BP Amoco

Piping Joints Handbook

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A “hard” pocket size version of this Handbook can be
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Further information is available from:

Mechanical Consultant, UTG, Dyce;
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Piping Joints Handbook

Introduction

This booklet has been written as an introduction to and a source of general information on pipe joints.

The flanged joint appears deceptively simple but in fact the science of flanges and joint sealing is complex and continuously developing. Sound joints are critical to piping integrity and plant safety.

A pipe joint thus relies on the skill and application of the fitter who puts it together. Correct selection of materials, application of procedures, correct use of tools combined with the fitter's skill are all required to ensure a joint of maximum integrity.

But mistakes have happened; choosing the wrong gaskets, using the wrong studbolts. Such mistakes cannot be ignored.

The purpose of this booklet is therefore to increase understanding about pipe joints; from pipe specifications and how to use them, to studbolts and how to identify them. With increased awareness and knowledge, it is expected that mistakes will be prevented.

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Section Nos.	Contents	Date Amended
-	Re-issue of handbook	May 2000

1. Technical Data - Company and National Standards

1.1 BP Amoco Engineering Standards

The following BP Amoco Standards are relevant to pipe flanged joints:

RP 42-1	Piping Systems
GS 142-7	Gaskets and Jointing
RP 42-2	Bolting for Flanged Joints (Inch Series)
GS 142-4	Flanges
GS 142-5	Fittings

1.2 ANSI/API Standards

The following American Standards are used for the standardisation of pipe joints:

ANSI BI.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI BI.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B16.9	Factory made Wrought Steel Butt Welding Fittings
ANSI B16.11	Forged Steel Fittings, Socket Welding and Threaded
ANSI B16.20	Ring-Joint Gaskets and Groves for Steel Pipe Flanges

ANSI B16.21	Non-Metallic Flat Gaskets for Pipe Flanges
API 601	Metallic Gaskets for RF Pipe Flanges and Flanged Connections
API 6A	Specification for Wellhead and Christmas Tree Equipment
ANSI B16.47	Large Diameter Steel Flanges (NPS26 through NPS60)
API 605	Large Diameter Carbon Steel Flanges
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings

1.3 British Standards

The following British Standards are also used for the standardisation of pipe joints:

BS 1560	Steel Pipe Flanges and Flanged Fittings
BS 3381	Metallic Spiral Wound Gaskets for Use with Flanges to BS 1560
BS 1832	Oil Resistant Compressed Asbestos Fibre Jointing
BS F125	Rubber Bonded Compressed Asbestos Fibre Jointing
BS 3293	Carbon Steel Pipe Flanges (over 24” NB) for the Petroleum Industry
BS 3799	Steel Pipe Fittings, Screwed and Socket-Welded for the Petroleum Industry
BS 1580	Specification for Unified Screw Threads

1.4 Piping Specifications

The Piping Specification is a document prepared during the design phase of any project. It provides the appropriate selection, specification and material grade of pipe and piping components for a given service.

For all subsequent maintenance and repair on a section of pipe, the piping specification remains as the key to correct material selection.

Before commencing any job, reference to the piping specification is essential to specify and use the correct materials. For the job check that you are using the latest revision of the specification.

Do not rely on "what was installed before must be right" as this is not always the case! If a discrepancy is found, it should be reported.

Note that a piping specification only applies to the defined plant, site or installation. Forties, Magnus, Dimlington Terminal for example each have their own piping specifications and they are NOT interchangeable.

To use the piping specification, reference must first be made to the Process and Instrument Diagram. Identify the section of pipe in the P&ID and a line number will be quoted, e.g:

8"-WF-1007-1A1E which is interpreted as follows:

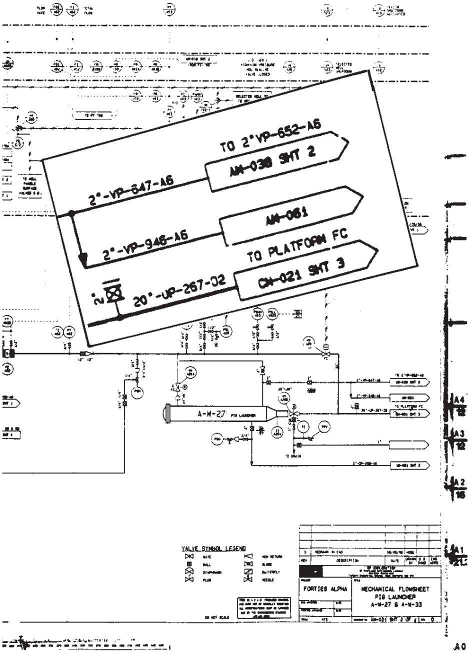
8" - The nominal pipe size of the line.

WF - The service code. This refers to the contents of the pipe. In this instance, WF refers to Fire Water.

1007 - The pipeline number which is a unique number allocated to a specific section or run of pipe during the design stages.

1A1E - **The piping specification number.** This is a short-hand reference into the piping specification document, and is also unique to that document. The letter normally refers to the pressure rating of the system.

Having determined the piping specification number, turn to the appropriate page in the piping specification document. There the correct type of gasket, the correct grade of studbolts, spectacle blinds, blind flanges, pipe material, pipe wall thickness and much more will be specified for the job in hand.



2. Flanges

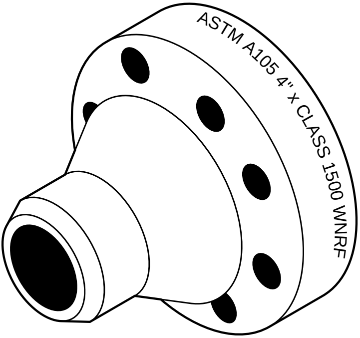
There are numerous types of flanges available. The type and material of a flange to be used is dependent on the service duty of the line. Reference to the piping specification will provide such information.

It is important to be able to accurately identify flanges as this enables **confirmation** of the joint location on a P&ID, **confirmation** of the piping specification and thus the **identification** of the correct materials for a job.

2.1 Flange Standards

For process and utilities pipework, the two commonly used flange standards are ANSI B16.5 (American National Standards Institute) and BS 1560 (British Standards). A third standard, API 6A (American Petroleum Institute) specifies flanges for Wellhead and Christmas Tree Equipment.

Flanges of different standards are not normally joined. If necessary to do so, engineering advice must first be sought to ensure the compatibility of the mating flanges.



2.2 Flange Facings

There are three types of flange facings commonly found on a plant. The surface finish of the facings is specified in the Flange Standards. Note that they are refined and superseded by BP Engineering GS 142-4 - Pipe Flanges and Fittings. A section on surface finish on the different flange facings is in this book extracted from GS 142-4.

a) **Ring Type Joint (RTJ)**

Typically found on the most severe duties, for example high pressure gas pipework. Ring type metal gaskets must be used on this type of flange facing.

- **RTJs to API 6A Type B, BS 1560 and ANSI B16.5:**
  The seal is made by metal-to-metal contact between the gasket and the flange groove. The faces of the two opposing flanges do not come into contact and a gap is maintained by the presence of the gasket. Such RTJ flanges will normally have raised faces but flat faces may equally be used or specified.

- **RTJs to API 6A Type BX:**
  API 6A Type BX flanges seal by the combined effect of gasket compression and flange face-to-face contact and will therefore always have raised faces. The flanges also use special metal ring joints. A Type BX flange joint which does not achieve face-to-face contact will not seal and should not be put into service.

b) **Raised Face (RF)**

Sealing on a RF flange is by a flat non-metallic gasket (or a flat metallic gasket for special applications), which fits within the bolts of the flange. The facing on a RF flange has a concentric or phonographic groove with a controlled surface finish. If the grooves are too deep (or a rough surface finish), then high compression is required to flow the relatively soft gasket material into the grooves. Too shallow (exceptionally smooth surface finish) and again high compression is required as a leak path then becomes more possible. It is important to always check the flange surface finish for imperfections which would make sealing difficult. A radial groove for example is virtually impossible to seal against.

Note that the surface finish on the flange facing depends on the type of gasket being used.

Further details are given in Section 3.8 (Spiral Wound Gaskets) and 3.9 (Sheet Gaskets).

c) **Flat Face (FF)**

Sealing is also by compression of a flat non-metallic gasket (very rarely a flat metallic gasket), between the phonographic/concentric grooved surfaces of the mating FF flanges. The gasket fits over the entire face of the flange.

FF flanges are normally used on the least arduous of duties such as low pressure water drains and in particular when using cast iron, cunifer or bronze alloy, where the large gasket contact area spreads the flange loading and reduces flange bending.

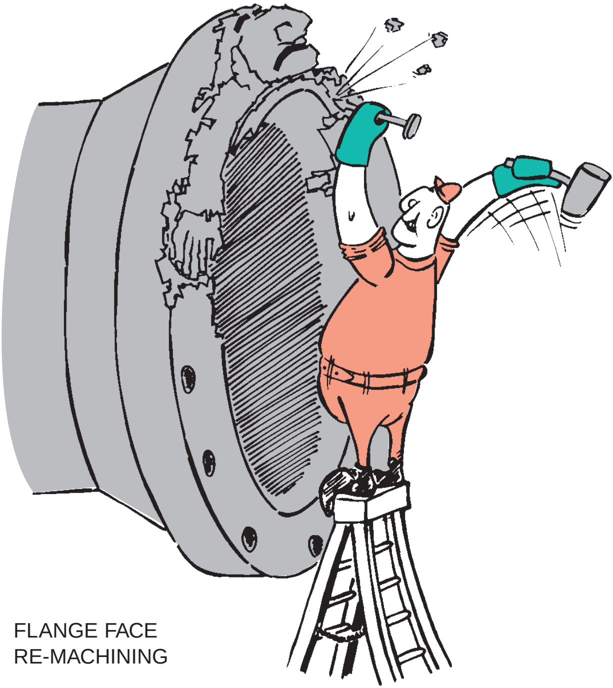
***NOTE**: Both ANSI B16.5 and BS 1560 specify Flat Face Flanges and Raised Face Flanges as well as RTJ Flanges. API 6A is specific to RTJ flanges only.*

2.3 Flange Face Re-Machining

Flange face re-machining may be carried out in order to repair the sealing face of a flange which has corroded, deteriorated or otherwise been damaged.

Flange face re-machining must be carried out by experienced personnel using the appropriate equipment. A procedure for the process should be in place and must be followed.

The extent of any re-machining must be such that the flange dimensions still remain within the tolerance specified in the flange manufacturing standard, ANSI B16, API 6A, BS 1560, etc. Incorrect re-machining which reduces the flange dimensions to below the minimum specified dimensions will result in possible leakage.



FLANGE FACE
RE-MACHINING

2.4 Flange Types

The way in which the flange is attached to the pipe defines the flange type, as follows.

a) **Weld-Neck Flange (WN)**

The WN flange is butt-welded to the pipe. WN flanges are typically used on arduous duties such as high pressures and/or hazardous fluids. The butt weld may be inspected by radiography or ultrasonics as well as MPI or DPI during fabrication. There is therefore a high degree of confidence in the integrity of the weld. A butt weld also has good fatigue performance and its presence does not induce high local stresses in the pipework.

b) **Socket Weld Flange (SW)**

Socket weld flanges are often used on high pressure, hazardous duties but will be limited to a nominal pipe size (NPS) of $1^{1}/_{2}$ inches.

The pipe is fillet welded to the hub of the SW flange. Radiography is not practical on the fillet weld and correct fit-up and welding is therefore crucial. The fillet weld will normally be inspected by MPI or DPI.

c) **Slip-On Weld Flange (SO)**

Used typically on low pressure, low hazard services such as fire water, cooling water, etc. The pipe is “double-welded” both to the hub and the bore of the flange and again radiography is not practical. MPI or DPI will be used to check the integrity of the weld.

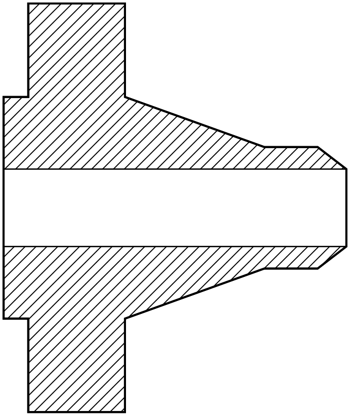
Where specified, the SO flange will be used on pipe sizes greater than 1 1/2 inches with a preference for the SW flange for sizes up to and including 1 1/2 inches.

d) **Composite Lap Joint Flange**

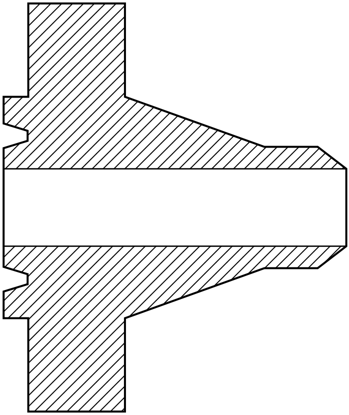
Comprises of a hub or "stub end" welded to the pipe and a backing flange or capped flange which is used to bolt the joint together. This type of flanged joint is typically found on Cunifer and other high alloy pipework. An alloy hub with a galvanised steel backing flange is cheaper than a complete alloy flange. The flange has a raised face and sealing is with a flat gasket such as a CAF sheet gasket.

e) **Swivel Ring Flange**

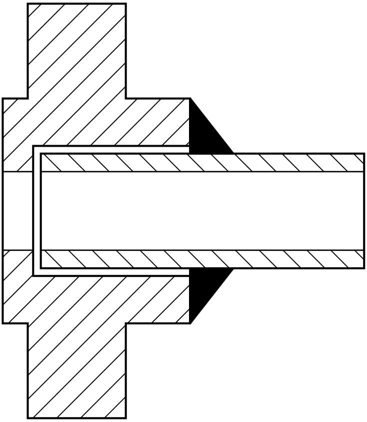
As with the Composite Lap Joint Flange, a hub will be butt welded to the pipe. A swivel ring sits over the hub and allows the joint to be bolted together. Swivel Ring Flanges are normally found on subsea services where the swivel ring facilitates flange alignment. The flange is sealed using a RTJ metal gasket.



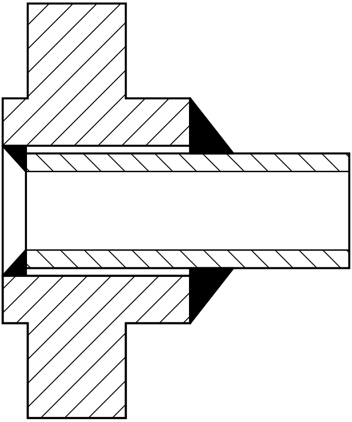
Raised Face Weld Neck Flange



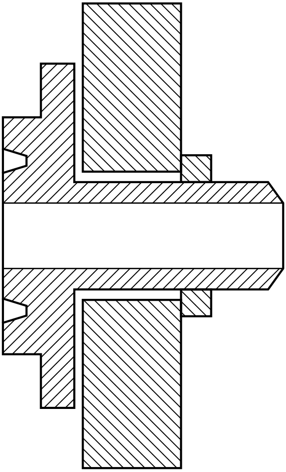
Ring Type Joint Flange



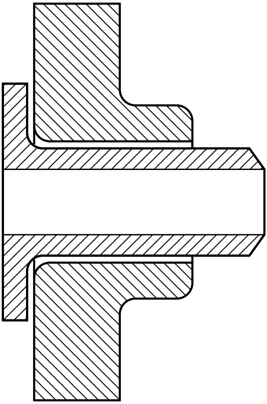
Raised Face Socket Weld Flange



Raised Face Slip-On Weld Flange



Swivel Ring Flange



Composite Lap Joint Flange

2.5 Flange Specification and Identification

2.5.1 Specification

A flange is specified by the following information:

a) **Type and Facing:** i.e. whether the flange is for example "Weld Neck, RTJ" or "Socket Weld, RF".

b) **Nominal Pipe Size:** required for all flanges, usually in inches.

c) **Flange Pressure Class:** required for all flanges, e.g. Class 150, 300, 900, 1500, 2500 etc.

d) **Standard:** i.e. ANSI B16.5, BS 1560, API 6A, API 605 or ASME B16.47.

e) **Material:** a material specification must be stated and will be as quoted in the piping specification.

f) **Pipe Schedule:** only for Weld Neck, Socket Weld, Composite Lap Joint and Swivel Ring flanges where the flange bore must match that of the pipe, e.g. Schedule 10, 30, 40, ,80, 120, 160, etc.

2.5.2 Identification

Normally, the flange specification will be hard stamped on the flange. In the case of existing plant, the information may not be legible and it is then necessary to identify the flange by visual observation and physical measurement.

a) **Visual Observation:** required to identify the type of flange and type of gasket used.

b) **Physical Measurement:** required to identify the nominal bore and the class of the flange. Check the number of studbolts, studbolt diameter, studbolt Pitch Circle Diameter (PCD) and the flange thickness. Compare these figures with standard flange data as found.

2.6 Pipe Flanges - Do's and Don'ts

Do's

a) Always visually inspect the surface finish of the flange for injurious defects. It should be clean, degreased and free of any defects, nicks or burrs. The permissible imperfections in flange surface finish specified in ASME B16.5, Table 3 are not allowed for critical applications. Raised Face and Flat Face flanges should also be checked for flatness with a straight edge.

b) All rust and burrs must be removed, small scratches should be removed by polishing, other defects may mean component replacement.

c) Check the phonographic or concentric groove on the face of Raised Face and Flat Face flanges. Any radial defects for example will be virtually impossible to seal against.

d) RTJ grooves must be kept scrupulously clean, corrosion free and undamaged.

Don'ts

a) When cleaning a flange face, never use a tool which may damage the surface finish. A soft wire brush is recommended.

b) Do not use unnecessary force, say by tirforing or pulling, to bring flanges which are clearly misaligned together. This may overstress adjacent pipework and will make sealing of the flanged joint difficult and unreliable. **Instead, report the situation.**

c) Do not mate flanges manufactured to different standards unless specified in an approved design.

2.7 Flange Surface Finish and Flange Distortion

To create a seal, gasket has to fill up the voids in the flange surface present because of surface finish and any flange rotation (or relative distortion) between the two surfaces.

The flange surface will thus give a broad indication of which gasket materials are likely to be suitable. Finishes of standard raised face flanges usually fall within the range 3.2 to 12.5µm, but this may be expressed in micro inch or roughness number.

Surface Finish	Micro metre µm	12.5	6.3	3.2	1.6
	Micro inch	500	250	125	63
Roughness Number (BS 308)		N10	N9	N8	N7

a) **Sheet Jointing**

The recommended surface finish for the compressed fibre jointing (above a thickness of 1 mm) is 3.2µm to 12.5µm Ra (125µ in 500µin. CLA). These values are also used for graphite laminate (above a thickness of 0.8mm).

For tongue and groove flange facings or for very thin gaskets (0.4mm or below), a surface finish of 1.6µm to 6.3µm Ra (63 to 200 in. CLA) is possible.

Surface finishes below 1.6μm are not recommended due to their negative effect on creep resistance of the gasket.

b) **Spiral Wound Gasketing**

This type of gasket requires a range of surface finishes dependent upon the application:

- General - 3.2μm to 5.1μm Ra (125μin. to 200μin. CLA)
- Critical - 3.2μm Ra (125μin. CLA).
- Vacuum applications - 2.0μm Ra (80μin. CLA)

c) **Solid Flat Metal**

A surface finish in the order of 1.6μm Ra is acceptable but for more critical conditions, a finish no more coarse than 0.8μm Ra is preferred. Again for optimum performance, the smoother the flange surface finish, the better the performance.

d) **Metallic Ring Joint Gaskets**

The angled surfaces (typically 23°) of both grooves and octagonal gaskets and the contact faces of oval gaskets should have a surface finish no rougher than 1.6μm Ra.

e) **Machining of Flange Faces**

Under no circumstances should flange seating surfaces be machined in a manner that tool marks extend radially across the seating surface. Such tool marks are practically impossible to seal regardless of the type of gasket being used.

3. Gaskets

3.1 Selection of Gasket Material

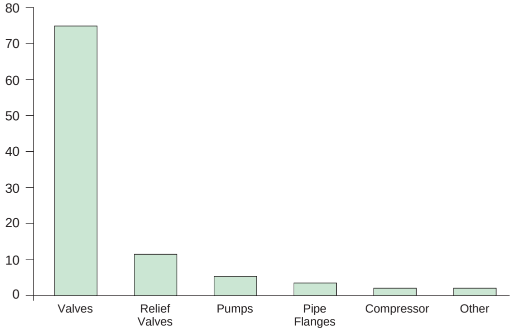
Assuming the mating flanges are in existence, the selection of the correct gasket material involves a logical series of considerations and these are considered in turn.

DO NOT CUT OR DEFORM A GASKET TO FIT A FLANGE.

3.2 Fugitive Emissions

Heightened awareness with regard to Health and the Environment is leading to new and more stringent standard procedures and legislation. The goal is to reduce emissions to target levels currently based on the best available technology. These targets will inevitably become tighter in the future. Large companies have been aware of the issues for a number of years and will have a major part to play in the future standards and legislation. As early as 1994, Fugitive Emissions had a major impact on meeting the challenge set by major petrochemicals companies. Some companies set their own high standards ahead of incumbent legislation.

Fugitive Emission Sources (Fluid Sealing Association)



PVRC (Pressure Vessel Research Committee)

Tightness Classification	Classification	Mass Leak Rate per mm for Gasket Diameter
Economy	T2	0.2 mg/sec.mm
Standard	T2	0.002 mg/sec.mm
Tight	T3	0.00002 mg/sec.mm

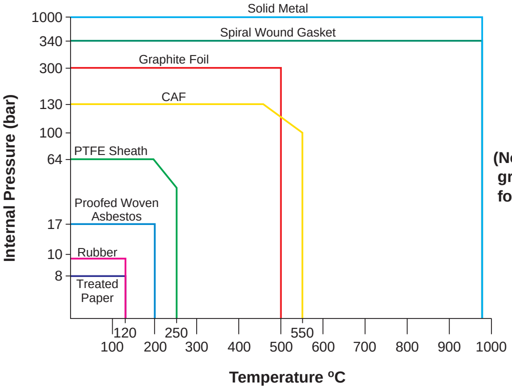
3.3 Compatibility with Fluid

The gasket should obviously not be affected by fluid being sealed over the whole range of operating conditions. The chemical resistance chart (see Appendix 1, Section 4) shows the resistance of many common jointing materials to a variety of chemicals. This is a guide only and should any doubt exist, then the gasket manufacturer should be consulted.

3.4 Temperature

The gasket selected should have reasonable life expectancy at the maximum temperature encountered (or the minimum temperature if for a low temperature application). A broad indication of the temperature pressure ratings of the common gasket materials is shown in the figure below.

Temperature/Pressure Guidelines for Common Gasket Materials



(Note: Some new grades suitable for 1600ºC)

Gasket materials are designed to compress under load to achieve the initial seal. However, to retain that seal, the gasket should be able to resist flow (or creep) to prevent loss of surface stress by bolt reduction. This property is very important and is the one that most readily separates high quality from low quality gaskets.

Under ambient temperature conditions, most gasket materials do not creep significantly, but as the temperature rises beyond 100°C, creep becomes a serious consideration.

For all applications but particularly for low temperature applications, the following points should be observed:

- The gasket should be completely dry when installed (gaskets for such applications should be stored in a dry atmosphere).

