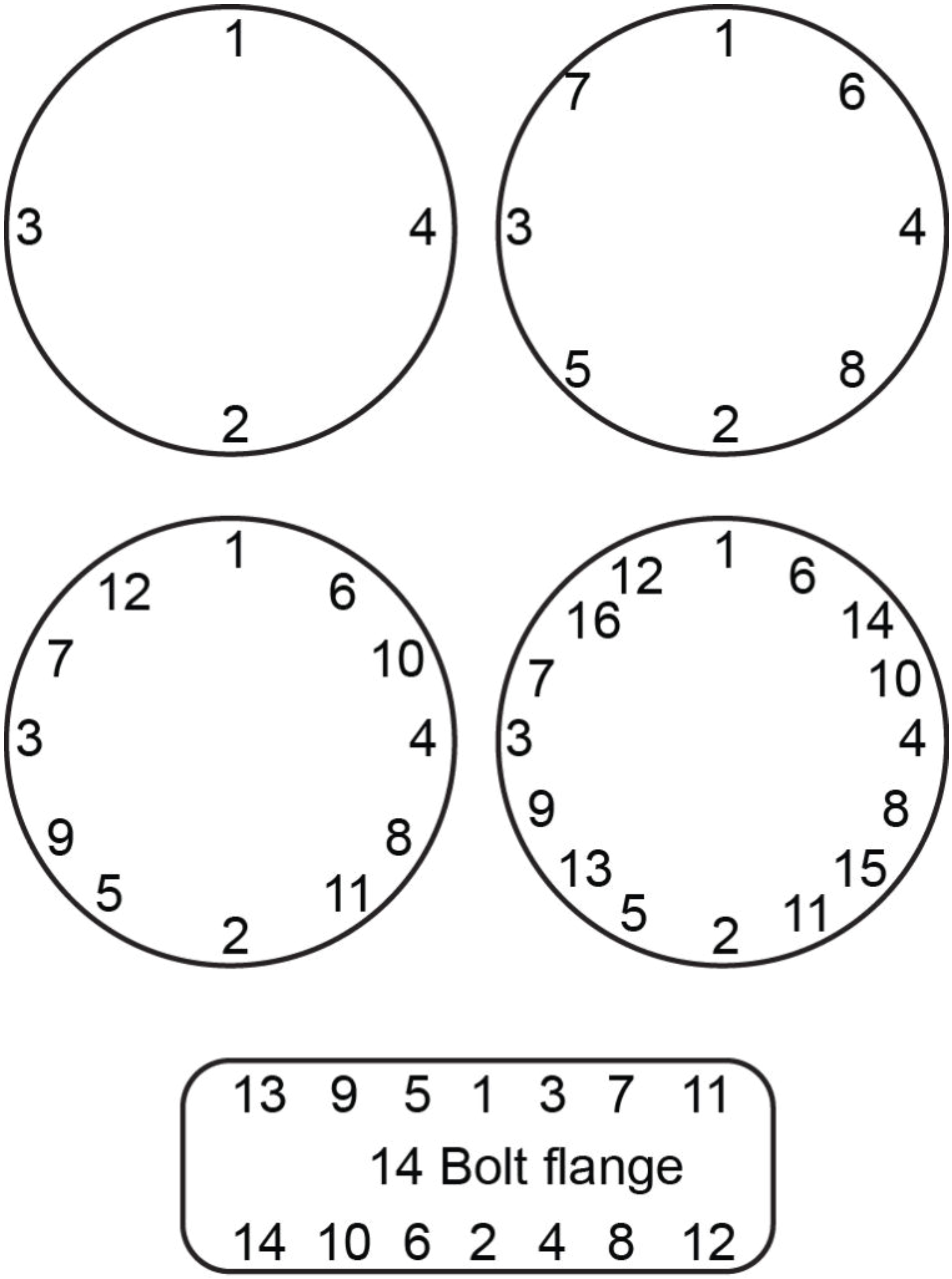
ASME B16.20 Color Code Chart

Spiral Wound Gasket Metallic Windings and Non-Metallic Fillers

Metal	O.D. Ring Color
304 Stainless Steel	Yellow
316L Stainless Steel	Green
317L Stainless Steel	Maroon
321 Stainless Steel	Turquoise
347 Stainless Steel	Blue
MONEL®	Orange
Nickel	Red
Titanium	Purple
Alloy 20	Black
INCONEL® 600	Gold
HASTELLOY® B	Brown
HASTELLOY® C	Beige
INCOLOY® 800	White

Material	Stripe Color
Flexible Graphite	Gray
PTFE	White
Ceramic	Lt. Green
Verdicarb (Mica Graphite)	Pink

Appendix 2: Torqueing sequence



Appendix 3: Methods of attaching flanges to pipes

There are five methods by which flanges are attached to piping. These methods are discussed in the following sections.

a. Screwed-on flange

In this method, the flange is screwed onto the pipe see Figure a. This type of flange is usually used on water piping.