- The required flange loading should be applied at ambient temperature.

Notes:

1. The above information is intended as a guide to the maximum possible ratings of each class of jointing. It does not imply that all the gaskets within each generic type are suitable for the temperatures and pressures shown.

2. Even if the material chosen is theoretically suitable for the temperature and pressure, other factors should be considered such as available bolting, flange facing type, shock loadings, etc.

3. Consultation with gasket experts should take place at the design stage to ensure that the gasket selected is suitable for all conditions of the application.

3.5 Internal Pressure

The gasket has to be suitable for the maximum internal pressure experienced; this is often the test pressure, which can be > 2 times the flange rating at ambient temperature.

Vacuum conditions need special considerations but as a guide:

- For coarse vacuum (760 torr to 1 torr): flat rubber or compressed asbestos fibre gaskets.

- For high vacuum (1 torr to $1x10^{-7}$ torr): rubber 'O' rings or moulded rectangular seals.

- For very high vacuum (below $1x10^{-7}$ torr): specialised seals required.

3.6 Special Considerations

There are many factors apart from those already considered that affect the selection of the correct gasket material and type.

- Cycling conditions.

- If the service conditions include frequent thermal or pressure cycles, then the gasket has to be resilient enough to allow for the flange movements and strong enough to resist the mechanical loading.

a) **Vibration**
If the pipeline is subjected to undue vibration, then the gasket has to withstand the mechanical effects involved.

b) **Erosive Media**
Certain media (e.g. solids suspended in liquids) can slowly erode gaskets leading to a much shorter life than expected. In

such cases, choice of gasket material and selection of gasket dimensions are critical.

c) **Risk of Contaminating the Fluid**
Sometimes the effect of contaminating the fluid by leaching chemicals from the gasket should be considered. Typical examples are in the sealing of potable water, blood plasma, pharmaceutical chemicals, food, beer, etc.

d) **Corrosion of Flanges**
Some flange metals are prone to stress corrosion cracking (e.g. austenitic stainless steel). When using these, care should be taken to ensure that the gasket material does not contain an unacceptable level of leachable impurities which may induce corrosion. Such impurities include chloride ions.

e) **Integrity**
When integrity of a gasket is of prime importance (e.g. when sealing a highly toxic chemical), the choice of gasket may be influenced by the requirement for a larger safety margin. As an example, a spirally wound gasket with an outer retaining ring may be selected in place of a compressed asbestos fibre gasket.

f) **Economy**
Although a gasket is a relatively low priced item, the consequential expense of leakage or failure should be considered when deciding on quality, type and material of the gaskets.

Guidance

The following guidance is offered where pre-selection has not been carried out. The table below is copied from BPA Standard GS 142-7 “Supply of Gaskets and Joint Rings for Bolted Joints”.

Service	Flange Design Conditions			
	Pressure Class	**Temp. °C**	**Flange Facing**	**Gasket Selection**
General Hydrocarbon	150 300	-196/500*	RF	Tanged Graphite Sheet or Spiral Wound with Flexible Graphite or Spiral Wound with Non Graphite Filter
Steam/Con-densate, Boiler Feed Water		-196/+500 -196/350		
General Utilities		-40/+250	RF	Nitrile Rubber Based Reinforced Sheet
General Hydro-carbon, Steam/ Condensate, Boiler Feed Water	600 900	-196/+500	RF	Spiral Wound with Flexible Graphite
General Hydro-carbon, Steam, Boiler Feed Water	1500 2500	As per flange material	RTJ	Metal Joint Ring
Hydrogen	150 300 600	-196/+500	RF	Spiral Wound with Flexible Graphite
	900 1500 2500	As per flange material	RTJ	Metal Joint Ring
Chemical Oxidisers/ HF Acid	150	-40/+200	RF	PTFE (reinforced or envelope)
	150 300 600	-40/+200	RF	Spiral Wound PTFE Filler

Correct gasket selection and installation is of paramount importance. The gasket creates the seal between the two flange faces and contains the internal pressure at that joint.

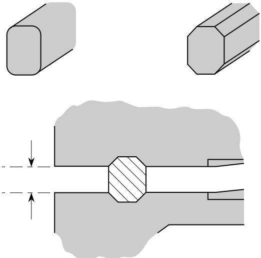
3.7 RTJ (Ring Type Joint) Gaskets

RTJ gaskets are forged rings that fit into the machined groove of an RTJ flange. RTJ gaskets are generally used for high pressure applications. Sealing is by metal-to-metal contact between gasket and flange. Solid metal joint rings have excellent tightness and tolerance to temperature and pressure changes once correctly bolted up. Very close attention must be given to their bolting up. Rings and groove faces must be free of imperfections.

There are four different types of ring commonly available: Types R, RX, BX and AX. The most commonly used is Type R.

R Type

These are either oval or octagonal in cross-section. The oval RTJ is the original design. The octagonal RTJ is a modification to the oval design and provides better sealing. **R type** rings may be specified for Class 150 to 2500 flanges though are typically found on Class 1500 flanges and often Class 900. The piping specification will state whether an octagonal or an oval joint is to be used. R type rings may be used on either flat face or raised fact RTJ flanges.

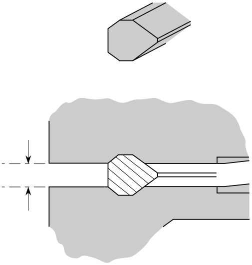


RX Type

RX gaskets fit and seal into the same groove sizes as do R type gaskets. Note that the RX gasket is wider than the R type gasket and the flange face-to-face separation will therefore be greater.

RX gaskets are normally specified up to Class 5000 API 6A Type B flanges. They are used when a more effective seal is required which is resistant to vibrations, shock loadings, etc., for example, on well-heads and Christmas trees.

The asymmetric cross-section makes the gasket self-energising. The outside bevel of the ring makes the initial contact with the grooves of the flange and thus preloads the gasket against the groove outer surface.



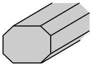
BX Type

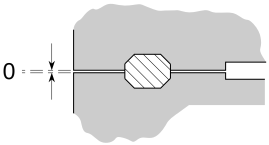
These are only used on API 6A Type BX flanges and are rated from Class 5000 to 15000.

The pitch diameter of the ring is slightly greater than the pitch diameter of the flange groove. This preloads the gasket and creates a pressure energised sea.

Type BX gaskets are NOT inter-changeable with R or RX gaskets. The groove on a flange which accommodates a BX gasket is dimensionally different to that for R and RX gaskets.

When correctly fitted, the flange face-to-face separation using a BX gasket is zero.





Note: It is particularly important to check the flange face-to-face separation which must be uniform around the entire circumference of the flange. RTJ flanged joints are particularly susceptible to uneven bolt tensioning and misalignment of the ring within the groove.

RTJ Gasket Identification and Specification

a) **Type:** Whether R, RX or BX. If R, state whether octagonal or oval. The type of ring to be used will be specified in the piping specification.

b) **Ring Number:** For example R46 will fit a 6 inch NB Class 1500 RTJ flange.

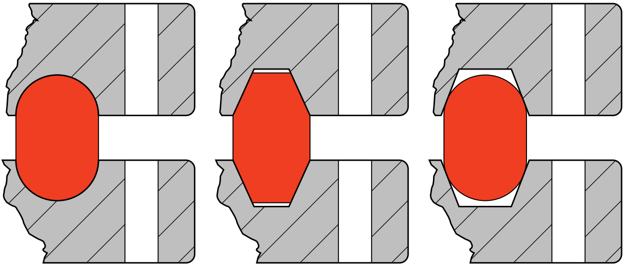
c) **Material:** A variety of materials is available. Again check with the piping specification for the correct material. The material grade will have an identifying code. For example:

Soft Iron: D
Stainless Steel 316 : S316

d) **Standard:** Either ANSI B16.20 or API 6A; as specified in the piping specification (these two standards are equivalent and interchangeable).

e) **Identification:** The type, ring number and material will always be marked on the side of the ring.

Oval RTJ in Oval Groove | **Octagonal RTJ in Octagonal Groove** | **Oval RTJ in Octagonal Groove**

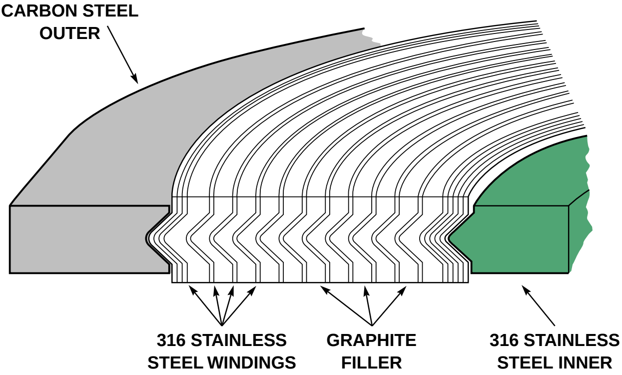


3.8 Spiral Wound Gaskets

The standard of SW gaskets can vary considerably between manufacturers, and they should be obtained only from reputable suppliers.

Most Spiral Wound Gaskets now being used are Spiral Wound 316 st/st Windings and Graphite Filler. These gaskets have a **316 st/st** inner ring and coated carbon steel outer guide ring, but on some occasions the outer ring could be stainless steel to provide corrosion resistance to the external environment.

Gasket Nominal Thickness	Recommended Compressed Thickness
3.2 mm	2.3 - 2.5 mm
4.5 mm	3.2 - 3.4 mm
6.4 mm	4.6 - 4.9 mm
7.2 mm	4.8 - 5.0 mm



These gaskets are fitted with an internal guide ring which:

- Provides an additional compression stop.
- Restricts the lateral flow of the gaskets toward the bore.
- Acts as a heat and corrosion barrier protecting the gasket and flange.

By filling the annular space between the gasket and flange, it reduces turbulent flow of the fluid or the possibility of the accumulation of solids, and possible corrosion.

Filler Materials	Temperature Limits
Special Canadian Asbestos	550ºC
PTFE	260ºC
Graphite	550ºC
Ceramic	800ºC

Flange Surface Finish	Micro Meter
General	3.2 - 5.1
Critical	3.2
Vacuum	2.0

The piping specifications for each individual plant will be changed to accommodate the new gaskets. The stores Vocab numbers will remain the same for the equivalent size spiral wound type.

Spiral Wound Gaskets that may be present in flanges:

Spiral wound gaskets are typically used on intermediate pressure systems and will be found on Class 300 flanges, Class 600 and Class 900 flanges.

SW gaskets are used on RF flanges with a smooth surface finish, as quoted in "Surface Finish Values for Flange Facings for Class 150 to 2500 Flanges".

Where SW gaskets are used with standard Class 150 flanges and smaller sizes of standard Class 300 flanges, the higher seating load requirements and low bolting availability necessitates use of high strength bolting and proper bolting up procedures.

The use of gaskets with inner rings also increases the required bolting load.

3.8.1 Spiral Wound Section

This part of the gasket creates the seal between the flange faces. It is manufactured by spirally winding a preformed metal strip and a filler material around a metal mandrel. Normally the outside and inside diameters are reinforced by several additional metal windings with no filler.

When compressed, the combined effect of the metal winding and the filler material will make the seal. The filler material will flow into the grooves on the flange face and the metal winding will then strengthen and support the filler against the flange face.

3.8.2 Inner Metal Ring

The inner metal ring provides inner confinement to the gasket. Being of a specified thickness smaller than that of the uncompressed spiral windings, it acts as a compression stop, i.e. it prevents the windings from being over-compressed say due to over-tensioning of the studbolts or thermal growth of the pipework when in operation. The inner ring also fills the annular space between the flange bore and the ID of the spiral wound section and therefore minimises turbulence of the process fluids at that location and prevents erosion of the flange faces.

Note that the spiral windings should never be exposed to the flow of the process fluids. The ID of the inner ring should be flush with the bore of the flange and this should be checked prior to bolting up.

3.8.3 Outer Metal Ring

The outer metal ring acts as a compression stop and an anti-blowout device. It also centres the gasket on the flange face.

The spiral wound gasket should be centred on the flange with the outer ring resting against the studbolts. If this is not the case, the incorrect gasket has been chosen and should be changed.

3.8.4 Filler Material

For most applications in the petro-chemical industry, an asbestos filler was usually specified. **Asbestos is hazardous to health and even though trapped within the spiral winding, SW gaskets should be handled with care. Full procedures are available and should be consulted. Piping specifications now quote a “non-asbestos” filler instead of asbestos. Graphite filler has now taken over as being the preferred filler material.**

For special applications other materials are available, such as graphite and ceramic fillers.

3.8.5 Spiral Wound Gasket Specification and Identification

Spiral wound gaskets are supplied and identified as follows:

a) **NPS and Flange Pressure Class:** A class and nominal pipe size must be specified and must match that of the flange concerned. The class and size of the gasket will always be stamped on the outer ring.

b) **Flange Type:** Spiral wound gaskets are normally used on RFWN flanges. If used on SO flanges, this should be stated as special gasket sizes will be required for NPS up to 1 1/2 inches.

c) **Filler Material:** A variety of materials is available. Normally asbestos was used but now graphite, PTFE, ceramic fillers, etc. are used predominantly. The filler material will be specified in the piping specification. Identification is by way of a colour code on the spiral wound section.

d) **Winding Material:** Winding material is important as it should be resistant to the process conditions. The winding material will be specified in the piping specification and is typically stainless steel. Identification is by a colour code on the outer ring.

e) **Inner Ring:** The inner ring will normally be the same material grade as the metal winding as it must equally resist the process conditions. Material grade will be specified in the piping specification.

f) **Outer Ring:** Not such a critical parameter as the inner ring as it does not come into contact with process fluids. It is normally carbon steel and again will be specified in the piping specification.

g) **Standard:** Usually ASME B16.20, BS 3381 or API 601.

3.8.6 Spiral Wound Gasket Colour Code Reference Chart

Warning:

There are some process applications where graphite is unsuitable. Refer to manufacturer's data sheets for details.

Winding Material Colour Code

The outer ring of the SW gasket will be coloured to identify the winding material. The ring may be only coloured on the outer edge.

Carbon Steel	Silver
304SS	Yellow
316SS	Green
347SS	Blue
321SS	Turquoise
Monel	Orange
Nickel 200	Red
Titanium	Purple
Alloy 20	Black
Hastalloy B	Brown
Hastalloy C	Beige
Inc 600	Gold
Incoloy	White

Filler Material Colour Code

The spiral wound section of the SW gasket will be coloured to identify the filler material, with flashes around the outer ring of the relevant colour.

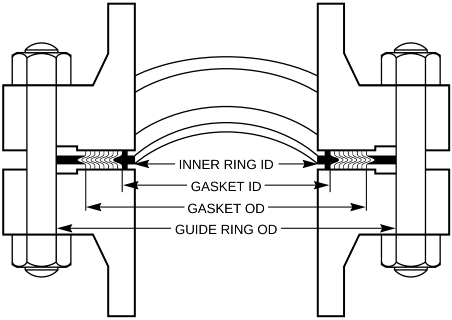
Non-Asbestos	Pink
Graphite	Grey
Asbestos	None
PTFE	White
Ceramic	Light Green

Note that the above colour coding is based on API 601.

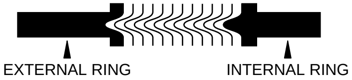
When inspecting gaskets already fitted to flanges, it can be difficult to distinguish between white grey and light green. Users must be aware of this problem.

3.8.7 Spiral Wound Gasket in its Uncompressed State

Joint in its Uncompressed State



Cross-Section through a Gasket



3.8.8 Surface Finish Values for Flange Facings

(Amends ANSI B16.5, 6.3.4.10)
(All dimensions in mm)

Flange Rating Class	Method of Machining	Depth of Serr.	Radius of Tool	Pitch of Serr.	Rz		Ra	
					Min. μm	Max. μm	Min. μm	Max. μm
					(Ref. Std. ISO 468)			
150	Turning†	0.05	1.6	0.8	12.5	50	3.2	12.75
300 - 2500	Turning†	0.015	0.8	0.3	12.5	25	3.2	6.3
ALL	Other than Turning	-	-	-	12.5	25	3.2	6.3

† The term "Turning" includes any method of machine operation producing either serrated concentric or serrated spiral grooves machined with a round nosed tool.

3.9 Sheet Gaskets

Non-Asbestos Fibre (NAF) gaskets have now replaced Compressed Asbestos Fibre (CAF) gaskets.

They are used for low pressure applications and are typically found on Class 150 and Class 300 flanges. They are normally used on Raised Face flanges (self-centering flat ring type gasket), but are also used on Flat Face flanges (full face type gaskets are required).

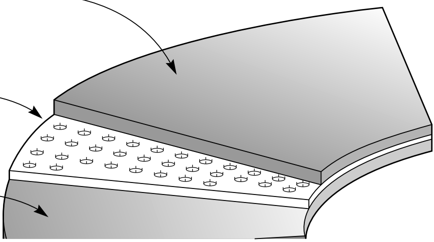
3.9.1 Tanged Graphite Gaskets

Previously the predominant gasket used in BP Amoco has been Compressed Asbestos Fibre (CAF). This material covers a wide range of applications, but has a known health risk.

The replacement gasket material which contains no asbestos has a stainless steel insert sandwiched between two layers of graphite. If not handled correctly, the insert may cut personnel. This type of gasket is known as a “tanged gasket”. The gaskets are non-stick, especially on stainless steel faces.

The stainless reinforcement increases the tensile strength of the material, its load bearing capacity and handling characteristics. It also improves its blow-out resistance under cycling conditions. For larger type gaskets, two stainless inserts may be used for greater rigidity and ease of handling.

When handling this type of gasket, always use gloves.



Service Temperature	-196°C to +450°C
Max. Pressure at 150 Mpa Stress	200 bar
Recovery	13 - 19%
Compressibility ASTM F36A	28 - 42%
Sheet Size	1 x 1m or 1 x 1.5m

The use of plain graphite gaskets is not recommended in oxygenated seawater handling systems. For such duties, a non-asbestos utility gasket should be used.

The piping specifications for each individual plant should be changed to accommodate the new gaskets.

3.9.2 Utility Gaskets

In utility non-hydrocarbon services up to Class 300, where the temperature is below 100^{o}C, and in equipment blinding applications, high performance nitrile rubber based reinforced sheet containing non-respirable glass fibres should be used.

3.9.3 Flat Rubber Gaskets

Flat rubber gaskets are normally found in the least hazardous and aggressive of conditions such as low pressure water services. Rubber gaskets are limited in use by temperature, pressure and chemical resistance. They are also liable to creep, e.g. if subjected to excessive bolt loading or repeated hydrotest.

Rubber gaskets are usually full face and are used on flat face flanges. Of the variety of rubbers available, that most commonly used as a gasket is neoprene. Other rubber materials include natural rubber, Viton and Nitrile.

Rubber Gasket Specification and Identification

a) **NPS and Flange Pressure Class:** Always to be quoted. It should be marked on the gasket. If not, check the correct fit of the gasket on the flange.

   Alternatively, the gasket may be cut from rubber sheet. The bore of the pipe must not be restricted by the gasket and the entire face of the flange must be covered.

   Check the thickness of the gasket by reference to the piping specification.

b) **Material:** Whether neoprene, nitrile, etc., refer to the piping specification.

NOW NOT IN USE (FOR INFORMATION ONLY)

3.10 Compressed Asbestos Fibre Gasket (CAF)

CAF gaskets were used for low pressure applications and were typically found on Class 150 and Class 300 flanges, and will probably still be in many flange applications.

CAF gaskets were normally used on Raised Face flanges (self-centering flat ring type gasket), but may also have been used on Flat Face flanges (full face type gaskets are required).

Though of apparently simple design, the CAF gasket should be treated with equal respect as with all gaskets to ensure effective sealing.

CAF gaskets are manufactured from asbestos fibres bonded in a nitrile rubber compound. Sealing is by a similar mechanism to the spiral wound gaskets where the gasket material is soft enough to flow into the phonographic groove on the flange face when compressed. Correct gasket thickness is therefore important.

The surface finish on RF flanges used with CAF gaskets will be relatively coarse compared to that for SW gaskets. The required surface finish will be as stated in the relevant section on Class 150 flanges.

The gasket may or may not be coated with graphite. The graphite has non-stick properties and enables the easy removal of the gasket when a flange is split. Graphite coated CAF gaskets **SHOULD NOT** be used in the following instances:

a) Austenitic stainless steel flanges on water duties.
b) Aggressive water duty (e.g. cement lined pipework).
c) Duties where temperatures exceed **450** degrees C.

Remember that CAF gaskets contain asbestos and should therefore be handled carefully. If shaping a CAF gasket, do so by cutting, shearing or punching - NOT by sawing, grinding or drilling. If removing an old CAF gasket from a flange, wet the gasket with water to absorb any asbestos dust that may be freed, especially if the flange has to be scraped clean. Loose CAF waste should be disposed of in sealed polythene bags and labelled as containing asbestos with an “asbestos warning” tag. Full procedures are available and should be consulted.

CAF Gasket Specification and Identification

a) **NPS and Flange Pressure Class:** Always to be specified. The information should also be marked on the gasket.

   If not, check the correct fit of the gasket on the flange. It should be centred when resting on the studbolts and the bore of the pipe should not be constricted. Alternatively the gasket may be a full face type, sized to the OD of the flange, particularly for small bore (less than 2 inch NB) pipework.

   Check the thickness of the gasket. It will be quoted in the piping specification.

b) **Gasket Coating:** i.e. whether graphited or non-graphited. The piping specification should be consulted.

c) **Standard:** Normally BS 1832 or BS 2815 will be specified.

3.11 Gaskets for Lined Pipework

Joints in lined pipework are invariably flanged and gaskets often need to create a seal despite many of the linings being of a soft nature. Correct gasket selection is particularly important since:

- Many linings, whilst having a smooth finish, have undulating surfaces on the flanges due to the method of manufacture (e.g. glass).

- There is usually a good reason for using lined pipework (e.g. chemically aggressive fluid or pharmaceutical fluid) and the gasket often has to be equal to the lining in terms of chemical resistance and freedom from contamination.

- Linings tend to be of a fragile nature and bolt loads have to be kept low to prevent damage. This limits the choice of gasket material.

- The gasket material has often to withstand the effects of aggressive cleaning fluids as well as the service fluids.

Types of Linings Available

Rubber Lined:
A soft rubber gasket can be applied. A steel or ebonite spacer can be used to prevent over-compression.

Plastic Lined:
Gaskets are not normally required, but there are exceptions:
- where there are dissimilar flange connections (e.g. pipe to valve);
- where the lining is too undulating;
- where the lining is applied via a dripping process, e.g. PVC.

Lead Lined:
Creep resistant PTFE or a PTFE envelope with soft rubber insert can be used.

Glass Lined:
PTFE.

3.12 Gaskets - Do's and Don'ts

Do's

a) Check the type, class, size and material specification of the gasket before using it. Check with the piping specification to confirm that it is correct. Only use gaskets with non-asbestos materials.

b) Check the gasket for damage, nicks, etc. Ensure that it is clean and free from any contaminants before use.

c) Ensure that the gasket fits correctly.

d) Check the flange face-to-face separation once the gasket has been installed and the bolts tensioned. A uniform separation is required. If not, the gasket could be locally crushed or deformed and will not seal properly.

e) Wire brush studs/bolts and nuts to remove any dirt on the threads. Ensure that the nuts can run freely down the threads before use. Coat the studs/bolts with a thin film of an approved lubricant prior to installation.

f) Use **pre-cut** tanged reinforced sheet gaskets.

g) Wear gloves when handling tanged reinforced gaskets.

Don'ts

a) Do not re-use old gaskets. For every joint being made up, a new gasket should be used.

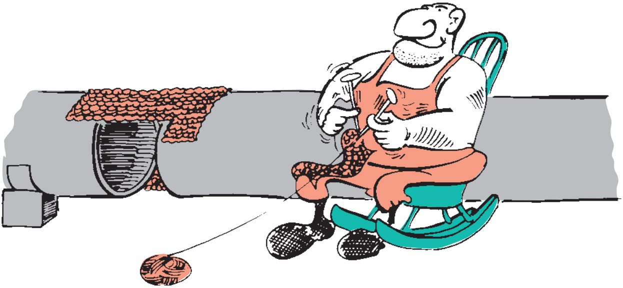
b) Do not use a gasket that has no identification. It may appear to fit the flange but this is not a guarantee.

c) Do not cut or deform a gasket to fit a flange. If the gasket doesn't fit, the wrong one has been chosen.

d) Do not hand-cut tanged reinforced gasket sheet. Use pre-cut gaskets.

4. Compact Flanged Joints

A variety of different joint designs fall under the category of compact flanges. Each design is unique to its manufacturer and subsequently reference to the joint normally involves quoting the manufacturer's name or a trade name, for example Graylok, Destec, Taper-lok and so on.



Compact flanges are used where savings in weight, space or material cost (especially so with exotic materials) are an advantage.

It is important to be able to recognise the different types of compact flanges available and brief descriptions of some available types follow.

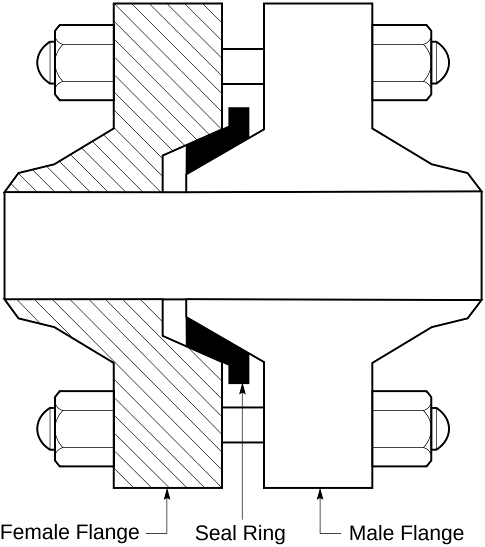
4.1 Taper-Lok

The Taper-lok flange employs a conical gasket which is wedged as the joint is tightened, thereby sealing on both its inside and outside surfaces. As internal pressure increases, the tapered gasket is forced in between the mating flanges, thereby further tightening the seal. Because of the male/female configuration requiring more parts, Taper-lok joints have not been widely used by BP Amoco.

The gasket - or joint ring - is externally visible allowing confirmation of installation. A relatively wide flange separation is required to remove the sealing ring and this may cause problems, especially where springing of pipework is difficult.

Taper-lok flanges have been shown to be sensitive to misalignment. The flange gap must be maintained within 0.3mm uniformity in order to prevent leakage. Sealing ring alignment must also be carefully observed during bolt tightening.

Overtightening of the bolts can result in damage to the seal ring and careful control of the bolt lubrication and torques is therefore essential.



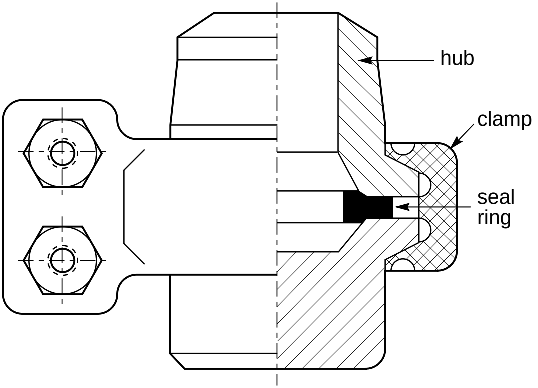
(Seal Ring is shown loose and not sealed)

4.2 Graylock Coupling

The Graylok Coupling comprises bolting, clamps, hubs and a seal ring as shown below. The function of the bolts is primarily to draw the two halves of the clamp together and not to resist internal pressure. The seal ring is self-energised and also pressure-energised.

When assembling a joint, before bolting up, the stand-off between the seal rib and the hub should be checked with a feeler gauge. If the stand-off is smaller than the manufacturer's recommendation, the seal must be replaced.

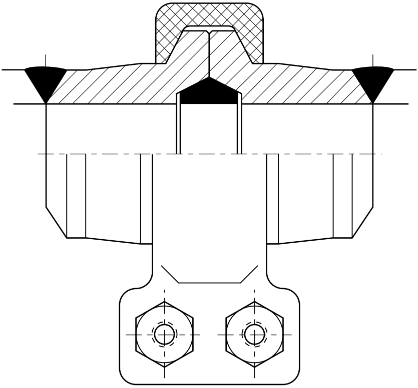
The seal ring and the hub sealing faces must always be lubricated before assembly. A thin coat of molybdenum disulphide is normally recommended.

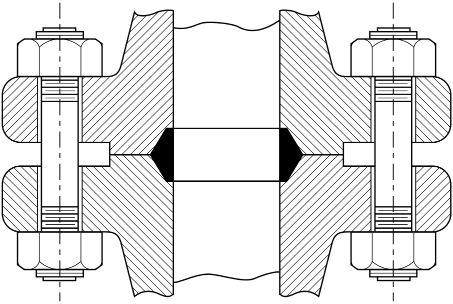


Other manufacturers produce compact flanges which are virtually identical to the Grayloc, for example, Destec, Seaboard Lloyd, Techloc, Spolok, etc. **NONE OF THESE DESIGNS IS INTERCHANGEABLE.**

4.3 Other Designs

There are a number of other compact flange designs, some of which are either no longer manufactured or for which the manufacturers have ceased to exist. The following diagrams illustrate a few such designs.





4.4 Compact Flanges Specification and Identification

a) **NPS and Flange Pressure Class:** Some compact flanges use ANSI B16.5 pressure ratings such as Class 600, 900, 1500, etc. Others require a design pressure to be specified.

b) **Pipe Schedule:** As specified in the pipe specification.

c) **Material:** Refer to the piping specification which will detail the material grade of the different components of the compact flange. Also obtain the manufacturer's product data which will interpret any abbreviations for material grade that may be stamped on the components.

d) **Manufacturer's Name/Trade Name/Model Number:** A model number may also be required for a particular compact flange design. Check with the manufacturer's product data. This is then sufficient to specify all the different components of the compact flange: the seal ring, clamps, hubs, even the studbolts. The components will all be unique to the one manufacturer.

4.5 Compact Flanges - Do's and Don'ts

Do's

a) Follow the manufacturer's installation procedures. Each procedure will be different so it is important to use the correct one.

b) When assembling compact flanges that consist of two clamps, such as Grayloc, always align the clamps such that they sit to the left and to the right of the pipe as opposed to top and bottom. This prevents water from collecting in the clamps.

c) Many manufacturers state that their gaskets may be re-used. Always inspect a gasket for damage, deformation and wear before re-using it.

d) Follow the manufacturer's disassembly procedures. Compact flange designs which include hubs, clamps and pressure energised seal rings such as Grayloc and Seaboard Lloyd Clamplok should be disassembled with care. Such designs can continue to contain residual pressure even with the studbolts removed, due to the wedging action of the clamp halves.

Always slacken the compact flange bolting and physically dislodge the clamp halves as a safeguard against any trapped residual pressure. Only then should bolting be fully removed and the flange disassembled.

Don'ts

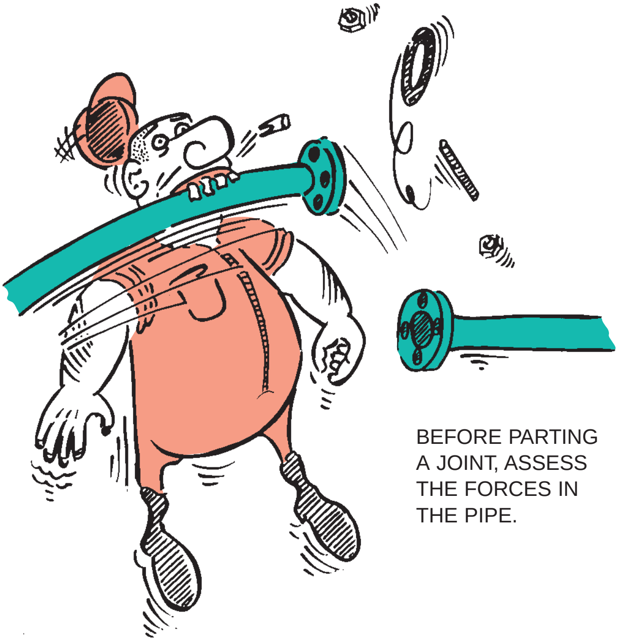
a) Never mix and attempt to match parts of different compact flanges. They may look the same but none are interchangeable. Only use the parts from the specified flange manufacturer.

4.6 Breaking Joints

a) Before starting, check that your permit to work is valid for the job in hand, and that the right protective clothing/equipment is worn.

b) Confirm that the line has been drained/vented or isolated as appropriate before attempting to break a joint.

c) Ensure that the correct tools for the job are available and are used.



BEFORE PARTING A JOINT, ASSESS THE FORCES IN THE PIPE.

d) When attempting to break a joint, avoid standing directly alongside or underneath the joint. Always break the bolt that is furthest away from you first, preferably the bottom furthest bolt.

e) Continually check for leakage, seepage or signs of pressure in the line - a hissing sound, a smell of gas, etc. Use a pair of wedges away from you to determine this.

f) **If at any stage there is a sign of pressure in the line, stop work immediately. Re-tighten the joint to contain the leak and then report the situation to your supervisor. The line isolation will have to be checked.**

g) Never remove nuts from the studs until you have ascertained that the pipework is empty.

h) If a blank or a spade is being removed, or a spectacle blind is being swung, check the weight from the tables. If necessary, support with a chain block before any work continues. Ensure the spectacle is clean and free from rust before releasing the studbolts.

i) Before finally parting a joint, always assess the forces on the pipe. Will the pipework spring apart? Is one half of the joint unsupported? Temporary supports may be needed.

4.7 Making Joints

a) Before starting, check that your permit to work is valid for the job in hand, and that the right protective clothing/ equipment is worn.

b) Check if there is a procedure in place for carrying out the intended work - and if so follow the procedure.

c) Determine the type, size and class of the flange to be bolted. Determine the piping specification number of the pipework. Check the material, coating and size of the studbolts. Check the type, pressure rating and size of the gasket. The studbolts and gasket specifications for the flanged joint must always match the descriptions in the piping specification document.

d) Only use the correct materials for the job. **Never use damaged materials and always use a new gasket when making up a joint.**

e) If using a “cut from sheet” gasket, ensure that the bolt holes and edges are flat with no burrs or ridges as these will result in uneven stress loading and may cause a leak.

f) Ensure that the correct tools for the job are available and are used.

g) Ensure the joint faces are clean before inserting joint.

h) Visually check the flanges for equal gap. If a larger gap appears on one side of the flange, tighten the bolt which corresponds with the larger gap first.

i) Ensure the flanges are parallel after tightening.

j) Attach any QA Tags to the flange when applicable.

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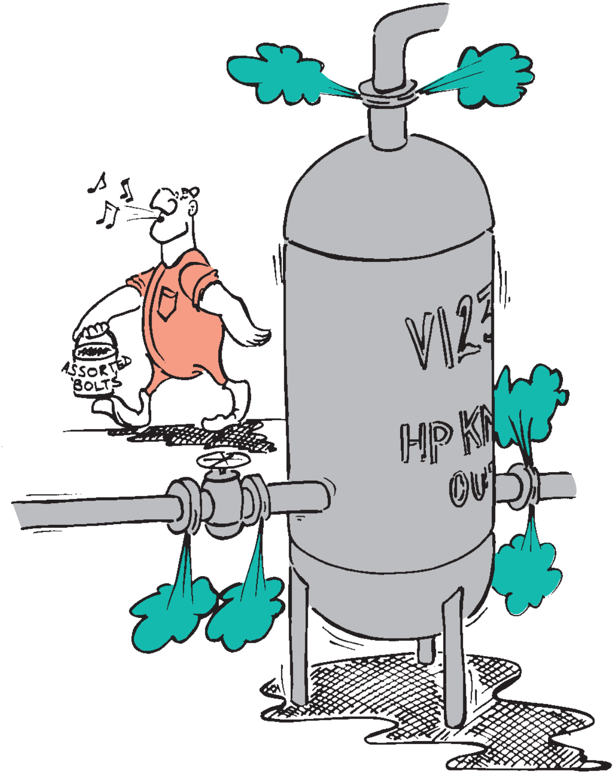
5. Bolting for Flanges and Covers

It is important to always use the correct nuts and bolts or studbolts in a given location and as defined in the piping specification.



5.1 Bolt Material Grade

Choice of material grade is dependent on the duty of the line. Using incorrect bolting could have serious consequences. For example, normal alloy steel bolting (B7) on a low temperature service is not suitable as the bolting will be susceptible to brittle fracture. Stainless steel bolting has limitations at high pressure due to the relatively low strength of the stainless steel.

The piping specification will always specify the correct material grade of bolting to be used on a flanged joint. Common bolt specifications are abbreviated as follows:

a) Normal alloy steel: Grade B7 bolts x Grade 2H nuts.

b) Low temperature alloy steel: Grade L7 bolts x Grade L4 nuts.

c) Austenitic stainless steel: Grade B8M bolts x Grade 8M nuts.

If cutting bolts, always cut the end which is not stamped (see drawing below).

5.2 Bolt Thread

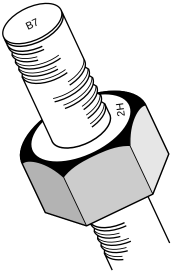
The thread on all studbolts used on flanged piping joints is a Unified Inch Series to either BS 1580 or ANSI BI.1. The thread is specified by quoting a certain number of threads per inch.

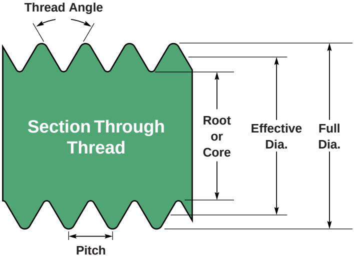
For alloy steel and stainless steel bolting, two thread types are used:

a) Bolt diameters up to and including 1 inch - a unified coarse (UNC) thread is used. The number of threads per inch depends on the diameter of the bolt.

b) Bolt diameters $1^1/_8$ inch and above - 8 threads per inch (TPI) or the 8 UN series is used.

All studbolts that are supplied to site should always conform to specification.





5.3 Bolt Coating/Plating

Corrosion of bolting:

- threatens mechanical integrity;
- increases maintenance costs (e.g. nut seizures);
- creates safety concerns (e.g. hot bolting operations, loss of integrity).

Bolting may be purchased with a variety of different coatings. The coatings are designed to protect the bolt material from corrosion. Typical bolt coatings and plating include zinc plating, cadmium plating and PTFE coating.

BP Amoco's North Sea experience over recent years has been of unsatisfactory performance of PTFE coated and electroplated low alloy steel bolting and that hot dipped spun galvanised bolting has provided better corrosion protection at reduced cost.

Bolts can be supplied with a variety of surface treatments. The common options are:

Type	Standard	Minimum Thickness
Zinc and Cadmium Electroplate	BS 1706	8 µm
PTFE Coating + Phosphate	-	30 µm PTFE
PTFE Coating + Electroplate (Zn or Cd)	-	30 µm PTFE / 8 µm Zn/Cd
Sheradising (Barrelled in Hot Zinc Dust)	BS 4921 Class 1/2	30 µm / 15 µm
Spun Galvanised (Dipped in Molten Zinc)	BS 729	43 µm

Note that **bolts with different coatings require different torque values** to achieve the same bolt tension. It is therefore important not to mix studbolts with different coatings on a given flange, as it will be difficult to achieve a uniform bolt tension on all the studbolts. Full procedures are available on bolt tightening and should be consulted.

A Note of Warning: Cadmium plated components give off toxic fumes when heated to sufficiently high temperatures. Therefore, heat should not be applied to release tight bolts. Furthermore, gloves should be worn when handling cadmium plated components to prevent skin abrasions.

5.4 Bolt Specification and Identification

a) **Bolt Diameter:** A flange of given class and size will have a specific bolt hole diameter and a bolt diameter to suit.

b) **Bolt Length:** This is specific to the flange type, class and size. Two exceptions to the standard bolt length are:

i) If the flanges are to be tightened using bolt tensioning equipment, the bolt length must be long enough to suit the equipment.

ii) For flanges separated by a spade or spacer, consider the spade thickness and the additional gasket for selection of the studbolt length.

c) **Material Grade:** As specified in the piping specification.

The studbolt material grade will be stamped on the end of the studbolt, either B7, L7, etc.

The nut material grade will be stamped on the end of the nut, e.g. 2H, L4, etc.

d) **Bolt Coating:** As specified in the piping specification, i.e. cadmium plating, zinc plating, PTFE coated, etc.

e) **Thread:** Should be the Unified Inch Series as specified in the previous section.

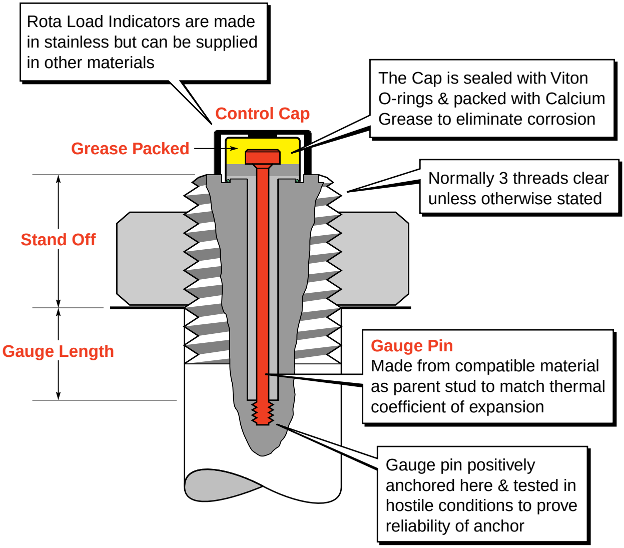
f) **Nuts:** Should be “heavy series” hexagon nuts.

g) **Standard:** Full bolt material specifications are given in further sections.

h) **Bolt Lubricant:** The screw thread of each studbolt (and the mating faces of each nut and washer) must be coated with a thin film of an approved lubricant (i.e. molybdenum disulphide).

5.5 Tension Controlled Fasteners - Rotabolt

The only practical direct stress/strain measurement technique currently available uses a specially adapted bolt such as "Rotabolt" (see drawing below).



These bolts can be utilised with any tightening technique to achieve the load, but the key is that the load (strain) is being measured directly to give an indication of bolt tightness.

The bolt consists of a standard industry bolt which is drilled at one end along the axis to accept a headed pin and cap mechanism which acts as a mechanical strain gauge.

The drawing shows the arrangement: the headed pin is positively anchored to the base of the hole and retains a rotor and cap which is free to spin in a pre-set air gap between the rotor and bolt face.

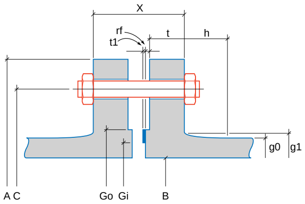
When tightening takes place, the stud begins to stretch (proportional to load) but the head pin does not, thus the air gap closes as tightening continues to extend the bolt. When the air gap is fully closed, the rotor locks. The pre-set air gap is directly proportional to the bolt extension (strain) and hence the stress in the bolt (and load transferred to the gasket joint). **The user simply turns the cap by finger and thumb while tightening the bolt until the cap locks.** Continued tightening is unnecessary and simply over-compresses the gasket and operates the bolt nearer to its yield point. Over-extension of the bolt does not damage the strain gauge mechanism since the now locked rotor transfers load to the pin which then starts to extend with the bolt. When the load is removed, the pin returns to its original length along with the bolt (unless it has been over-stressed beyond yield).

Every Rotabolt is individually loaded in the factory in order to pre-set the air gap for the required load. The set load is then stamped on the end of the cap for easy identification.

Rotabolts are, however, much more expensive than standard bolting and should only be used where service duty is severe or previous history of joint leakage justifies. For example, the cost of continually Furmaniting a troublesome joint, together with the possible hydrocarbon losses and even unscheduled plant shutdowns, may easily justify the added expense. Rotabolts have already been used throughout BP Amoco on troublesome heat exchangers and flanges.

For such troublesome joints or new exchanger designs, a standard data sheet is available to allow engineers to collect all the essential details for a joint design check to be made.

Gasket / Bolting Design Data Sheet



Dimensions to: BS 5500: 1994
ASME VIII Appendix 2 - ANSI B16.5

(Delete as appropriate)

General Notes for Rotabolt Supply and Installation:

1. Bolt grade is stamped on opposite end of bolt to Rotabolt cap.
2. If bolt tensioning is to be used for the tightening mechanism, then the extra length will be supplied at the opposite end to the Rotabolt cap. When bolt tensioning, the Rotabolt cap must be at the opposite end to the extra length.
3. On large flanges, to obtain uniform and "locked" Rotabolts requires several trips around the bolt circle when the unit is cold.

As the temperature rises, you can expect to flog the bolts a further 2-4 times to obtain the required tension settings. It is important that your detail plans reflect this significant man-hour content correctly.