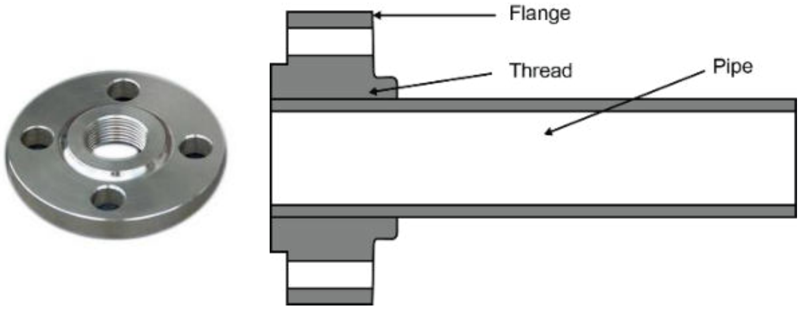


Figure a: Screwed-on flange

b. Slip-on flange

The slip-on (SO) flange Figure Figure b is slipped over the end of the pipe and welded to the pipe at the flange collar and the pipe face. This method is usually used on low-pressure product lines (process) and steam lines. These lines usually use pipeline sizes of 2” and above for American National Standards Institute (ANSI) flanges.

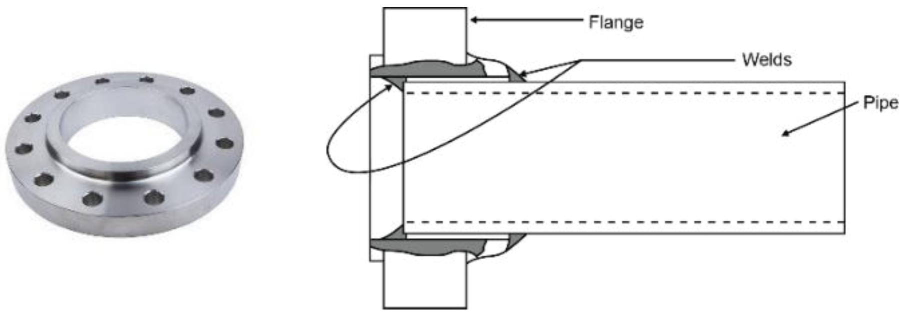


Figure b: Slip-on flange

c. Weld neck (WN) flange

The diameter of the weld neck (WN) flange’s neck is the same as that of the piping. In this method this flange is welded to the pipeline Figure c shows an example of this flange. This type of flange is usually used for high-pressure product lines and steam lines.

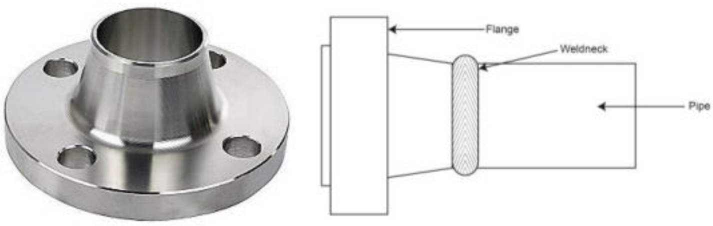


Figure c: Weld neck flange

d. Socket-weld flange

With this method, the pipe is stuck into the recess of the socket-weld (SW) flange. The pipe is then only welded to the flange collar. Refer to Figure d. This method is usually used on low-pressure product lines (process) and steam lines, which usually use smaller pipeline sizes.

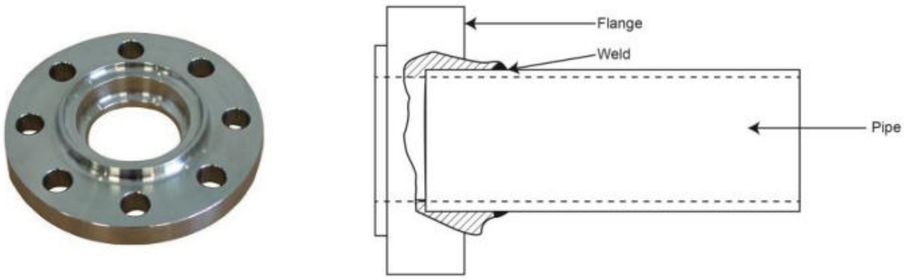


Figure d: Socket weld flange

e. Lap-joint flange

This flanged connection is supplied with a stub which is butt welded to the pipe. The flange itself can be slid away from the actual gasket face in order to allow for easy maintenance. This means that the lap-joint (LJ) flange is made up of two main components: the LJ stub and the LJ flange Figure e.

Figure e: LJ flange

Appendix 4: First break procedure for process systems

The following methodology can be followed when process equipment or systems are to be opened after being prepared by production for maintenance purposes:

- The equipment to be worked on must be positively identified by using the relevant identification procedure. Production personnel can further positively identify the equipment that needs to be worked on to the maintenance personnel required to do the work as described in the permit to work.

- All feed and outlet lines must be isolated to prevent exposure of maintenance personnel to product.

- Personnel carrying out the task as described under the permit to work conditions must wear the appropriate PPE as prescribed by their trade or as prescribed in the permit to work to meet the special PPE requirements in order to ensure that the work is safely executed.

- Production personnel must be present when process equipment is opened for the first time.

- All flanges on process equipment / piping must be approached with caution when being broken. The process system must be treated as if it is still under pressure.

- The person unbolting the flange must preferably stand upwind with the flange in front of him so that any escaping product is blown away from his body should it leak out when the flange is broken.

- When loosening the bolts, the person must start with the bolts on the opposite side of the flange from him to ensure that any product still in the system does not spill onto him when the flange is loosened. Bolts should not be removed until the flange gasket seal is broken.

- Maintenance personnel must request production personnel to clean the equipment / piping should the equipment / piping still be contaminated with product after being opened.

- The correct bolt loosening procedure shall be used when breaking flanges and equipment covers. These procedures shall be available for all maintenance personnel.

- If a liquid or gas leaks from the flange that is being worked on, work shall be temporarily ceased. The Production supervisor shall be informed so that the conditions as prescribed on the permit to work can be checked by the production personnel. Once the conditions are reinstated to the requirements stipulated on the permit, work may then be allowed to proceed.

- Should the precautions and conditions as stipulated on the permit not be met, the permit shall be cancelled. Work must not be allowed to proceed.

List of References

Internet:
1. https://www.indiamart.com/proddetail/flat-face-flanges-11207054691.html
2. http://www.mpjainco.com/pipe-flanges/rtj-ring-type-joint-flanges-manufacturer-exporter/.
3. https://www.tandfonline.com/doi/pdf/10.1179/1432891715Z.0000000001469.
4. https://www.mestainc.net/asme-b16-21-non-metallic-gasket-manufacturer-india.php.
5. https://www.idv.co.za/product/burgmann-spiral-wound-gaskets/.
6. https://khonglieng.com.sg/products/klinger/metallic-gaskets/klinger-maxiprofile-109/
7. https://m.made-in-china.com/product/PTFE-Gasket-of-High-Quality-for-Sealing-749794142.html
8. https://www.indiamart.com/proddetail/screw-flange-7420022473.html
9. https://shop.dnow.com/product/577038-10-in-slip-on-flange-class-150-rf-ss
10. https://mdlily.en.made-in-china.com/product/IjwEiWgdlHcV/China-ANSI-B16-6-ASME-B16-47-Socket-Weld-Flange.html
11. https://www.indiamart.com/proddetail/lap-joint-stub-end-flange-12029978430.html
12. https://www.scribd.com/document/416046016/Procedure-System-of-Flange-Management-Procedure-Site
13. https://idoc.pub/download/flange-management-procedure-d4pqjd85j6np
14. https://en.wikipedia.org/wiki/Gasket
15. https://en.wikipedia.org/wiki/Bolt

Standards:
1. ASME B16.5 Pipe Flanges and Flanged Fittings
2. ASME B16.20 Metallic Gaskets for Pipe Flanges
3. ASME B16.21 Non-metallic Flat Gaskets for Pipe Flanges
4. ASME PCC-1 Guidelines for Pressure Boundary Bolted Assembly Joint
5. ASME PCC-2 Repair of Pressure Equipment and Piping

Other:
1. Bolt joint integrity - Klinger
2. CDMS 3952 - Flange Management for Cape Town Refinery – Astron Energy
3. Assembly of Flanged Joints – PetroSA
4. Standard Procedure for The Management of Flanged Joints -Sapref
5. Assembly of Flange Connections – Sasol Eurasia
6. Learning manual Flanges and Gaskets – Sasol Secunda
7. Gasket Handbook 1st Edition – European Sealing Association

END