Identification from Drawing Insert:

WIN No.	
TAG No. and Unit	
Joint Identification	
Original Design Code	
Year of Manufacture	
Manufacturer	

Sketch or Attachments

Design Data Required for Calculations for Bolting / Joint

	Shell Side	Tube Side
Design Pressure		
Design Temperature		
Operating Pressure		
Corrosion Allowance		
Duty Fluid		
Original Test Pressure		

Comments

Flange and Bolt Information

Dimension on Drg.	Dim.	Bolt Data				
Flange **OD**	**A**	No. of Bolts				
Flange **OD**	**B**	Diameter of Bolts				
Bolt **PCD**	**C**	**Special Bolting YES / NO - tick approp. box**				
Face to Face **(Site Check)**	**X**	Rotabolt Required	YES	☐	NO	☐
Flange Thickness (not including raised face)	**t**	Bolt/Tension Required	YES	☐	NO	☐
Raised Face	**rf**	*Unless requested otherwise, all Rotabolts will be supplied with extra length of 2 1/2 - 3 threads at each end over dimension X and 2 standard nuts.				
Hub Length	**h**					
Hub Thickness, Flange End	**g1**	or Hub OD Flange End				
Hub Thickness, Shell End	**g0**	or Hub OD Shell End				
Flange Face Surface Finish	Smooth Face: 3.2 - 6.3 µm	Spiral Finish: 6.5 / 12.5 µm	Spiral Finish: 12.5 / 25 µm			
Special Joint Configuration, i.e. tongue and groove - detail required		YES (drg. attached) ☐	NO ☐			

Material Grades

Flange:	Shell:	Bolting:

Existing Gasket Data	Material:	Thickness (**t1**)	OD (**Go**)	I/D (**Gi**)
Type:				

Requester	Phone/Fax No.	Asset	Date

Comparison of Techniques

The table below gives a guide to the accuracy of achieving the target bolt load:

Techniques:

- Impact Wrenches ± 60%
- Hand Spanners ± 60%
- Manual Torque Wrenches ± 30%
- Torque Multipliers ± 30%
- Pneumatic Torque Multipliers ± 40%
- Hydraulic Torque Wrenches ± 30%
- Hydraulic Bolt Tensioners ± 10%
- Rotabolt ± 5%

5.6 Hydraulic Bolt Tensioning

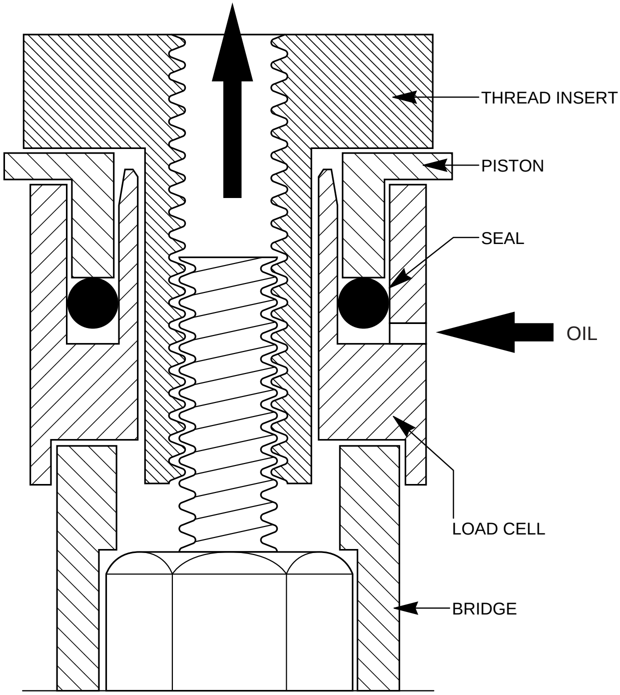
High pressure flanges, large diameter flanges and flanges on hazardous services are often made up using Hydraulic Bolt Tensioners.

The Bolt Tensioners operate by hydraulically "stretching" the studbolt to a pre-defined limit after which the operator is then able to hand-tighten the nuts. The hydraulic load is then released and the studbolt remains tensioned. The advantage of tensioning (stretching) against torquing is that the process is not dependent on the type of lubrication used and eliminates the effect of friction under the nut and between threads. Accurate bolt tensions are therefore obtained.

To pull down the flange evenly, several bolts can be tensioned at the same time. All the studbolts will eventually be tensioned after successive "passes" of the bolt tensioning eqiupment.

Note that the use of the bolt tensioning equipment usually requires the studbolts to protrude past the nut by an additional bolt diameter. Obstructions such as pipe supports and instrument tappings may prevent the bolt tensioning equipment from being fitted over the studbolt. In such cases, hydraulic torque wrenches will then be used to tension the bolts.

Hydraulic Bolt Tensioning is a specialised activity. Only trained personnel carry out the bolt tensioning using equipment in good order.



Hydraulic Bolt Tensioner
or
Jacking Tool

5.7 Flange and Bolt Protection

Considerable time may be lost when attempting to loosen rusty studbolts. Therefore, to protect the studbolts from deterioration, particularly those in an exposed environment, flange protectors and bolt (or thread) protectors are used.

Flange protectors fit around the circumference of the two mating flanges and the enclosed space is then filled with a grease. Thread protectors fit over the nut and are also filled with a grease via a grease nipple. Alternatively, grease impregnated fabric such as "Densotape" may be used to protect studbolts.

Flange and thread protectors are most typically found on flanges which have been hydraulically bolt tensioned.

5.8 Bolting - Do's and Don'ts

Do's

a) Ensure that the correct size and material of bolting is used. (Refer to the piping specification.)

b) Allow for two threads to be exposed outside the nut once tightened; this is good practice. The only exception is when a flange requires hydraulic bolt tensioning and the additional length of bolt to be exposed outside the nut will be specified.

c) Only use clean, rust-free nuts and studbolts.

d) Coat the stud, the nut thread, the nut and the flange bearing surfaces with the selected bolt thread lubricant.

Don'ts

a) Do not use damaged or worn studbolts, bolts or nuts.

b) Do not use nuts or bolts that do not fit correctly together.

c) Do not use bolting that cannot be correctly identified.

d) Do not mix studbolts with different coatings on a particular flange. Different bolt coatings require different torques to achieve the same bolt tension, as some coatings are more lubricating than others.

e) Nuts should not be assembled with the hard stamp or pad against the flange. The machined face should always come into contact with the flange.

f) Do not use bolting which is not clearly marked with the correct material grade - a wrong assumption could have serious consequences.

5.9 Manual Bolt Tightening

Once a flanged joint has been prepared, the correct gasket obtained (as confirmed by reference to the piping specification), the bolts and nuts cleaned or replaced (and material confirmed correct by reference to the piping specification), the joint may be assembled.

Guidance on the torque required for the joint, and for the type of lubricant to be used, must be obtained. The torque required to achieve a given bolt tension (recommended to be 50,000 psi) will be affected by the following factors:

a) Nominal bolt diameter.
b) Bolt material grade.
c) Bolt and nut face lubricant.

5.9.1 Manual Bolt Tightening Procedure

For successful jointing of a flange, it is important to evenly tension the stud bolts. Uneven or incorrect bolt tensions will not seat the gasket properly and the end result will be a flange that is likely to leak under test or in service. Tested joints may leak in service due to temperature variations across the flange face which are not seen during testing.

The recommended manual flange bolt tightening procedure is as follows:

a) Ensure that the flanges are parallel and axially aligned.

b) Lubricate the nut and bolt threads, and the contact face of the nut on the flange.

c) Locate the gasket and lightly nip the bolts.

d) Tighten evenly to approximately one third of the final torque working on diametrically opposed bolts following the sequence shown in "Typical "Criss-Cross" Bolt Tightening Sequence on page 76.

e) Repeat the tightening sequence in at least three more steps to the full torque. If required by the procedure, use a torque wrench.

f) Finally re-tighten adjacent bolts, start and finish at the same bolt, e.g. 1, 3, 2, 4 and 1. Use a torque wrench if required by the procedure.

5.9.2 Troubleshooting

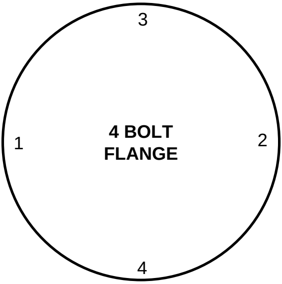
Persistent leakage may be due to one or a combination of the following:

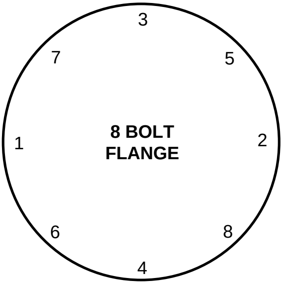
a) Inadequate or uneven bolt tension. Note that excessive tightening may lead to bolt yielding, gasket damage, flange distortion, etc. All of these will make the leak worse.

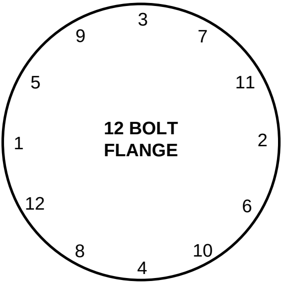
b) Damage to the flange sealing faces, particularly radial dents and scratches, or the wrong surface finish. If in doubt, ask for help from a competent Supervisor or Engineer.

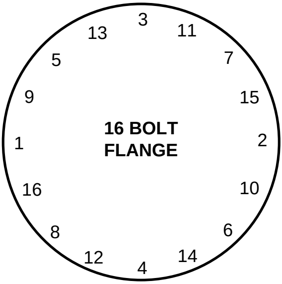
c) Hot or cold joints are generally more problematic than ambient joints. For a flange at ambient temperature being heated by hot process fluids, initially the inner part of the flange is heated and expands, whilst the bolts remain at ambient temperature. Hence the bolt load increases. If this load increase yields the bolts or crushes the gasket, when the bolts heat up and the load evens out, the flange may leak. This is one of the reasons why great care is required to obtain the correct bolt load when making up joints.

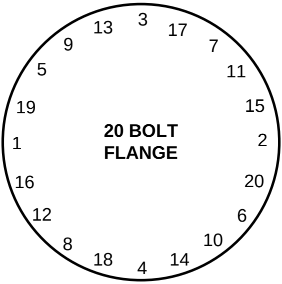
Typical “Criss-Cross” Bolt Tightening Sequence

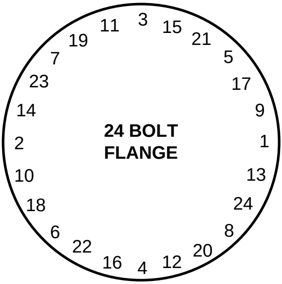












5.10 Bolt Tightening - Do's and Don'ts

Do's

a) Full bolt tightening procedures should be available for the flange size and ratings and the bolt material to be worked upon. The procedure will specify the tools and lubricant to be used. If in doubt, consult a competent Supervisor or Engineer.

b) Number the studs and the nuts as an aid to identification and for applying the criss-cross bolt tightening sequence depicted in the following figure.

c) If using a torque wrench, hand-tighten the studbolts with a short wrench first before torquing. Use the criss-cross bolt tightening sequence. Confirm that the torque wrench is still in calibration. **If in doubt, ASK.**

d) When using a torque wrench, consult the bolt tightening procedure to determine the correct torque settings.

Don'ts

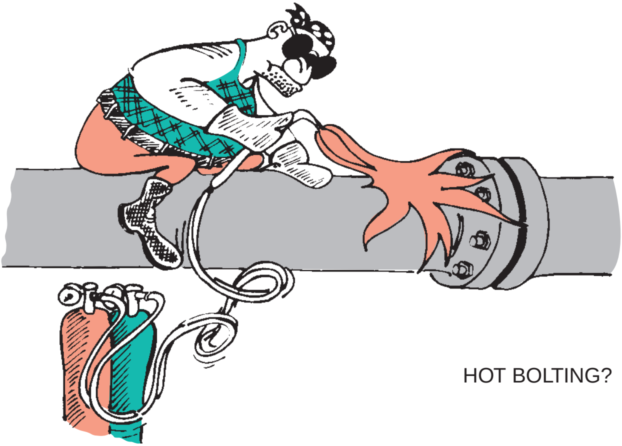
a) Do not draw the flange up tight on one or two bolts only. This will cause local gasket crushing or pinching and will ultimately result in a leaking flange.

b) Do not overtighten bolts and take particular care with small bolts, i.e. those less than 1 inch in diameter.

c) Do not align/draw misaligned pipework spools together using flange bolts **without specific agreement** from the Mechanical Supervisor

d) Do not flog - results are variable and indeterminate.

5.11 Hot Bolting



HOT BOLTING?

The removal and replacement of flange bolts on live piping and equipment is practised for several reasons:

- for replacing corroded or damaged bolts;
- for upgrading the material specification/grades of bolts; or
- to minimise the time spent freeing bolts during plant shutdown.

The practice of removing and replacing or freeing and re-tightening bolts on live equipment is potentially hazardous and the utmost caution therefore needs to be exercised when planning and carrying these operations.

The replacement must only be carried out under permit, and under controlled conditions. Because it involves working on live equipment, each application must be specially reviewed beforehand.

Detailed procedures must be in place for the control of hot bolting and must be observed.

For further information, see EEMUA Information Sheet No. 17 Rev. 1, dated May 1999.

5.12 Restrictions on Hot and Odd Bolting

a) Marginal time savings during shutdowns on disjointing should not be considered sufficient incentive for Hot Bolting operations.

b) A formal engineering review of the proposed Hot Bolting operation must be carried out to establish that there are no unacceptably high external loads and bending moments acting on the joint. The review should consider, as a minimum, the following:

    i) Contents of the line or eqiupment.
    ii) Design and operating pressures and temperatures.
    iii) Possible upset conditions.
    iv) Position and functionality of piping supports.
    v) Position and type of expansion bellows fitted.
    vi) Maintenance history of the joint.

c) Flanges should have a minimum of 8 bolts.

d) Hot Bolting shall not be considered when the operating pressure exceeds 60% of that specified in ASME/ANSI B16.5, Annex G, Table G for any given flange rating.

e) A thorough inspection of the flange assembly should be conducted to verify the integrity of the flange and fasteners. These operations should not be allowed if bolts and nuts show signs of corrosion, necking or are suspected of having cracks.

f) Equipment containing toxic materials shall not be Hot Bolted.

g) Consideration must be given to the accessibility of the area and that adequate escape routes are available, should uncontrolled flange leakage occur.

To repeat - it is essential that each application is reviewed beforehand. The operation must be carried out under strictly controlled conditions.

5.13 Insulation Kits for Bolts

Insulation kits are designed to prevent galvanic corrosion between flanges of dissimilar metals, for example a carbon steel flange bolted to a stainless steel flange. A conducting liquid such as water must be present between the two flanges for galvainc corrosion to occur. On oil and dry gas duties, insulating gaskets ARE NOT required.

Because of the general unreliability of insulating gaskets, their use should be minimised to areas where only absolutely necessary and only then when agreed with by your Engineering Department.

If used, the insulation kit will consist of the following:

a) insulating gasket;

b) insulating sleeves to be placed around the studbolts;

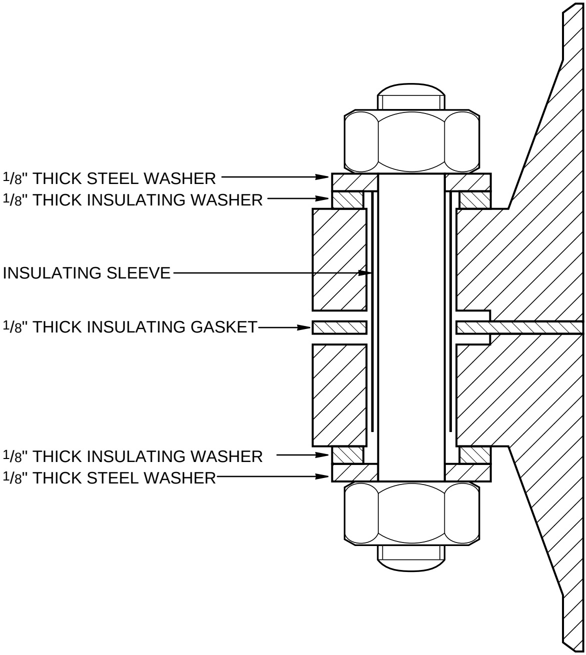
c) insulating washers and steel washers.

Note: The conditions that cause galvanic corrosion (two dissimilar metals brought into contact with a conducting medium) must be guarded against. Uncoated carbon steel studbolts used on stainless steel flanges in a wet environment, and carbon steel pipework screwed into brass gate valves on water duties, are two examples of "galvanic cells" which can easily be avoided.

Three types of kit are available:

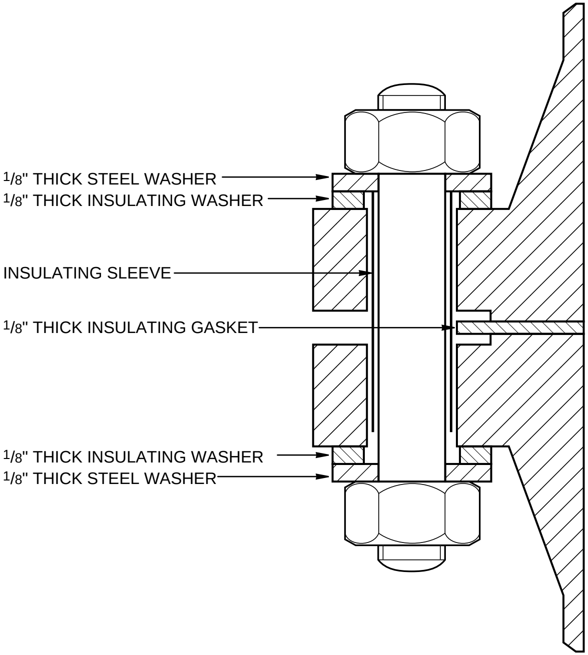
a) **Full Face Gasket Insulating Set**

This set is suitable for both flat face and raised face flanges. The gasket style has the advantage of minimising the ingress of foreign matter between the flanges and therefore reduces the risk of a conductive path between the two flanges.



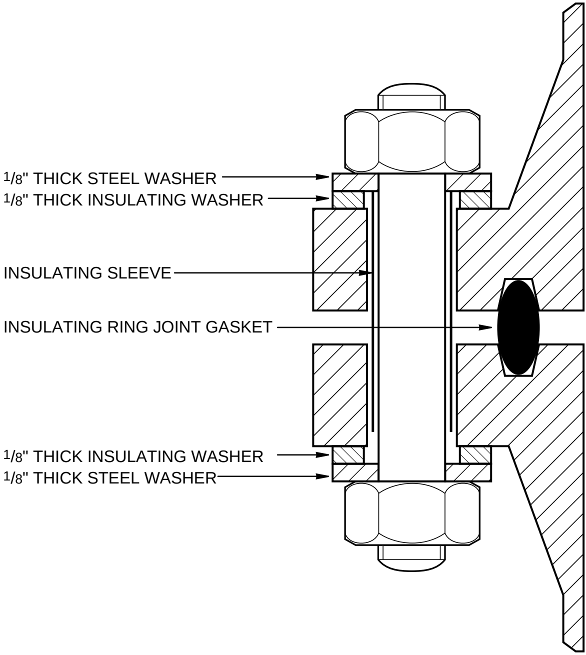
b) **Inside Bolt Location Gasket Insulating Set**

Is only suitable for raised face flanges and the gasket is located within the bolts.



c) **Ring Joint Gasket Insulating Set**

The insulating oval RTJ will fit into a standard RTJ flange ring groove. **The kits are not used on BP Amoco sites as they are presently considered to be too unreliable.**



5.14 Insulating Kit Identification and Specification

a) **Nominal Pipe Size and Pipe Schedule:** Must always be specified. Insulating gaskets, unlike CAF gaskets, are an exact fit, from the OD to the ID of the flange.

b) **Flange Pressure Class:** Always to be specified.

c) **Style of Insulating Kit:** Full face or inside bolt location. RTJ gasket insulating sets are not used by BP Amoco.

d) **Gasket Material:** Usually phenolic laminate or neoprene faced phenolic laminate.

5.15 Insulating Kits - Do's and Don'ts

Do's

a) Always use a new insulating kit which has not been removed from the manufacturer's sealed package. Good insulation requires the insulating parts of the kit to be clean and undamaged.

b) Follow the manufacturer's installation instructions.

c) Use a torque wrench or tensioning equipment to tension the studbolts to the manufacturer's recommendations. This is important as insulating gaskets are particularly susceptible to splitting or crushing if overloaded.

d) Ensure that the flange face and the studbolts are clean.

e) Check for any conducting paths between the two mating flanges which would otherwise render the insulating gaskets ineffective.

f) If in doubt, seek advice from your Engineering Department.

Don’ts

a) Do not re-use old, damaged or unclean insulating kits. These will not provide effective insulation and may be subject to gasket failure.

b) Do not mix and match parts from different insulation kits.

c) Do not use air driven impact tools when bolting up a flange as the may cause the insulating washers to crack.

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6. Spading and Blanking of Flanges

A line is positively isolated by either inserting a spade between two flanges, swinging a spectacle/blind or installing a blind flange on the end of a flange.

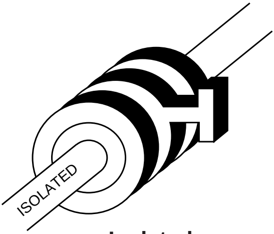
Use of the correct spade or blind is imperative as the thickness of the spade is calculated to withstand the full test pressure of the line being isolated. If too thin, the spade may bow between the flanges or even fail!

See a selection list of reversible spade thicknesses for different flange sizes and classes.

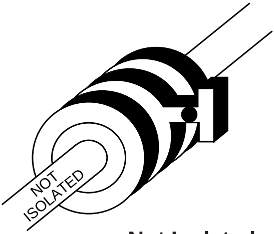
Before inserting or swinging a spade, the line must be depressurised and gas freed. Check the face of the spade or spectacle for pitting as this face may have been out in the weather for a considerable period of time. The same safety precautions as when breaking any flanged joint apply here.

When inserting a spade or spectacle blind, always use new gaskets and use the same procedure for bolting up a flange of equivalent size and class.

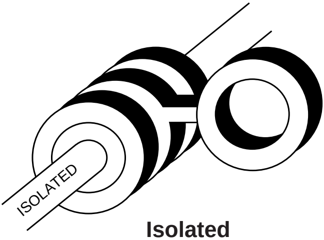
It is important to recognise the status of a spade as this indicates whether the line has been isolated or not. The following diagrams illustrate the basic differences.



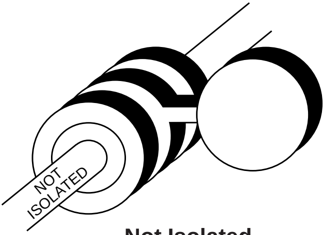
Isolated Spade



Not Isolated Spacer with Indicator Hole



Isolated Spectacle



Not Isolated Spectacle

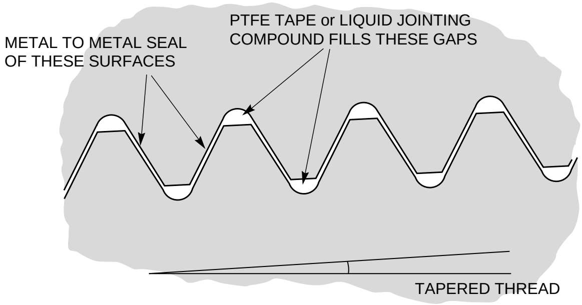
7. Screwed Piping Joints

The use of screwed piping joints, especially on new installations or plants, is becoming increasingly uncommon. On older sites, an abundance of screwed joints may still be found on a variety of services.

7.1 Threaded Joints

A variety of threaded joints exists. Those used on pipework are always tapered and identified by a standard, either NPT (American National Taper Pipe Thread) or BSP (British Standard Pipe Taper Thread). The two threads are **not interchangeable**. Both 1/2" and 3/4" NB BSP and API have the same number of threads (TPI) but have differing thread angles.

Sealing on a threaded joint will only take place on 2 to 3 threads within the joint once fully tightened. A thread compound is used to lubricate the threaded joint when initially making it up. As the joint is tightened, the compound is forced into the peaks and troughs of the thread, thereby blocking potential spiral leak paths. Sealing between the



mating sides of the thread is primarily by metal-to-metal contact; the thread compound will assist this by filling any surface imperfections such as scratches on the thread faces.

7.2 Sealing on a Threaded Joint

a) **Reference Documents**

BP RP 42-1 (formerly CP12)

BPOGRL Piping Specification EM/STAN/42-01

BPOGRL Practice - Use of Threaded Fittings EM/P0U42-02

BS 6920 Pt 1 Suitability of Non-Metallic Products on Potable Water Duties

b) **Aim**

Jointing compound is to act as a lubricant and sealant to provide a pressure-tight joint. No compound or tape to be used if the fittings are to be welded.

It shall be stable and not react unfavourably with either the service fluid or the piping material and shall not be subject to any disintegration that could lead to line blockages. The system should also have an earth continuity.

c) **PTFE Tape**

PTFE tape is the most common "thread compound" available. The correct amount of PTFE tape used on a threaded joint is very important. Too little, and a seal is unlikely to be made. **Too much could be lethal. PTFE tape must never be used to build up a thread - when under pressure the joint could blow apart.**

PTFE is not to be used on bull plugs on heat exchangers. Liquid thread compound only is to be used as there is no isolation between the thread and the process.

PTFE tape is supplied in several thicknesses ranging from Standard (0.075 mm thick) to Heavy Duty (0.2 mm thick). Which to use depends on the pipe (or tubing) size and the maximum pressure. Heavy Duty tape is used on "mechanical" pipe joints. Standard tape is commonly used on low pressure (up to 10 bar) small bore (3 to 25 mm diameter) instrument tubing.

d) **Liquid Thread Compounds**

A variety of liquid thread compounds is available that will lubricate and seal a threaded joint. There is no risk in the "over-application" of a liquid compound, as there is with PTFE tape. Excess liquid will simply exude from the joint.

The manufacturer's recommendations on use must always be followed. Some compounds have limitations on service duties. Others require a setting time before pressure can be applied to the system. Lists of the variety of thread jointing compounds and their limitations on use are given below.

Jointing compounds should not be applied to any threaded joints on stainless steel or other exotic materials until the chemical compatibility has been checked.

7.3 Table of Thread Jointing Compounds

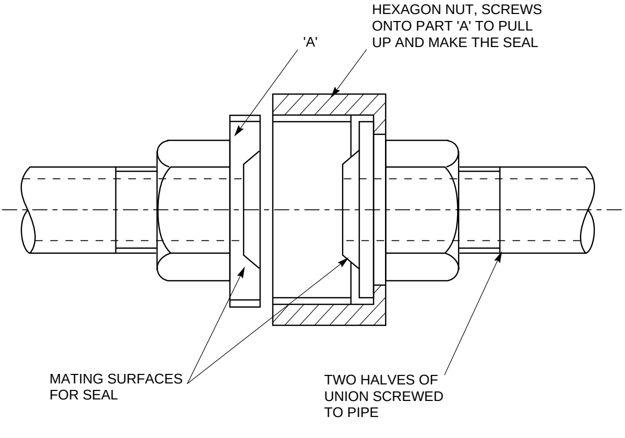
Thread Services Sealant	Service	Thread Size	Temp. (°C)	Pressure Range (bar g)
PTFE Tape (to BS5292, Standard, 0.075mm)	All services, except: - Downstream of Instrument Air Filter/ Regulators - Air to Breathing Apparatus	Up to 1" NB	-190 to +200	Up to 10
PTFE Tape (to BS5292, Heavy Duty, 0.2mm)	All services, except: - Downstream of Instrument Air Filter/ Regulators - Air to Breathing Apparatus	Up to 1.5" NB	-190 to +200	Up to 100
Permabond A131 (Anaerobic Adhesive/ Sealant)	All services, except: - Refrigerant R22 - Low Temperature Cyclic duties with differing metals	Up to 1.5" NB	-55 to +150	Up to 207
Rocol "Oilseal" (Thixotropic Liquid)	All services, except: - Sodium Hypochlorite - Methanol - Refrigerant R22 - Firefighting Chemicals - Chemical Injection Fluids	Up to 1.5" NB	-50 to +200	Up to 138
Rocol "Foliac Manganese" Applications (with PX' Linseed Oil Slight Oil Based Paste)	High Pressure Water Applications (with Slight Oil Comtamination) Not Suitable for Oil Service	Up to 1.5" NB	600 Maximum	200 Maximum

	Water Portable	Water Non-Portable	100 psig Steam	Air	Hydro-carbons	HF Acid	Brine
Boss White		✓	✓	✓			✓
Boss Green	✓	✓	✓	✓			
Boss Graphite		✓	✓	✓	✓		✓
Boss Magnesia		✓	✓	✓			✓
Stag A		✓	✓	✓	✓		
Stag B*		✓					
PTFE Paste Gold End						✓	
Capaltite			✓		✓		

*** Stag B is recommended for use in corroded or poorly machined threads, but only when the preferable alternative of a correctly made, good condition joint is not feasible.**

7.4 Screwed Unions

When pipe rotation is not permissible or practicable, say when joining a screwed pipe system, a screwed union is used. A threaded ring nut connects the two halves of the union and the seal is made by metal to metal contact of the profiled faces shown below. The two halves of the union may either be screwed or socket welded to the pipe, as permitted by the pipe specification.

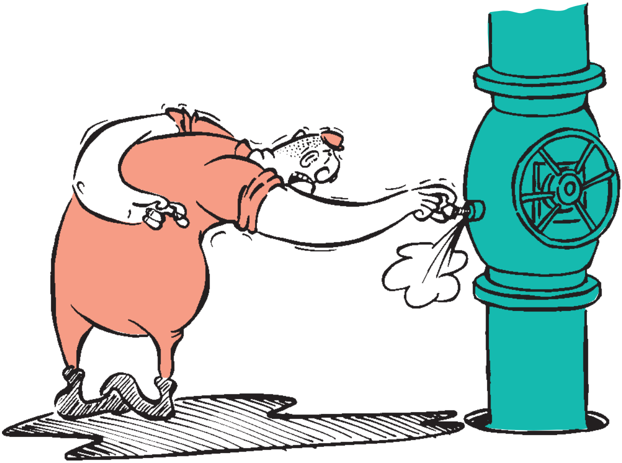


7.5 Screwed Joints Specification and Identification

a) **Nominal Pipe Size:** Always to be specified (only Sch. 80 and above pipe to be threaded).

b) **Thread:** Whether NPT, NPS, BSP, etc. The only reliable way to identify a thread is by using a profile gauge.

c) **Note:** NPT and NPS are **60 deg.** thread angle while BSP is **55 deg.** thread angle.



7.6 Screwed Joints - Do's and Don'ts

Do's

a) Take care when unscrewing a joint, even though the system may have been depressurised:

- The seal on a union type joint breaks as soon as the ring nut is slackened.

- Threaded joints continue to seal until the threads finally release, giving no warning of internal pressure. **It is therefore particularly important not to stand in front of plugs or caps when slackening them.**

b) Prior to making a joint, check for thread damage, correct profile and correct engagement. Check with thread gauge if necessary.

c) Before applying any thread compound, a threaded joint should be made up dry by hand. For pipe sizes up to 1 $^{1}/_{2}$ inch NB, ensure that at least 4 to 5 threads engage.

d) Check if there are any restrictions on the use of PTFE tape. There may be a total ban on PTFE tape, or it may be restricted to low pressure non-hazardous duties or just to non-hydrocarbon duties.

- **If using PTFE tape,** ensure that you are using Heavy Duty PTFE tape (0.2 mm thick) on the mechanical (as opposed to instrument) threaded joints. Wrap the tape in a clockwise direction, no more than two layers thick and starting at the end of the pipe.

- **If using a liquid thread compound,** follow the manufacturer's recommendations. Some compounds have restricted use and others require a setting time.

e) Thread tape should not be used on **Bull Plugs**, i.e. testing points onn exchanger nozzles.

f) When wrenching up screwed joints from hand-tight, for pipe sizes up to 1 $^1/_2$ inch NB at least 3 more threads should be engaged (at least 7 to 8 threads engaged in total). For larger pipe sizes, thread engagement should be checked from ANSI BI.20.1 - Pipe Threads, General Purpose.

g) It may be necessary to use a thread locking compound on the lock nut of union type joints. This prevents them from loosening due to vibrations.

Don’ts

a) Do not cross threads, force screwed joints together or attempt to mate unmatched threads. A seal will not be made.

b) Do not make a seal by applying excessive PTFE tape to threaded joints. If a seal cannot be made, the threads are probably damaged and new threads should be cut on a fresh section of pipe.

c) PTFE tape should never extend beyond or overhang the first thread on a joint as tape could shred and enter the fluid system.

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8. Compression Fittings

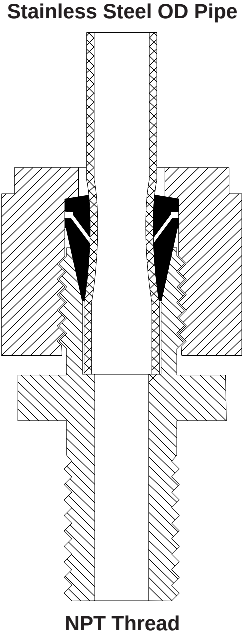
Compression Fittings are predominantly used on instrument pipework. There are numerous designs available but that used most by BP Amoco for low pressure instrument duties is the SWAGELOK double ferrule compression fitting. Other types of compression fittings are used on high pressure and/or hydraulic duties.

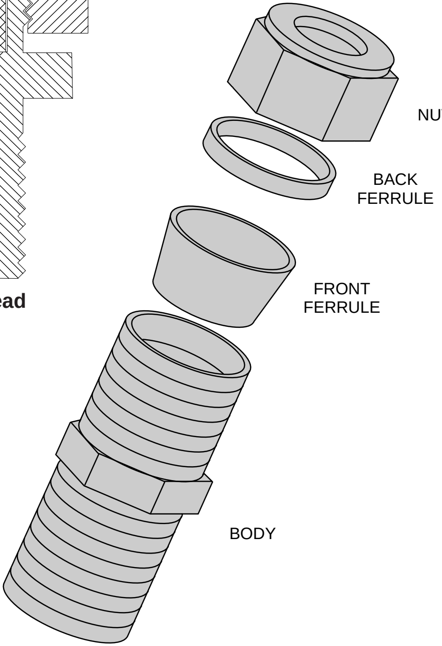
The **SWAGELOK** compression fitting comprises 4 parts - a nut, a back ferrule, a front ferrule and a body. When making a connection from new parts, the action of tightening the nut results in both the front and back ferrules swaging the tube. In particular, the back ferrule acts as a wedge and forces the front ferrule against the tube. This swaging process usually requires about 1¼ turns of the nut from hand-tight to achieve.

No torque is transmitted to the tube when tightening the nut. The tube will therefore not require restraint and there is no initial strain which would otherwise weaken the tube.

Once the compression fitting has been made, it may be repeatedly undone and retightened with no adverse effects to its sealing capability. As the tube will have already been swaged, only a ¼ turn of the nut from hand-tight will be required to make the seal. Note that the front and back ferrules on a correctly swaged tube (when dismantled) should both be **free to rotate**.

Instrument pipe specifications are available and should be used to specify material requirements in exactly the same manner as with pipe and pipe fittings. The appropriate “instrument piping specification” will be referenced in the piping specification for a particular pipe class. Hence it is necessary to identify the pipe class of the pipework to which the instrument fittings are connected.


Stainless Steel OD Pipe
NPT Thread


NUT
BACK
FERRULE
FRONT
FERRULE
BODY

8.1 Compression Fitting Specification and Identification

a) **Fitting Manufacturer:** State the manufacturer and the manufacturer's reference code for the particular fitting that you require. Refer to the instrument piping specification.

b) **Tube OD:** **CARE!!** Metric and imperial compression fittings are incompatible. Refer to the instrument pipe specification to check which is used.

c) **Tube Wall Thickness:** Normally not required. If in doubt about what appears to be a very thick or thin wall, check with the manufacturer, as they normally set limitations on the tube wall thickness.

d) **Pressure:** Again, not normally required but quote if in doubt. Other types of compression fittings will be specified for high pressure applications.

e) **Fitting Material:** Must be quoted and will be as specified in the instrument piping specification.

f) **Fitting Body Connection:** Dependent on the application. A variety of body connections is available and must be quoted to complete the description of the compression fitting, e.g. male NPT straight, elbow or tee connectors, female connectors for parallel pipe thread, unions, reducing unions, etc.

8.2 Compression Fittings - Do's and Don'ts

Do's

a) Ensure that the compression fitting is free of dirt or any foreign material. The tube to be fitted must also be clean. The tube end must be cut square and any burrs should be removed.

b) Follow the manufacturer's recommended procedure for tightening up the fitting when new. Swagelok compression fittings generally require 1 1/4 turns of the nut from finger-tight to obtain an effective seal. (Small tubing - 2, 3 and 4 mm - only requires a 3/4 turn.)

c) Once tightened, check the gap between the nut and the body of the fitting with a Swagelok Inspection Gauge. If the gauge fits, then additional tightening of the nut is required.

d) When retightening a disconnected fitting, the nut will not require as much tightening as when making the connection from new. Swagelok fittings require about 1/4 of a turn from hand-tight to regain the seal. Use the inspection gauge to check.

e) Metric and Imperial compression fittings are incompatible, therefore check which is being used. Swagelok metric compression fittings have a stepped shoulder machined on the nut hex and the body hex. The letters MM will also be stamped on shaped body fittings.

Don'ts

a) Do not combine or mix parts from various compression fitting manufacturers. The components may have different dimensions and tolerances and a seal will be difficult to achieve.

b) Never turn the fitting body to make up the joint. The body should be held and the nut rotated.

c) Do not use stainless steel tubing with brass fittings. The metal tubing material should either be the same or softer than the fitting material.

d) Do not use tubing which is scratched, depressed or deformed. Similarly, do not force oval tube into a fitting. The tube should be cut back to sound material.

e) Do not use PTFE tape of any other thread sealing compound between the nut and the body of the compression fitting.

f) Never bleed down a system by loosening the compression fitting nut.

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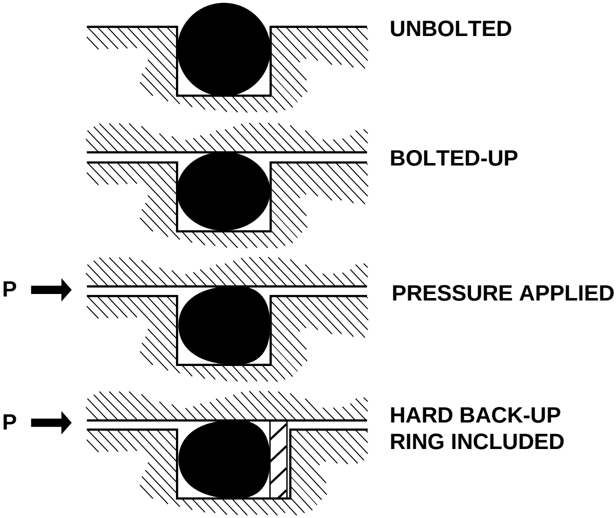
9. Elastomeric O-Ring Seals

This section only applies to O-rings used on static seals such as bolted covers and joints. Dynamic seals, as found on pump shafts for example, are not covered.

The sealing arrangement on a static seal typically involves a groove cut into the face of the joint surface and into which the O-ring is placed. The O-ring will stand slightly proud of the groove until axially compressed by the closure cover, thereby making the seal. Once bolted up, application of pressure forces the O-ring across the groove and increases its sealing effect. Hard back-up rings may be used to prevent the O-ring extruding into the clearance gap between the joint surfaces.



9.1 Selection of Elastomeric O-Rings

Selection of elastomeric O-rings ALWAYS needs careful attention. Selection is normally made by the designer of the joint who will consider both the service duty and the joint design as follows:

Service Duty:

a) **Fluid, including any contaminants and/or additives.** Certain elastomers may be susceptible to chemical attack,for example by H_2S, methanol or glycol.

Always check chemical resistance of a variety of elastomers and plastics (see Appendix 1, Section 4).

b) **Temperature range.** Elastomers have operating temperature ranges outside which their desirable properties may degenerate. For example, chemical hardening at high temperatures, brittleness at low temperatures.

c) **Pressure range.** Note that certain operating conditions can produce a "full vacuum" and may require a special joint design.

d) **Any transient or cyclic conditions, including the number of cycles.** For example, rapid decompression or "blow-down" may have serious consequences on certain gas permeable O-rings. Special grades of elastomer are available where explosive decompression might be a problem (see "Explosive Decompression Damage").

e) **Required operating life.** Note that ozone, UV light, radioactivity, heat and oxygen may result in premature ageing and gradual loss of properties even before installation.

Design of Joint:

a) **Deformation of the O-ring.** There is an optimum compression for O-rings used in static seals, above or below which permanent deformation and loss of sealing capability may result.

b) **Hardness of the O-ring.** Hardness of elastomers is measured in units of Shore A or D or in International Rubber Hardness Degrees (IRHD). In general, harder O-rings are selected for higher pressures and/or to reduce extrusion; softer O-rings are selected for lower pressures.

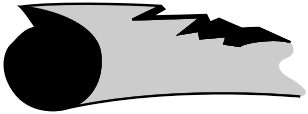
c) **Clearance gap.** The clearance gap of the joint depends on machining tolerances, eccentricities and metallic “breathing”. Poor machining may result in extrusion damage of the O-ring.

d) **Use of back-up rings.** Hard back-up rings may be specified to reduce or eliminate O-ring extrusion, typically for higher pressures and/or softer O-rings.

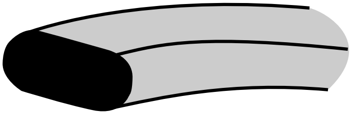
9.2 Elastomeric O-Ring Failures

The following examples of O-ring failure may be a result of incorrect O-ring specification or poor joint design and manufacture. O-rings removed from joints should always be checked for evidence of such failure. Failed O-rings should be kept safe for further investigation by your Engineeirng Department and the O-ring manufacturer.

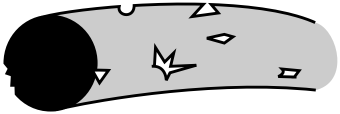
a) **Extrusion Damage.** Extrusion is characterised by “peeling” or “nibbling” of the O-ring surface. The O-ring extrudes too far into the clearance gap and shears.



b) **Compression Set Failure.** The O-ring loses its elastomeric memory and flattens.



c) **Explosive Decompression Damage.** Under high pressure, gases may diffuse into the elastomer. On rapid decompression, the absorbed gases expand quickly and cause blistering and rupture of the O-ring.



9.3 Elastomeric O-Rings - Specification and Identification

a) **O-Ring Manufacturer, O-Ring Trade Name and Grade:** This information should be specified on the schematic, arrangement drawing or parts list associated with the equipment being maintained.

b) **O-Ring Type:** Fully moulded O-rings should always be specified.

c) **O-Ring Dimensions:** These will also be specified on the relevant schematic, arrangement drawing or parts list.

d) **Back-Up Rings:** Should only be used when indicated on the relevant schematic or drawing. Dimensions and material specification will also be specified.

e) **Service Duty:** When appropriate, full service details should be provided, e.g. for supply of new equipment.

In particular, service duty details should be provided when the original O-ring specification is unknown or if considering use of a different O-ring specification. The equipment manufacturer must be consulted and confirmation that the O-ring is suitable for the service duty should be sought. Any proposed material must then be endorsed by your Engineering Department.

9.4 Installation of Elastomeric O-Rings - Do's and Don'ts

Do's

a) Prior to installation, check for the correct material specification, trade name and manufacturer. Check that the O-ring (and back-up ring if specified) is the correct size, undamaged and clean. Template gauges are recommended for checking larger O-ring sizes.

b) Follow the manufacturer's recommended installation instructions. This applies to both the O-ring manufacturer and the equipment manufacturer.

c) Check the condition of the ring groove and any bearing surfaces. Ensure that they are thoroughly cleaned with a recommended cleanser and dried before installation of the O-ring. **CARE! Many cleaning of degreasing agents may chemically attack the elastomer.**

d) O-rings may be lubricated only where specified lubricants are recommended by the supplier.

e) Always use fully moulded O-rings.

f) Take care not to cut, pinch or shear an O-ring when assembling the joint.

Don'ts

a) Never force or stretch the O-ring into a groove for which it is not specifically designed.

b) Do not use unmarked O-rings or O-rings that have not been stored in the supplier's packing.

c) Do not install an O-ring with an expired shelf life.

d) Do not make up an O-ring joint if the previous O-ring showed evidence of faliure. Check with your Engineering Department first.

e) Never cut O-rings to size and then glue or bond back together.

f) Do not estimate O-ring dimensions from the groove dimensions. Only use the schematic, arrangement drawing or parts list for the equipment you are dealing with.

g) Do not re-use hard back-up rings. New back-up rings must be fitted when installing new O-rings.

Appendix 1
Miscellaneous Technical Data

1. Bolts Material Specifications
2. Hydraulic Bolt Tensioning
3. Surface Finish Values for Tongue and Groove Small Male/ Female and Ring Joint Facings
4. Chemical Resistance - Selected Elastomers and Plastics

1. Bolts Material Specifications

Working Temp °C		Alloy Type	Material Specification and Bolt Grade		Nut Grade	
Min.	Max.		Min.	Max.	BS	ASTM
-20	400	1% Chromium Molybdenum	4882 B7	A193 B7	4882 2H or 4	A194 2H or 4
-100	400	1% Chromium Molybdenum	4882 L7 (Impact Tested)	A320 L7 (Impact Tested)	4882 K4	A194 4 (Impact Tested)
-20	520	1% Chromium Molybdenum - Vanadium	4882 B16	A193 B16	4882 7	A194 7
-200	575	Austenitic Chromium Nickel 18/8 (Type 321 and 347)	4882 B8T, B8TX, B8C and B8CX	Aa193/A320 B8T and B8C	4882 8T and 8C	A194 8T and 8C
-200	575	Austenitic Chromium Nickel 18/8 (Type 304)	4882 B8	A193/A320 B8	4882 8	A194 8
-200	600	Austenitic Chromium Nickel Molybdenum (Type 316)	4882 B8M	A193/A320 B8M	4882 8M	A194 8M
-200	600	Precipitation Hardening Austenitic Nickel Chromium	4882 B17B	-	4882 17B	-
-250	750	Precipitation Hardening Nickel Chromium Titanium Aluminium Alloy	4882 B08A	-	80A	-
AMBIENT		Austenitic Nickel Chromium Molybdenum Copper	-	B473 (UNS-N08020)	-	-
AMBIENT		Duplex Stainless Steel Higher Chromium	-	- (UNSS-S32550)	-	-
AMBIENT		Duplex Stainless Steel	-	A276 (UNS-S31803)	-	-
AMBIENT		Nickel Copper Alloy	3076 NA13	B164 (UNS-04400)	-	-
AMBIENT		Nickel Copper Alloy Precipitation Hardening	3076 NA18	- (SAE AMS 4676)	-	-

2. Hydraulic Bolt Tensioning

The following flange sizes, classes, services will normally be tensioned by a hydraulic bolt tensioning contractor:

Nominal Bolt	Diameter Condition
50mm and over	All joints.
38mm and over	(a) Class 600 and over. (b) Hydrogen Service. (c) Toxic Service.
25mm and over	(a) Joints subject to high temperature or cyclic duties. (b) Joints with a leakage history. (c) Joints where high integrity is required. (d) Other duties specified by BP.

3. Surface Finish Values for Tongue and Groove Small Male/Female and Ring Joint Facings

(Amends ANSI B16.5 - 1981, 6.3.4.2 and 6.3.4.3)

	Rz		Ra	
	Min. μm	**Max. μm**	**Min. μm**	**Max. μm**
Tongue and Groove: Small Male/Female	3.2	12.5	0.8	3.2
Ring Joint (including side walls)	1.6	6.3	0.4	1.6

4. Chemical Resistance - Selected Elastomers and Plastics

The following tables are only intended as guidance. Further specialised advice should be sought from your Engineering Department when assessing material suitability for a particular application.

Key to Performance:

Code	*Rating*	*Significance*
1	Good	Satisfactory performance in relatively high level of chemical.
2	Fair	Satisfactory only if low temperature and/ or low level of chemical.
3	Poor	Performance depends on required life and level of chemical.
4	Bad	No tolerance to chemical - DO NOT USE.
5	Unknown	No data available.

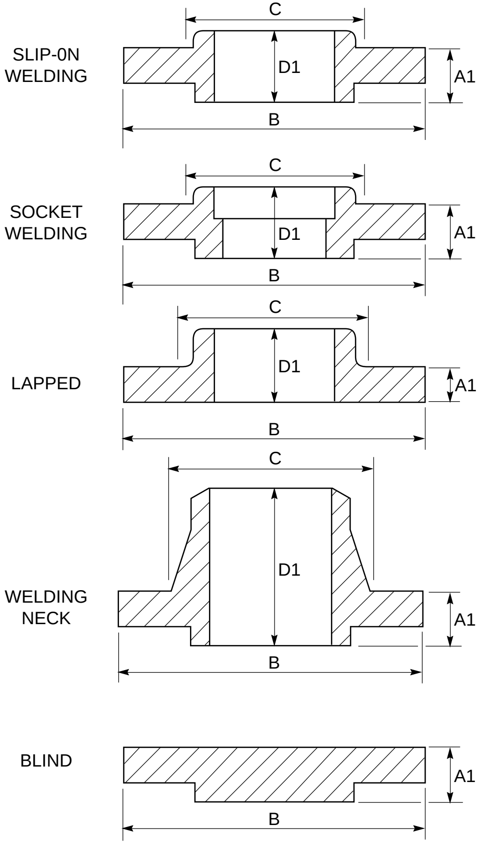
	ELASTOMERIC SEALING MATERIALS									**ENGINEERING PLASTIC BACK-UP MATERIALS**		
MATERIAL CODE **CHEMICAL NATURE** **TRADENAME**	**CR** **Polychloroprene Rubber** **NEOPRENE**	**AE/AU** **Polyurethane Rubber** **ADIPRENE**	**NBR** **Nitrile Rubber** **BUNA-N**	**ECO/CO** **Epichloro-hydrin** **HYDRIN**	**HNBR** **Hydrogenated Nitrile** **THERBAN**	**EPDM** **Ethylene-propylene-diene** **NORDEL**	**FKM** **VDF Fluoro-elastomer** **VITON**	**FCM** **TFE/P Fluoro-elastomer** **AFLAS**	**FFKM** **Perfluoro-elastomer** **CHEMBRAZ/KALREZ**	**ETFE** **E/TFE Fluoro-Polymer** **TEFZEL**	**PEEK** **Polyether-etherketone** **VICTREX**	**PTFE** **Polytetra-fluoroethylene** **TEFLON**
OIL Aliphatic Hydrocarbons	2	2	1	1	2	4	1	1	1	1	1	1
Aromatic Hydrocarbons	3	3	2	1	3	4	1	2	1	1	1	1
Crude Oil (< 120^{o}C)	2	2	1	1	2	4	1	2	1	1	1	1
Crude Oil (> 120^{o}C)	4	4	4	4	3	4	2	2	1	1	1	1
SOUR CRUDE OIL	3	3	2	3	2	4	2	2	2	1	1	1
SOUR NATURAL GAS	3	3	2	3	2	3	2	2	2	1	1	1
OIL BASED MUD	2	2	1	1	2	4	1	2	1	1	1	1
WATER BASED MUD	2	1	1	1	1	1	1	1	1	1	1	1
WATER	2	1	2	1	1	1	2	1	1	1	1	1
STEAM	3	3	3	2	1	1	1	1	1	1	1	1
INHIBITORS Amines	3	2	2	2	2	2	3	1	1	1	1	1
COMPLETION FLUIDS CaCl/CaBr	1	1	1	1	1	1	1	1	1	1	1	1
ZnBr	1	1	4	1	3	2	1	1	1	1	1	1
K2CO3	1	2	2	2	1	1	1	1	1	1	1	1
BRINE Seawater	2	4	1	1	1	1	1	1	1	1	1	1
CONTROL FLUIDS Mineral Oils	2	1	1	1	1	3	1	2	1	1	1	1
Glycol Based	1	2	1	1	1	1	1	1	1	1	1	1
ALCOHOLS Methanol	1	4	1	1	1	1	4	1	1	1	1	1
ACIDS HCl (dilute)	3	2	3	1	2	1	1	1	1	1	1	1
HCl (concentrated)	4	4	4	3	4	3	1	1	1	1	2	1
HF (< 65% cold)	1	5	3	5	3	1	1	1	1	1	2	1
Acetic Acid (Hot)	4	4	4	2	3	3	4	3	1	1	2	1
SURFACTANTS	2	4	1	5	3	1	1	1	1	1	1	1
CHLORINATED SOLVENTS	4	4	4	4	3	4	1	3	1	1	1	1
METHANE	2	2	1	1	1	4	1	1	1	1	1	1
CARBON DIOXIDE	2	1	1	1	1	2	2	2	1	1	1	1
H2S (< 80^{o}C and < 100 ppm)	1	3	2	2	1	1	2	1	1	1	1	1
H2S (> 150^{o}C and > 15%)	4	4	4	4	4	4	3	2	1	1	1	1
TEMPERATURE LIMITS												
Normal Low Temp Duty (^{o}C)	-45	-30	-30	-40	-25	-40	-20	10	0	-190	-190	-190
Normal High Temp Duty (^{o}C)	100	90	120	135	150	150	200	230	230	200	250	290

Appendix 2
Dimensional Data

1. ANSI B16.5 Basic Flange Dimensions.
2. ANSI B16.5 Flange Bolt Hole and Studbolt Dimensions.
3. ANSI B16.5 Ring Joint Facing and RTJ Gasket Dimensions.
4. Spades for RF Flanges.
5. Spades for RTJ Flanges.
6. Pipe Schedules.
7. ANSI B16.9 and ANSI B16.28 Butt Welding Elbows and Return Bends.
8. ANSI B16.9 Butt Welding Reducers, Tees, Lap Joint Stub Ends and Caps.
9. Weight of Welded and Seamless Pipe.
10. Table of Gauges.
11. Decimal Equivalents of Fractions.

1. ANSI B16.5 Basic Flange Dimensions

1.1 Basic Flange Dimensions for Classes 150 and 300



1.1.1 Basic Flange Dimensions for ANSI B16.5 Class 150

PIPE	Nominal Pipe Size	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
	Outside Diameter	27/32	1 3/64	1 5/16	1 29/32	2 3/8	3 1/2	4 1/2	6 5/8	8 5/8	10 3/4	12 3/4	14	16	18	20	24
FLANGE	Thickness A1	7/16	1/2	9/16	11/16	3/4	15/16	15/16	1	1 1/8	1 3/16	1 1/4	1 3/8	1 7/16	1 9/16	1 11/16	1 7/8
	Outside Diameter B	3 1/2	3 7/8	4 1/4	5	6	7 1/2	9	11	13 1/2	16	19	21	23 1/2	25	27 1/2	32
	Hub Diameter C	1 3/16	1 1/2	1 15/16	2 9/16	3 1/16	4 1/4	5 5/16	7 9/16	9 11/16	12	14 3/8	15 3/4	18	19 7/8	22	26 1/8
	LENGTH THRO' HUB D1 – Slip-On	5/8	5/8	11/16	7/8	1	1 3/16	1 5/16	1 9/16	1 3/4	1 15/16	2 3/16	2 1/4	2 1/2	2 11/16	2 7/8	3 1/4
	LENGTH THRO' HUB D1 – Lapped	5/8	5/8	11/16	7/8	1	1 3/16	1 5/16	1 9/16	1 3/4	1 15/16	2 3/16	3 1/8	3 7/16	3 13/16	4 1/16	4 3/8
	LENGTH THRO' HUB D1 – Weld Neck	1 7/8	2 1/16	2 3/16	2 7/16	2 1/2	2 3/4	3	3 1/2	4	4	4 1/2	5	5	5 1/2	5 11/16	6

NOTES:
(1) Socket weld flanges only specified for 1/2 to 3 inch N.B. Dimension D1 as for slip-on flanges.
(2) All dimensions in inches.
(3) Raised face thickness for RF flanges = 0.06 inch. See 5.3 for RTJ flanges.

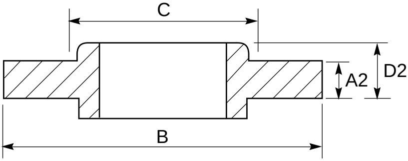
1.1.2 Basic Flange Dimensions for ANSI B16.5 Class 300

		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
PIPE	Nominal Pipe Size	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
PIPE	Outside Diameter	27/32	1 3/64	1 5/16	1 29/32	2 3/8	3 1/2	4 1/2	6 5/8	8 5/8	10 3/4	12 3/4	14	16	18	20	24
FLANGE	Thickness A1	9/16	5/8	11/16	13/16	7/8	1 1/8	1 1/4	1 7/16	1 5/8	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 3/4
FLANGE	Outside Diameter B	3 3/4	4 5/8	4 7/8	6 1/8	6 1/2	8 1/4	10	12 1/2	15	17 1/2	20 1/2	23	25 1/2	28	30 1/2	36
FLANGE	Hub Diameter C	1 1/2	1 7/8	2 1/8	2 3/4	3 5/16	4 5/8	5 3/4	8 1/8	10 1/4	12 5/8	14 3/4	16 3/4	19	21	23 1/8	27 5/8
FLANGE – LENGTH THRO' HUB D1	Slip-On	7/8	1	1 1/16	1 3/16	1 5/16	1 11/16	1 7/8	2 1/16	2 7/16	2 5/8	2 7/8	3	3 1/4	3 1/2	3 3/4	4 3/16
FLANGE – LENGTH THRO' HUB D1	Lapped	7/8	1	1 1/16	1 3/16	1 5/16	1 11/16	1 7/8	2 1/16	2 7/16	3 3/4	4	4 3/8	4 3/4	5 1/8	5 1/2	6
FLANGE – LENGTH THRO' HUB D1	Weld Neck	2 1/16	2 1/4	2 7/16	2 11/16	2 3/4	3 1/8	3 3/8	3 7/8	4 3/8	4 5/8	5 1/8	5 5/8	5 3/4	6 1/4	6 3/8	6 5/8

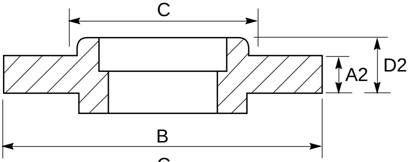
NOTES:
(1) Socket weld flanges only specified for 1/2 to 3 inch N.B. Dimension D1 as for slip-on flanges.
(2) All dimensions in inches.
(3) Raised face thickness for RF flanges = 0.06 inch. See 5.3 for RTJ flanges.

1.2 Basic Flange Dimensions for Classes 600 and Above

SLIP-0N
WELDING



SOCKET
WELDING



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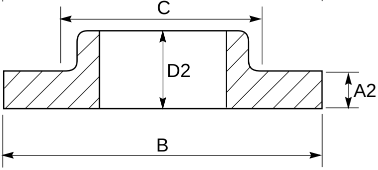
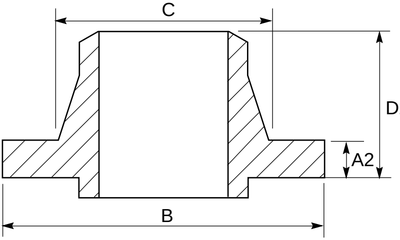


WELDING
NECK



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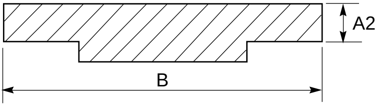


1.2.1 Basic Flange Dimensions for ANSI B16.5 Class 600

PIPE	Nominal Pipe Size	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
	Outside Diameter	27/32	1 3/64	1 5/16	1 29/32	2 3/8	3 1/2	4 1/2	6 5/8	8 5/8	10 3/4	12 3/4	14	16	18	20	24
FLANGE	Thickness A2	9/16	5/8	11/16	7/8	1	1 1/4	1 1/2	1 7/8	2 3/16	2 1/2	2 5/8	2 3/4	3	3 1/4	3 1/2	4
	Outside Diameter B	3 3/4	4 5/8	4 7/8	6 1/8	6 1/2	8 1/4	10 3/4	14	16 1/2	20	22	23 3/4	27	29 1/4	32	37
	Hub Diameter C	1 1/2	1 7/8	2 1/8	2 3/4	3 5/16	4 5/8	6	8 3/4	10 3/4	13 1/2	15 3/4	17	19 1/2	21 1/2	24	28 1/4
	LENGTH THRO' HUB D2 — Slip-On	7/8	1	1 1/16	1 1/4	1 7/16	1 13/16	2 1/8	2 5/8	3	3 3/8	3 5/8	3 11/16	4 3/16	4 5/8	5	5 1/2
	LENGTH THRO' HUB D2 — Lapped	7/8	1	1 1/16	1 1/4	1 7/16	1 13/16	2 1/8	2 5/8	3	4 3/8	4 5/8	5	5 1/2	6	6 1/2	7 1/4
	LENGTH THRO' HUB D2 — Weld Neck	2 1/16	2 1/4	2 7/16	2 3/4	2 7/8	3 1/4	4	4 5/8	5 1/4	6	6 1/8	6 1/2	7	7 1/4	7 1/2	8

NOTES:
(1) Socket weld flanges only specified for 1/2 to 3 inch N.B. Dimension D2 as for slip-on flanges.
(2) All dimensions in inches.
(3) Raised face thickness for RF flanges = 0.25 inch. See 5.3 for RTJ flanges.

1.2.2 Basic Flange Dimensions for ANSI B16.5 Class 900

		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
PIPE	Nominal Pipe Size	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
	Outside Diameter	27/32	1 3/64	1 5/16	1 29/32	2 3/8	3 1/2	4 1/2	6 5/8	8 5/8	10 3/4	12 3/4	14	16	18	20	24
FLANGE	Thickness A2	**USE CLASS 1500 DIMENSIONS IN THESE SIZES**					1 1/2	1 3/4	2 3/16	2 1/2	2 3/4	3 1/8	3 3/8	3 1/2	4	4 1/4	5 1/2
	Outside Diameter B						9 1/2	11 1/2	15	18 1/2	21 1/2	24	25 1/4	27 3/4	31	33 3/4	41
	Hub Diameter C						5	6 1/4	9 1/4	11 3/4	14 1/2	16 1/2	17 3/4	20	22 1/4	24 1/2	29 1/2
	LENGTH THRO' HUB D2: Slip-On						2 1/8	2 3/4	3 3/8	4	4 1/4	4 5/8	5 1/8	5 1/4	6	6 1/4	8
	LENGTH THRO' HUB D2: Lapped						2 1/8	2 3/4	3 3/8	4 1/2	5	5 5/8	6 1/8	6 1/2	7 1/2	8 1/4	10 1/2
	LENGTH THRO' HUB D2: Weld Neck						4	4 1/2	5 1/2	6 3/8	7 1/4	7 7/8	8 3/8	8 1/2	9	9 3/4	11 1/2

NOTES:
(1) Socket weld flanges only specified for 1/2 to 3 inch N.B. Dimension D2 as for Class 1500 slip-on flanges.
(2) All dimensions in inches.
(3) Raised face thickness for RF flanges = 0.25 inch. See 5.3 for RTJ flanges.

1.2.3 Basic Flange Dimensions for ANSI B16.5 Class 1500

PIPE: Nominal Pipe Size	PIPE: Outside Diameter	FLANGE: Thickness A2	FLANGE: Outside Diameter B	FLANGE: Hub Diameter C	FLANGE: Length Thro' Hub D2: Slip-On	FLANGE: Length Thro' Hub D2: Lapped	FLANGE: Length Thro' Hub D2: Weld Neck
1/2	27/32	7/8	4 3/4	1 1/2	1 1/4	1 1/4	2 3/8
3/4	1 3/64	1	5 1/8	1 3/4	1 3/8	1 3/8	2 3/4
1	1 5/16	1 1/8	5 7/8	2 1/16	1 5/8	1 5/8	2 7/8
1 1/2	1 29/32	1 1/4	7	2 3/4	1 3/4	1 3/4	3 1/4
2	2 3/8	1 1/2	8 1/2	4 1/8	2 1/4	2 1/4	4
3	3 1/2	1 7/8	10 1/2	5 1/4	NOT SPECIFIED FOR CLASS 1500	2 7/8	4 5/8
4	4 1/2	2 1/8	12 1/4	6 3/8		3 9/16	4 7/8
6	6 5/8	3 1/4	15 1/2	9		4 11/16	6 3/4
8	8 5/8	3 5/8	19	11 1/2		5 5/8	8 3/8
10	10 3/4	4 1/4	23	14 1/2		7	10
12	12 3/4	4 7/8	26 1/2	17 3/4		8 5/8	11 1/8
14	14	5 1/4	29 1/2	19 1/2		9 1/2	11 3/4
16	16	5 3/4	32 1/2	21 3/4		10 1/4	12 1/4
18	18	6 3/8	36	23 1/2		10 7/8	12 7/8
20	20	7	38 3/4	25 1/4		11 1/2	14
24	24	8	46	30		13	16

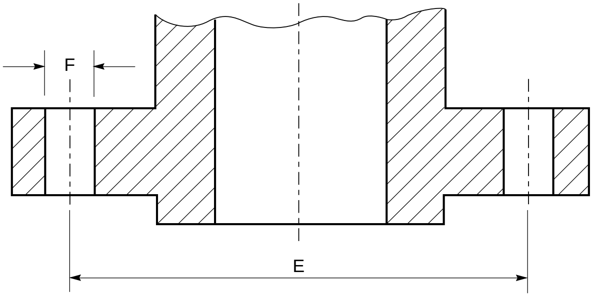
NOTES:
(1) Socket weld flanges only specified for 1/2 to 3 inch N.B. Dimension D2 as for slip-on flanges.
(2) All dimensions in inches.
(3) Raised face thickness for RF flanges = 0.25 inch. See 5.3 for RTJ flanges.

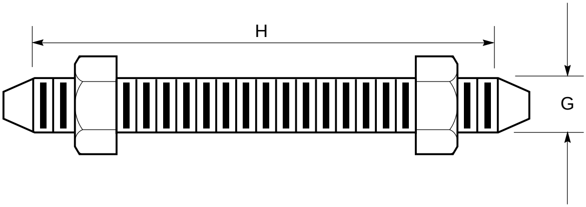
1.2.4 Basic Flange Dimensions for ANSI B16.5 Class 2500

PIPE	Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
	Outside Diameter		27/32	1 3/64	1 5/16	1 29/32	2 3/8	3 1/2	4 1/2	6 5/8	8 5/8	10 3/4	12 3/4	CLASS 2500 FLANGES NOT SPECIFIED IN THESE SIZES				
FLANGE	Thickness	A2	1 3/16	1 1/4	1 3/8	1 3/4	2	2 5/8	3	4 1/4	5	6 1/2	7 1/4					
	Outside Diameter	B	5 1/4	5 1/2	6 1/4	8	9 1/4	12	14	19	21 3/4	26 1/2	30					
	Hub Diameter	C	1 11/16	2	2 1/4	3 1/8	3 3/4	5 1/4	6 1/2	9 1/4	12	14 3/4	17 3/8					
	LENGTH THRO' HUB D2	Slip-On	NOT SPECIFIED FOR CLASS 2500															
		Lapped	1 9/16	1 11/16	1 7/8	2 3/8	2 3/4	3 5/8	4 1/4	6	7	9	10					
		Weld Neck	2 7/8	3 1/8	3 1/2	4 3/8	5	6 5/8	7 1/2	10 3/4	12 1/2	16 1/2	18 1/4					

NOTES:
(1) Socket weld flanges not specified in Class 2500.
(2) All dimensions in inches.
(3) Raised face thickness for RF flanges = 0.25 inch. See 5.3 for RTJ flanges.

2. ANSI B16.5 Flange Bolt Hole and Stud Bolt Dimensions





2.1 Flange Bolt Hole and Stud Bolt Dimensions for ANSI B16.5 Class 150

Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
Diameter of Bolt Circle (PCD) E		2 3/8	2 3/4	3 1/8	3 7/8	4 3/4	6	7 1/2	9 1/2	11 3/4	14 1/4	17	18 3/4	21 1/4	22 3/4	25	29 1/2
Diameter of Bolt Holes F		5/8	5/8	5/8	5/8	3/4	3/4	3/4	7/8	7/8	1	1	1 1/8	1 1/8	1 1/4	1 1/4	1 3/8
Diameter of Bolts G		1/2	1/2	1/2	1/2	5/8	5/8	5/8	3/4	3/4	7/8	7/8	1	1	1 1/8	1 1/8	1 1/4
LENGTH OF STUDBOLTS H	0.06 inch Raised Face Flange	2 1/4	2 1/2	2 1/2	2 3/4	3 1/4	3 1/2	3 1/2	4	4 1/4	4 1/2	4 3/4	5 1/4	5 1/4	5 3/4	6 1/4	6 3/4
	Ring Joint Flange	-	-	3	3 1/4	3 3/4	4	4	4 1/2	4 3/4	5	5 1/4	5 3/4	5 3/4	6 1/4	6 3/4	7 1/4
Number of Bolts		4	4	4	4	4	4	8	8	8	12	12	12	16	16	20	20

NOTE: (1) All dimensions in inches.

2.2 Flange Bolt Hole and Stud Bolt Dimensions for ANSI B16.5 Class 300

Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
Diameter of Bolt Circle (PCD) E		2 5/8	3 1/4	3 1/2	4 1/2	5	6 5/8	7 7/8	10 5/8	13	15 1/4	17 3/4	20 1/4	22 1/2	24 3/4	27	32
Diameter of Bolt Holes F		5/8	3/4	3/4	7/8	3/4	7/8	7/8	7/8	1	1 1/8	1 1/4	1 1/4	1 3/8	1 3/8	1 3/8	1 5/8
Diameter of Bolts G		1/2	5/8	5/8	3/4	5/8	3/4	3/4	3/4	7/8	1	1 1/8	1 1/8	1 1/4	1 1/4	1 1/4	1 1/2
LENGTH OF STUDBOLTS H	0.06 inch Raised Face Flange	2 1/2	3	3	3 1/2	3 1/2	4 1/4	4 1/2	4 3/4	5 1/2	6 1/4	6 3/4	7	7 1/2	7 3/4	8	9
	Ring Joint Flange	3	3 1/2	3 1/2	4	4	4 3/4	5	5 1/2	6	6 3/4	7 1/4	7 1/2	8	8 1/4	8 3/4	10
Number of Bolts		4	4	4	4	8	8	8	12	12	16	16	20	20	24	24	24

NOTE: (1) All dimensions in inches.

2.3 Flange Bolt Hole and Stud Bolt Dimensions for ANSI B16.5 Class 600

Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
Diameter of Bolt Circle (PCD) E		2 5/8	3 1/4	3 1/2	4 1/2	5	6 5/8	8 1/2	11 1/2	13 3/4	17	19 1/4	20 3/4	23 3/4	25 3/4	28 1/2	33
Diameter of Bolt Holes F		5/8	3/4	3/4	7/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 3/8	1 1/2	1 5/8	1 3/4	1 3/4	2
Diameter of Bolts G		1/2	5/8	5/8	3/4	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/4	1 3/8	1 1/2	1 5/8	1 5/8	1 7/8
LENGTH OF STUDBOLTS H	0.25 inch Raised Face Flange	3	3 1/2	3 1/2	4 1/4	4 1/4	5	5 3/4	6 3/4	7 1/2	8 1/2	8 3/4	9 1/4	10	10 3/4	11 1/4	13
	Ring Joint Flange	3	3 1/2	3 1/2	4 1/4	4 1/4	5	5 3/4	6 3/4	7 3/4	8 1/2	8 3/4	9 1/4	10	10 3/4	11 1/2	13 1/4
Number of Bolts		4	4	4	4	8	8	8	12	12	16	20	20	20	20	24	24

NOTE: (1) All dimensions in inches.

2.4 Flange Bolt Hole and Stud Bolt Dimensions for ANSI B16.5 Class 900

Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
Diameter of Bolt Circle (PCD) E		USE CLASS 1500 DIMENSIONS IN THESE SIZES					7 1/2	9 1/4	12 1/2	15 1/2	18 1/2	21	22	24 1/4	27	29 1/2	35 1/2
Diameter of Bolt Holes F							1	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 5/8	1 3/4	2	2 1/8	2 5/8
Diameter of Bolts G							7/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 1/2	1 5/8	1 7/8	2	2 1/2
Length of Studbolts H	0.25 inch Raised Face Flange						5 3/4	6 3/4	7 1/2	8 3/4	9 1/4	10	10 3/4	11 1/4	12 3/4	13 3/4	17 1/4
	Ring Joint Flange						5 3/4	6 3/4	7 3/4	8 3/4	9 1/4	10	11	11 1/2	13 1/4	14 1/4	18
Number of Bolts							8	8	12	12	16	20	20	20	20	20	20

NOTE: (1) All dimensions in inches.

2.5 Flange Bolt Hole and Stud Bolt Dimensions for ANSI B16.5 Class 1500

Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
Diameter of Bolt Circle (PCD) E		3 1/4	3 1/2	4	4 7/8	6 1/2	8	9 1/2	12 1/2	15 1/2	19	22 1/2	25	27 3/4	30 1/2	32 3/4	39
Diameter of Bolt Holes F		7/8	7/8	1	1 1/8	1	1 1/4	1 3/8	1 1/2	1 3/4	2	2 1/8	2 3/8	2 5/8	2 7/8	3 1/8	3 5/8
Diameter of Bolts G		3/4	3/4	7/8	1	7/8	1 1/8	1 1/4	1 3/8	1 5/8	1 7/8	2	2 1/4	2 1/2	2 3/4	3	3 1/2
LENGTH OF STUDBOLTS H	0.25 inch Raised Face Flange	4 1/4	4 1/2	5	5 1/2	5 3/4	7	7 3/4	10 1/4	11 1/2	13 1/4	14 3/4	16	17 1/2	19 1/2	21 1/4	24 1/4
	Ring Joint Flange	4 1/4	4 1/2	5	5 1/2	5 3/4	7	7 3/4	10 1/2	12 3/4	13 1/2	15 1/4	16 1/4	18 1/2	20 3/4	22 1/4	25 1/2
Number of Bolts		4	4	4	4	8	8	8	12	12	12	16	16	16	16	16	16

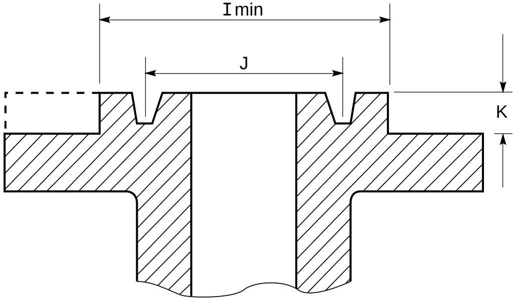
NOTE: (1) All dimensions in inches.

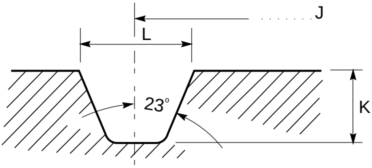
2.6 Flange Bolt Hole and Stud Bolt Dimensions for ANSI B16.5 Class 2500

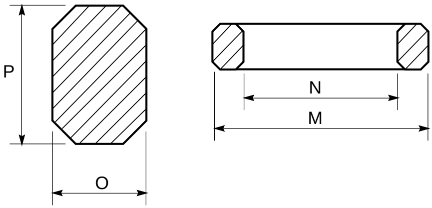
Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
Diameter of Bolt Circle (PCD) E		3 1/2	3 3/4	4 1/4	5 3/4	6 3/4	9	10 3/4	14 1/2	17 1/4	21 1/4	24 3/8	CLASS 2500 FLANGES NOT SPECIFIED IN THESE SIZES				
Diameter of Bolt Holes F		7/8	7/8	1	1 1/4	1 1/8	1 3/8	1 5/8	2 1/8	2 1/8	2 5/8	2 7/8					
Diameter of Bolts G		3/4	3/4	7/8	1 1/8	1	1 1/4	1 1/2	2	2	2 1/2	2 3/4					
LENGTH OF STUDBOLTS H	0.25 inch Raised Face Flange	4 3/4	5	5 1/2	6 3/4	7	8 3/4	10	13 1/2	15	19 1/4	21 1/4					
	Ring Joint Flange	4 3/4	5	5 1/2	6 3/4	7	9	10 1/4	14	15 1/2	20	22					
Number of Bolts		4	4	4	4	8	8	8	8	12	12	12					

NOTE: (1) All dimensions in inches.

3. Ring Joint Facing and RTJ Gasket Dimensions







R TYPE
RING TYPE JOINT
(OCTAGONAL)

3.1 Ring Joint Facing and RTJ Gasket Dimensions for ANSI B16.5 Class 150

		Nominal Pipe Size	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
FLANGE GROOVE	Diameter of Raised Section	I	CLASS 150 FLANGES NOT SPECIFIED IN THESE SIZES		2 1/2	3 1/4	4	5 1/4	6 3/4	8 5/8	10 3/4	13	16	16 3/4	19	21 1/2	23 1/2	28
	Groove Pitch Diameter	J			1 7/8	2 9/16	3 1/4	4 1/2	5 7/8	7 5/8	9 3/4	12	15	15 5/8	17 7/8	20 3/8	22	26 1/2
	Depth of Groove	K			1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
	Width	L			11/32	11/32	11/32	11/32	11/32	11/32	11/32	11/32	11/32	11/32	11/32	11/32	11/32	11/32
OCTAGONAL RING TYPE JOINT GASKET	Outside Diameter	M			2 3/16	2 7/8	3 9/16	4 13/16	6 3/16	7 15/16	10 1/16	12 5/16	15 5/16	15 15/16	18 3/16	20 11/16	22 5/16	26 13/16
	Inside Diameter	N			1 9/16	2 1/4	2 15/16	4 3/16	5 9/16	7 5/16	9 7/16	11 11/16	14 11/16	15 5/16	17 9/16	20 1/16	21 11/16	26 3/16
	Width	O			5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
	Thickness	P			1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
	R Number				15	19	22	29	36	43	48	52	56	59	64	68	72	76

NOTE: (1) All dimensions in inches.
(2) Ring dimensions as per ANSI B16.20.

3.2 Ring Joint Facing and RTJ Gasket Dimensions for ANSI B16.5 Class 300

			1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
Nominal Pipe Size			1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
FLANGE GROOVE	Diameter of Raised Section	I	2	2 1/2	2 3/4	3 9/16	4 1/4	5 3/4	6 7/8	9 1/2	11 7/8	14	16 1/4	18	20	22 5/8	25	29 1/2
	Groove Pitch Diameter	J	1 11/32	1 11/16	2	2 11/16	3 1/4	4 7/8	5 7/8	8 5/16	10 5/8	12 3/4	15	16 1/2	18 1/2	21	23	27 1/4
	Depth of Groove	K	7/32	1/4	1/4	1/4	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	3/8	7/16
	Width	L	9/32	11/32	11/32	11/32	15/32	15/32	15/32	15/32	15/32	15/32	15/32	15/32	15/32	15/32	17/32	21/32
OCTAGONAL RING TYPE JOINT GASKET	Outside Diameter	M	1 19/32	2	2 5/16	3	3 11/16	5 5/16	6 5/16	8 3/4	11 1/16	13 3/16	15 7/16	16 15/16	18 15/16	21 7/16	23 1/2	27 7/8
	Inside Diameter	N	1 3/32	1 3/8	1 11/16	2 3/8	2 13/16	4 7/16	5 7/16	7 7/8	10 3/16	12 5/16	14 9/16	16 1/16	18 1/16	20 9/16	22 1/2	26 5/8
	Width	O	1/4	5/16	5/16	5/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	1/2	5/8
	Thickness	P	3/8	1/2	1/2	1/2	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	11/16	13/16
	R Number		11	13	16	20	23	31	37	45	49	53	57	61	65	69	73	77

NOTE: (1) All dimensions in inches.
(2) Ring dimensions as per ANSI B16.20.

3.3 Ring Joint Facing and RTJ Gasket Dimensions for ANSI B16.5 Class 600

	Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
FLANGE GROOVE	Diameter of Raised Section	I	2	2 1/4	2 3/4	3 9/16	4 1/4	5 3/4	6 7/8	9 1/2	11 7/8	14	16 1/4	18	20	22 5/8	25	29 1/2
	Groove Pitch Diameter	J	1 11/32	1 11/16	2	2 11/16	3 1/4	4 7/8	5 7/8	8 5/16	10 5/8	12 3/4	15	16 1/2	18 1/2	21	23	27 1/4
	Depth of Groove	K	7/32	1/4	1/4	1/4	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	3/8	7/16
	Width	L	9/32	11/32	11/32	11/32	15/32	15/32	15/32	15/32	15/32	15/32	15/32	15/32	15/32	15/32	17/32	21/32
OCTAGONAL RING TYPE JOINT GASKET	Outside Diameter	M	1 19/32	2	2 5/16	3	3 11/16	5 5/16	6 5/16	8 3/4	11 1/16	13 3/16	15 7/16	16 15/16	18 15/16	21 7/16	23 1/2	27 7/8
	Inside Diameter	N	1 3/32	1 3/8	1 11/16	2 3/8	2 13/16	4 7/16	5 7/16	7 7/8	10 3/16	12 5/16	14 9/16	16 1/16	18 1/16	20 9/16	22 1/2	26 5/8
	Width	O	1/4	5/16	5/16	5/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	1/2	5/8
	Thickness	P	3/8	1/2	1/2	1/2	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	11/16	13/16
	R Number		11	13	16	20	23	31	37	45	49	53	57	61	65	69	73	77

NOTE: (1) All dimensions in inches.
(2) Ring dimensions as per ANSI B16.20.

3.4 Ring Joint Facing and RTJ Gasket Dimensions for ANSI B16.5 Class 900

Group	Nominal Pipe Size		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
FLANGE GROOVE	Diameter of Raised Section	I	USE CLASS 1500 DIMENSIONS IN THESE SIZES					6 1/8	7 1/8	9 1/2	12 1/8	14 1/4	16 1/2	18 3/8	20 5/8	23 3/8	25 1/2	30 3/8
	Groove Pitch Diameter	J						4 7/8	5 7/8	8 5/16	10 5/8	12 3/4	15	16 1/2	18 1/2	21	23	27 1/4
	Depth of Groove	K						5/16	5/16	5/16	5/16	5/16	5/16	7/16	7/16	1/2	1/2	5/8
	Width	L						15/32	15/32	15/32	15/32	15/32	15/32	21/32	21/32	25/32	25/32	1 1/16
OCTAGONAL RING TYPE JOINT GASKET	Outside Diameter	M						5 5/16	6 5/16	8 3/4	11 1/16	13 3/16	15 7/16	17 1/8	19 1/8	21 3/4	23 3/4	28 1/4
	Inside Diameter	N						4 7/16	5 7/16	7 7/8	10 3/16	12 5/16	14 9/16	15 7/8	17 7/8	20 1/4	22 1/4	26 1/4
	Width	O						7/16	7/16	7/16	7/16	7/16	7/16	5/8	5/8	3/4	3/4	1
	Thickness	P						5/8	5/8	5/8	5/8	5/8	5/8	13/16	13/16	15/16	15/16	1 1/4
	R Number							31	37	45	49	53	57	62	66	70	74	78

NOTE: (1) All dimensions in inches.
(2) Ring dimensions as per ANSI B16.20.

3.5 Ring Joint Facing and RTJ Gasket Dimensions for ANSI B16.5 Class 1500

		Nominal Pipe Size	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
FLANGE GROOVE	Diameter of Raised Section	I	2 3/8	2 5/8	2 13/16	3 5/8	4 7/8	6 5/8	7 5/8	9 3/4	12 1/2	14 5/8	17 1/4	19 1/4	21 1/2	24 1/8	26 1/2	31 1/4
	Groove Pitch Diameter	J	1 9/16	1 3/4	2	2 11/16	3 3/4	5 3/8	6 3/8	8 5/16	10 5/8	12 3/4	15	16 1/2	18 1/2	21	23	27 1/4
	Depth of Groove	K	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	7/16	7/16	9/16	5/8	11/16	11/16	11/16	13/16
	Width	L	11/32	11/32	11/32	11/32	15/32	15/32	15/32	17/32	21/32	21/32	29/32	1 1/16	1 3/16	1 3/16	1 5/16	1 7/16
OCTAGONAL RING TYPE JOINT GASKET	Outside Diameter	M	1 7/8	2 1/16	2 5/16	3	4 3/16	5 13/16	6 13/16	8 13/16	11 1/4	13 3/8	15 7/8	17 1/2	19 5/8	22 1/8	24 1/4	28 5/8
	Inside Diameter	N	1 1/4	1 7/16	1 11/16	2 3/8	3 5/16	4 15/16	5 15/16	7 13/16	10	12 1/8	14 1/8	15 1/2	17 3/8	19 7/8	21 3/4	25 7/8
	Width	O	5/16	5/16	5/16	5/16	7/16	7/16	7/16	1/2	5/8	5/8	7/8	1	1 1/8	1 1/8	1 1/4	1 3/8
	Thickness	P	1/2	1/2	1/2	1/2	5/8	5/8	5/8	11/16	13/16	13/16	1 1/16	1 1/4	1 3/8	1 3/8	1 1/2	1 5/8
	R Number		12	14	16	20	24	35	39	46	50	54	58	63	67	71	75	79

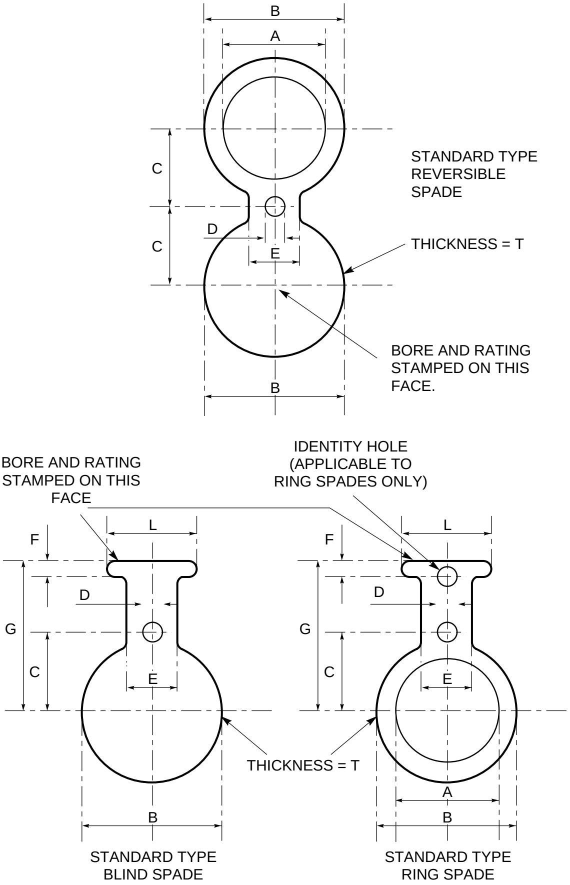
NOTE: (1) All dimensions in inches.
(2) Ring dimensions as per ANSI B16.20.

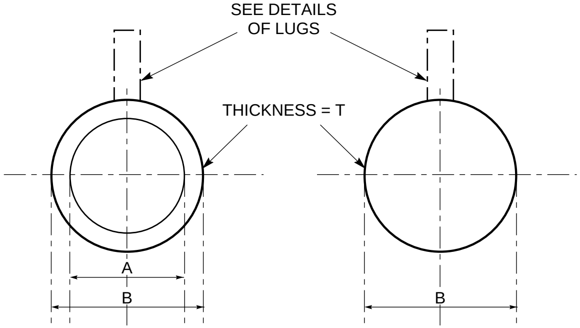
3.6 Ring Joint Facing and RTJ Gasket Dimensions for ANSI B16.5 Class 2500

		Nominal Pipe Size	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
FLANGE GROOVE	Diameter of Raised Section	I	2 9/16	2 7/8	3 1/4	4 1/2	5 1/4	6 5/8	8	11	13 3/8	16 3/4	19 1/2	CLASS 2500 FLANGES NOT SPECIFIED IN THESE SIZES				
	Groove Pitch Diameter	J	1 11/16	2	2 3/8	3 1/4	4	5	6 3/16	9	11	13 1/2	16					
	Depth of Groove	K	1/4	1/4	1/4	5/16	5/16	3/8	7/16	1/2	9/16	11/16	11/16					
	Width	L	11/32	11/32	11/32	15/32	15/32	17/32	21/32	25/32	29/32	1 3/16	1 5/16					
OCTAGONAL RING TYPE JOINT GASKET	Outside Diameter	M	2	2 5/16	2 11/16	3 11/16	4 7/16	5 1/2	6 13/16	9 3/4	11 7/8	14 5/8	17 1/4					
	Inside Diameter	N	1 3/8	1 11/16	2 1/16	2 13/16	3 9/16	4 1/2	5 9/16	8 1/4	10 1/8	12 3/8	14 3/4					
	Width	O	5/16	5/16	5/16	7/16	7/16	1/2	5/8	3/4	7/8	1 1/8	1 1/4					
	Thickness	P	1/2	1/2	1/2	5/8	5/8	11/16	13/16	15/16	1 1/16	1 3/8	1 1/2					
	R Number		13	16	18	23	26	32	38	47	51	55	60					

NOTE: (1) All dimensions in inches.
(2) Ring dimensions as per ANSI B16.20.

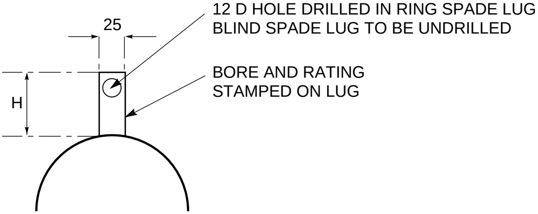
4. Spades for Raised Face Flanges to Suit ANSI B16.5



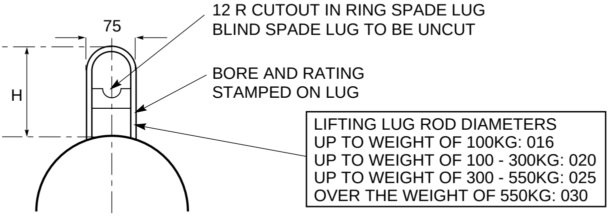


ALTERNATIVE TYPE
OF RING SPADE

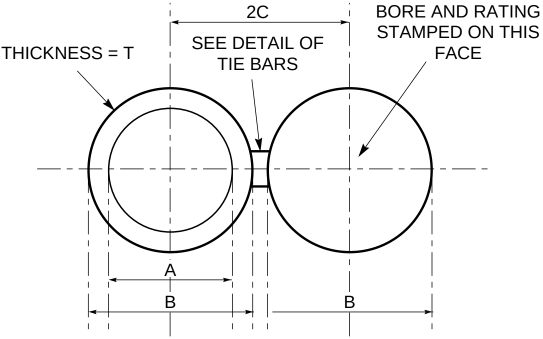
ALTERNATIVE TYPE
OF BLIND SPADE



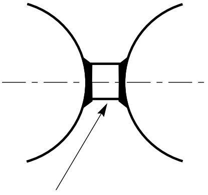
DETAIL OF LUG FOR RING AND SPADES - 22KG AND UNDER



DETAIL OF LUG FOR RING AND BLIND SPADES - 22KG

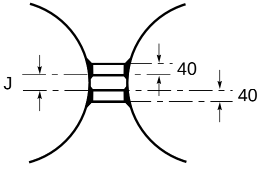


ALTERNATIVE TYPE
REVERSIBLE SPADE

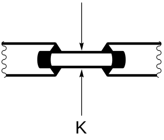


TIE BAR 25x6 THICK
FOR REVERSIBLE
SPADES WEIGHING 12KG
AND UNDER

AND 40x10 THICK FOR
REVERSIBLE SPADES
WEIGHING 45KG AND UNDER



TIE BAR FOR REVERSIBLE
SPADES WEIGHING OVER 45KG



4.1 Spades for Raised Face Flanges to Suit ANSI B16.5 Class 150

Pipe Size	CLASS 150														
	DIMENSIONS (MM)												WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	L	T	Ring	Blind	Rev
1	28	64	40	16	38	20	95	150	-	-	100	6.5	0.25	0.28	0.3
1 1/2	40	82	49	16	38	20	100	150	-	-	100	6.5	0.32	0.39	0.5
2	54	102	60	20	45	22	130	150	-	-	100	6.5	0.44	0.55	0.73
3	80	135	76	20	50	22	160	158	-	-	100	6.5	0.68	0.95	1.14
4	108	172	95	20	50	22	180	158	-	-	100	9.5	1.4	2.08	2.8
6	158	220	121	22	75	25	220	158	-	-	150	13	2.6	4.62	5.5
8	210	275	149	22	75	25	250	165	-	-	150	13	3.4	6.8	8.6
10	260	335	181	25	100	32	300	165	-	-	200	16	6.4	14.3	17.2
12	310	405	216	25	100	32	350	165	-	-	200	19	10.4	22	27.7
14	340	445	238	30	100	38	380	172	-	-	200	22	14.5	31	39.5
16	390	510	270	30	100	38	420	172	40	12	200	22	17.7	39	46.3
18	440	545	289	32	100	45	450	172	40	16	200	25	19.9	51	63.5
20	500	605	318	32	100	45	500	178	40	16	200	28	26.3	70	86
24	600	715	375	35	100	50	560	178	45	20	200	35	39.5	118	144

NOTE: (1) Dimensions from BP Standard Drawing S-0755M.

4.2 Spades for Raised Face Flanges to Suit ANSI B16.5 Class 300

Pipe Size	CLASS 300														
	DIMENSIONS (MM)											WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	L	T	Ring	Blind	Rev
1	28	70	44	20	50	20	100	158	-	-	100	6.5	0.3	0.33	0.36
1½	40	92	57	22	50	22	130	158	-	-	100	6.5	0.5	0.58	0.64
2	54	108	64	20	50	22	130	158	-	-	100	9.5	0.86	1.04	1.25
3	80	145	84	22	50	25	150	158	-	-	100	9.5	1.27	1.63	2.15
4	108	178	100	22	50	25	180	165	-	-	100	13	2.09	3.0	4.0
6	158	248	135	22	75	25	220	165	-	-	150	16	4.63	7.0	10
8	210	304	165	25	75	25	250	165	-	-	150	22	8.16	14.3	20
10	260	360	194	30	100	32	300	172	-	-	200	25	12.7	23	30
12	310	420	225	32	100	32	360	178	-	-	200	28	17.7	35	45
14	340	480	257	32	100	38	380	178	40	20	200	32	26.8	50	68
16	390	535	286	35	100	38	440	185	45	20	200	38	37.6	73	100
18	440	595	314	35	100	45	480	190	45	22	200	42	48.5	99	130
20	500	650	343	35	100	45	540	190	45	25	200	44	58	127	167
24	600	770	405	42	100	50	600	205	50	28	200	54	91	201	280

NOTE: (1) Dimensions from BP Standard Drawing S-0755M.

4.3 Spades for Raised Face Flanges to Suit ANSI B16.5 Class 600

Pipe Size	CLASS 600														
	DIMENSIONS (MM)												WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	L	T	Ring	Blind	Rev
1	28	70	44	20	50	20	100	158	-	-	100	6.5	0.3	0.33	0.36
1½	40	92	57	22	50	22	130	158	-	-	100	9.5	0.63	0.73	0.9
2	54	108	64	20	50	22	130	158	-	-	100	9.5	0.82	1.0	1.2
3	80	145	84	22	50	25	165	158	-	-	100	13	1.6	1.9	2.9
4	108	190	105	25	50	25	200	172	-	-	100	16	2.9	3.8	5.2
6	158	265	146	30	75	32	250	178	-	-	150	22	7.2	10	15.6
8	210	318	175	32	75	32	280	178	-	-	150	28	10.8	18.4	28.5
10	260	395	216	35	100	38	340	185	35	20	200	35	20.9	37	54.4
12	310	455	245	35	100	38	380	185	35	22	200	42	29.9	54	80
14	340	490	264	38	100	45	440	185	45	22	200	44	38.1	71	100
16	390	560	302	42	100	45	480	190	50	25	200	50	55.8	105	150
18	440	610	327	45	100	50	500	198	50	28	200	58	68	139	195
20	500	680	362	45	100	60	580	198	50	32	200	64	89	188	270
24	600	785	420	50	100	60	640	205	58	40	200	74	128	291	403

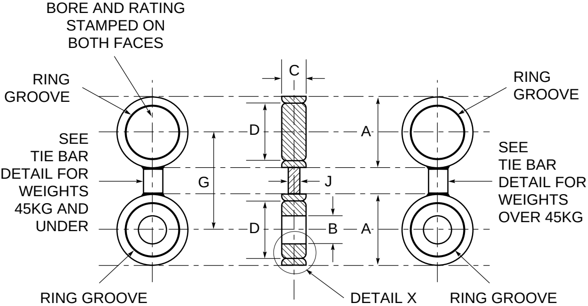
NOTE: (1) Dimensions from BP Standard Drawing S-0755M.

4.4 Spades for Raised Face Flanges to Suit ANSI B16.5 Class 900

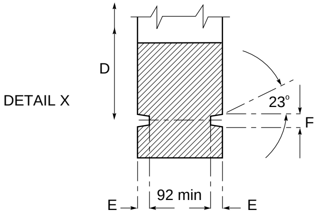
Pipe Size	CLASS 900														
	DIMENSIONS (MM)												WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	L	T	Ring	Blind	Rev
1	32	76	51	25	75	25	130	165	-	-	150	7	0.4	0.5	0.6
$1\frac{1}{2}$	48	95	62	28	75	28	145	170	-	-	150	9	0.6	0.8	0.9
2	60	140	83	25	75	25	160	170	-	-	150	10	1.2	1.8	2.1
3	89	165	95	25	75	25	180	175	-	-	150	15	2.5	3.1	4.2
4	114	203	118	32	75	32	210	180	-	-	150	20	4.7	6.3	8.2
6	168	286	159	32	75	32	270	200	-	-	150	30	12	17	23
8	219	355	197	38	100	32	320	200	-	-	200	35	21	32	33
10	273	431	235	38	100	38	380	220	48	20	200	44	30	55	67
12	324	495	267	38	100	38	420	220	48	22	200	50	52	85	102
14	355	517	279	41	125	45	450	240	51	25	250	55	70	112	129
16	406	571	308	45	125	45	490	240	55	30	250	63	73	135	169
18	457	635	343	50	125	50	530	250	60	35	250	70	97	185	240
20	508	695	374	54	125	60	580	250	70	35	250	78	172	248	282
24	609	835	451	67	170	70	680	260	80	40	320	94	218	426	560

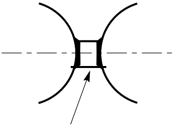
NOTE: (1) Dimensions from BP Standard Drawing S-0756M.

5. Spades for Ring Type Joint Flanges to Suit ANSI B16.5



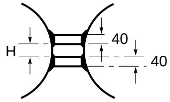
REVERSIBLE SPADE



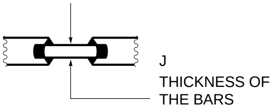


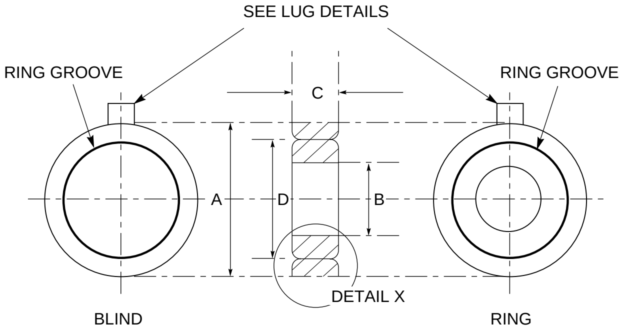
TIE BAR 25x6 THICK
FOR REVERSIBLE
SPADES WEIGHING 12KG
AND UNDER

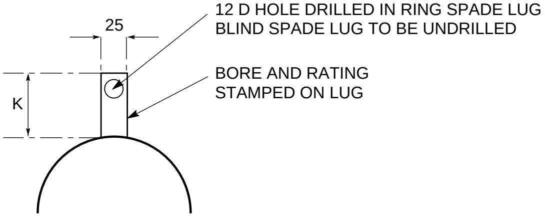
AND TIE BAR 40x10 THICK
FOR REVERSIBLE SPADES
WEIGHING 45KG AND UNDER



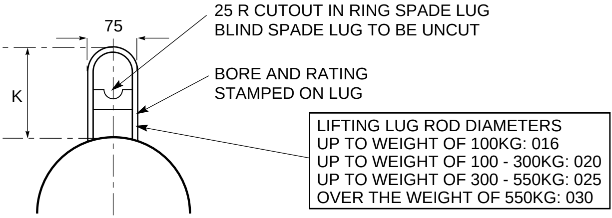
TIE BAR FOR REVERSIBLE
SPADES WEIGHING OVER 45KG







DETAIL OF LUG FOR RING AND SPADES - 22KG AND UNDER



DETAIL OF LUG FOR RING AND BLIND SPADES - 22KG

5.1 Spades for Ring Type Joint Flanges to Suit ANSI B16.5 Class 300

Pipe Size	CLASS 300												
	DIMENSIONS (MM)										WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	Ring	Blind	Rev
1	70	25	22	50.8	6.4	8.7	115	-	6	158	0.6	0.7	1.2
1½	90	40	22	68.3	6.4	8.7	140	-	6	158	0.9	1.1	2
2	110	55	25	82.6	7.9	11.9	150	-	6	158	1.4	2.0	3.5
3	145	80	25	123.8	7.9	11.9	190	-	10	158	2.4	3.3	5.5
4	175	105	26	149.2	7.9	11.9	230	-	10	165	3.3	5	8
6	240	155	34	211.1	7.9	11.9	290	-	10	165	7.1	12	19
8	300	205	36	269.9	7.9	11.9	355	-	15	165	10.7	20	30.5
10	355	260	40	323.8	7.9	11.9	420	30	15	172	16.4	32	48.5
12	415	310	45	381.0	7.9	11.9	480	40	15	178	21.7	48	70
14	455	335	48	419.1	7.9	11.9	535	40	20	178	28.2	61.5	90
16	510	385	52	469.9	7.9	11.9	600	40	20	185	34.2	83	120
18	575	440	58	533.4	7.9	11.9	660	40	25	190	48.8	177	166
20	635	490	64	584.2	9.5	13.5	725	40	25	190	64.8	158	225
24	750	590	76	692.2	11.1	16.7	850	45	30	205	101	264	369

NOTE: (1) Dimensions from BP Standard Drawing S-1243M.

5.2 Spades for Ring Type Joint Flanges to Suit ANSI B16.5 Class 600

Pipe Size	CLASS 600												
	DIMENSIONS (MM)										WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	Ring	Blind	Rev
1	70	25	22	50.8	6.4	8.7	115	-	6	158	0.6	0.7	1.2
1 1/2	90	40	25	68.3	6.4	8.7	140	-	6	158	1.1	1.3	2.3
2	110	55	27	82.6	7.9	11.9	150	-	6	158	1.4	2	3.5
3	145	80	32	123.8	7.9	11.9	190	-	10	158	2.5	4.6	7
4	175	105	34	149.2	7.9	11.9	245	-	10	172	4.15	6.4	10.5
6	240	155	44	211.1	7.9	11.9	320	-	10	178	9.1	15.4	24.5
8	300	205	50	269.9	7.9	11.9	370	-	15	178	14.9	28.6	40.5
10	355	260	56	323.8	7.9	11.9	445	40	15	185	17.4	42.6	60.5
12	415	310	62	381.0	7.9	11.9	495	40	20	185	28.4	64	93
14	455	335	66	419.1	7.9	11.9	545	45	20	185	46.2	85.2	132
16	510	385	73	469.9	7.9	11.9	610	45	20	200	48	115	165
18	575	440	80	533.4	7.9	11.9	675	50	25	205	67	161	228
20	635	490	89	584.2	9.5	13.5	735	50	25	205	88.5	220	310
24	750	590	104	692.2	11.1	16.7	865	55	40	220	150	360	512

NOTE: (1) Dimensions from BP Standard Drawing S-1243M.

5.3 Spades for Ring Type Joint Flanges to Suit ANSI B16.5 Class 900

Pipe Size	CLASS 900												
	DIMENSIONS (MM)										WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	Ring	Blind	Rev
1	70	25	22	50.8	6.4	8.7	125	-	6	158	0.6	0.7	1.2
1 1/2	90	40	25	68.2	6.4	8.7	150	-	6	158	1.07	1.38	2.5
2	125	50	32	95.2	7.9	11.9	190	-	6	158	2.5	2.88	5.4
3	155	75	38	123.8	7.9	11.9	215	-	10	158	4.3	5.55	9.9
4	180	100	41	149.2	7.9	11.9	255	-	10	172	7.9	8.25	16.2
6	240	150	50	211.1	7.9	11.9	330	-	10	185	12.8	18.3	30
8	310	195	60	269.9	7.9	11.9	405	45	15	185	23.2	35.4	60
10	350	245	66	323.8	7.9	11.9	470	45	20	200	29.5	49.5	84.5
12	420	290	76	381.0	7.9	11.9	535	45	20	205	42.4	83	126
14	465	320	89	419.2	11.1	16.7	570	45	25	205	58.8	118	180
16	525	365	95	469.8	11.1	16.7	635	50	25	205	76.5	160	238
18	595	415	108	533.4	12.7	19.8	710	55	25	215	124	238	364
20	650	455	114	584.2	12.7	19.8	760	55	40	215	147	300	448
24	770	560	132	692.2	15.9	27	915	55	40	240	245	514	760

NOTE: (1) Dimensions from BP Standard Drawing S-1243M.

5.4 Spades for Ring Type Joint Flanges to Suit ANSI B16.5 Class 1500

Pipe Size	CLASS 1500												
	DIMENSIONS (MM)										WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	Ring	Blind	Rev
1	70	25	24	50.8	6.4	8.7	125	-	6	158	0.64	0.74	1.3
$1\frac{1}{2}$	90	40	27	68.2	6.4	8.7	150	-	6	158	1.1	1.4	2.6
2	125	50	35	95.2	7.9	11.9	190	-	6	158	2.74	3.3	5.1
3	170	75	43	136.5	7.9	11.9	230	-	10	158	5.86	7.38	13.4
4	195	100	48	161.9	7.9	11.9	265	-	10	172	8.24	10.86	19.3
6	250	150	60	211.1	9.5	13.5	345	-	10	178	14.6	22.9	37.7
8	315	195	75	269.9	11.1	16.7	420	50	20	190	28.35	46.1	75
10	370	245	84	323.8	11.1	16.7	510	55	20	205	40	69.6	111
12	440	290	101	381.0	14.3	23	595	55	25	205	65.7	118.8	187
14	490	310	111	419.1	15.9	27	660	65	25	230	96.4	162.5	261
16	545	360	124	469.9	17.5	30.2	735	70	30	230	126.8	226.2	356
18	610	410	136	533.4	17.5	30.2	785	75	30	250	171.5	313.9	489
20	675	465	145	584.2	17.5	33.3	865	85	40	260	213.1	405.5	523
24	795	565	173	692.2	20.6	36.5	1015	95	40	285	329.3	667.6	1002

NOTE: (1) Dimensions from BP Standard Drawing S-1243M.

5.5 Spades for Ring Type Joint Flanges to Suit ANSI B16.5 Class 2500

Pipe Size	CLASS 2500												
	DIMENSIONS (MM)										WEIGHT (KG)		
NPS	A	B	C	D	E	F	G	H	J	K	Ring	Blind	Rev
1	85	25	29	60.4	6.4	8.7	140	-	6	158	1.1	1.2	2.3
$1^1/_2$	115	35	37	82.5	7.9	11.9	180	-	6	158	2.65	2.9	5.6
2	135	45	41	101.5	7.9	11.9	205	-	6	158	4	4.5	8.5
3	170	70	51	127.0	9.5	13.4	255	-	10	158	7.3	8.82	16.3
4	205	90	62	157.2	11.1	16.6	305	-	10	172	12.54	15.7	28.6
6	280	135	81	228.6	12.7	19.8	395	60	15	178	30	38.7	69
8	340	160	97	279.4	14.3	23.0	455	60	20	178	53.5	68.5	123
10	425	210	118	342.9	17.5	30.1	560	70	25	185	98.6	130.2	230
12	495	260	133	406.4	17.5	33.3	650	75	30	185	145	200.3	348

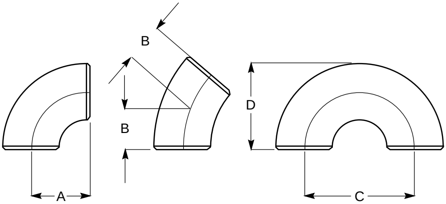
NOTE: (1) Dimensions from BP Standard Drawing S-1243M.

6. Normal Wall Thickness for Pipe Schedule Sizes

Nominal Pipe Size	Outside Diameter	SCH 5	SCH 10	SCH 20	SCH 30	SCH 40	SCH	SCH 60	SCH 80	SCH XS	SCH 100	SCH 120	SCH 140	SCH 160	SCH XXS
3.17mm 1/8"	10.3mm .405"					1.73 .068	1.73 .068		2.41 .095	2.41 .095					
6.35mm 1/4"	13.7mm .540"	1.20 .049	1.72 .065			2.24 .088	2.24 .088		3.02 .119	3.02 .119					
9.52mm 3/8"	21.3mm .840"	1.20 .049	1.72 .065			2.31 .091	2.31 .091		3.20 .126	3.20 .126					
12.7mm 1/2"	10.3mm .405"	1.72 .065	2.11 .083			2.77 .109	2.77 .109		3.73 .147	3.73 .147				4.78 .187	7.47 .294
19.1mm 3/4"	26.7mm 1.050"	1.72 .065	2.11 .083			2.87 .113	2.87 .113		3.91 .154	3.91 .154				5.54 .218	7.82 .308
25.4mm 1"	33.4mm 1.315"	1.72 .065	2.77 .109			3.38 .133	3.38 .133		4.55 .179	4.55 .179				6.35 .250	9.09 .358
31.8mm 1 1/4"	42.2mm 1.660"	1.72 .065	2.77 .109			3.56 .140	3.56 .140		4.85 .191	4.85 .191				6.35 .250	9.70 .382
38.1mm 1 1/2"	48.3mm 1.900"	1.72 .065	2.77 .109			3.68 .145	3.68 .145		5.08 .200	5.08 .200				7.1 .281	10.16 .400
50.8mm 2"	60.3mm 2.375"	1.72 .065	2.77 .109			3.91 .154	3.91 .154		5.54 .218	5.54 .218				8.74 .343	11.07 .436
63.5mm 2 1/2"	73.0mm 2.875"	2.11 .083	3.04 .120			5.16 .203	5.16 .203		7.01 .276	7.01 .276				9.52 .375	14.02 .552
76.1mm 3"	88.9mm 3.500"	2.11 .083	3.04 .120			5.49 .216	5.49 .216		7.62 .300	7.62 .300				11.13 .438	15.24 .600
88.9mm 3 1/2"	101.6mm 4.000"	2.11 .083	3.04 .120			5.70 .226	5.70 .226		8.10 .318	8.10 .318					15.91 .636
101.6mm 4"	114.3mm 4.500"	2.11 .083	3.04 .120			6.02 .237	6.02 .237	7.1 .281	8.56 .337	8.56 .337		11.13 .438		13.49 .531	17.12 .674

Nominal Pipe Size	Outside Diameter	SCH 5	SCH 10	SCH 20	SCH 30	SCH 40	SCH	SCH 60	SCH 80	SCH XS	SCH 100	SCH 120	SCH 140	SCH 160	SCH XXS
127.0mm 5"	141.3mm 5.563"	2.77 .109	3.38 .134			6.55 .258	6.55 .258		9.52 .375	9.52 .375		12.7 .500		15.88 .625	19.1 .750
152.4mm 6"	168.3mm 6.625"	2.77 .109	3.38 .134			7.11 .280	7.11 .280		10.97 .432	10.97 .432		14.28 .562		18.26 .718	21.95 .864
203.2mm 8"	219.1mm 8.625"	2.77 .109	3.73 .148	6.35 .250	7.04 .277	8.18 .322	8.18 .322	10.31 .406	12.7 .500	12.7 .500	15.08 .593	18.26 .718	20.63 .812	23.0 .906	22.22 .875
254.0mm 10"	273.0mm 10.750"	3.38 .134	4.08 .165	6.35 .250	7.80 .307	9.27 .365	9.27 .365	12.7 .500	15.08 .593	12.7 .500	18.26 .718	21.43 .843	25.4 1.000	28.58 1.125	25.4 1.000
304.8mm 12"	323.9mm 12.750"	3.96 .156	4.55 .180	6.35 .250	8.38 .330	10.31 .406	9.52 .375	14.28 .562	17.48 .687	12.7 .500	21.43 .843	25.4 1.000	25.58 1.125	32.0 1.312	25.4 1.000
355.6mm 14"	355.6mm 14"		6.35 .250	8.0 .312	9.52 .375	11.07 .437	9.52 .375	15.08 .593	19.1 .750	12.7 .500	23.8 .937	27.0 1.093	31.75 1.250	35.71 1.406	
406.4mm 16"	406.4mm 16"		6.35 .250	8.0 .312	9.52 .375	12.7 .500	9.52 .375	16.66 .656	21.4 .843	12.7 .500	26.19 1.031	30.95 1.218	36.51 1.437	40.48 1.593	
457.2mm 18"	457.2mm 18"		6.35 .250	8.0 .312	11.07 .437	14.28 .562	9.52 .375	19.1 .750	23.8 .937	12.7 .500	29.3 1.156	34.92 1.375	39.6 1.562	45.24 1.781	
508.0mm 20"	508.0mm 20"		6.35 .250	9.52 .375	12.7 .500	15.08 .593	9.52 .375	20.62 .812	26.19 1.031	12.7 .500	32.51 1.280	38.1 1.500	44.5 1.750	50.0 1.968	
609.6mm 24"	609.6mm 24"		6.35 .250	9.52 .375	14.28 .562	17.48 .687	9.52 .375	24.6 .968	30.95 1.218	12.7 .500	38.89 1.531	46.03 1.812	52.38 2.062	59.53 2.343	
762.0mm 30"	762.0mm 30"	6.35 .250	8.0 .312	12.7 .500	15.88 .625		9.52 .375			12.7 .500					
914.4mm 36"	914.4mm 36"		8.0 .312	12.7 .500	15.88 .625	19.1 .750	9.52 .375			12.7 .500					

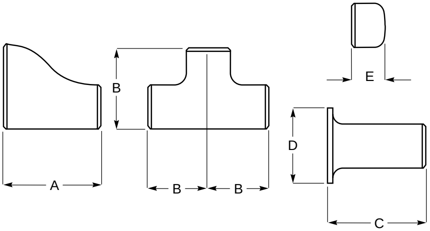
7. Butt Welding Elbows and Return Bends to ANSI B16.9 and ANSI B16.28



Nom. Bore	90° Elbow		45° Elbow	Return Bend			
	Centre to End A		Centre to End B	Centre to Centre C		Back to Face D	
	Short Radius	Long Radius	Long Radius	Short Radius	Long Radius	Short Radius	Long Radius
1/2	-	1 1/2	5/8	-	3	-	1 7/8
3/4	-	1 1/8	7/16	-	2 1/4	-	1 11/16
1	1	1 1/2	7/8	2	3	1 5/8	1 3/16
1 1/2	1 1/2	2 1/4	1 1/8	3	4 1/2	2 7/16	3 1/4
2	2	3	1 3/8	4	6	3 3/16	4 3/16
3	3	4 1/2	2	6	9	4 3/4	6 1/4
4	4	6	2 1/2	8	12	6 1/4	8 1/4
6	6	9	3 3/4	12	18	9 5/16	12 5/16
8	8	12	5	16	24	12 5/16	16 5/16
10	10	15	6 1/4	20	30	15 3/8	20 3/8
12	12	18	7 1/2	24	36	18 3/8	24 3/8
14	14	21	8 3/4	28	42	21	28
16	16	24	10	32	48	24	32
18	18	27	11 1/4	36	54	27	36
20	20	30	12 1/2	40	60	30	40
24	24	36	15	48	72	36	48

Notes: (1) Long radius elbows and return bends to ANSI B16.9.
(2) Short radius elbows and return bends to ANSI B16.28.
(3) All dimensions in inches.

8. Butt Welding Reducers, Tees, Lap Joint Stub Ends and Caps to ANSI B16.9



Nom. Bore	Reducers	Tees	Lap Joint Stub Ends		Caps		
	A	B	C	D	E	W.T. Limit for E	E1
1/2	-	1	3	1 3/8	1	0.18	1
3/4	1 1/2	1 1/8	3	1 11/16	1	0.15	1
1	2	1 1/2	4	2	1 1/2	0.18	1 1/2
1 1/2	2 1/2	2 1/4	4	2 7/8	1 1/2	0.22	1 1/2
2	3	2 1/2	6	3 5/8	1 1/2	0.22	1 3/4
3	3 1/2	3 3/8	6	5	2	0.3	2 1/2
4	4	4 1/8	6	6 3/16	2 1/2	0.34	3
6	5 1/2	5 5/8	8	8 1/2	3 1/2	0.43	4
8	6	7	8	10 5/8	4	0.5	5
10	7	8 1/2	10	12 3/4	5	0.5	6
12	8	10	10	15	6	0.5	7
14	13	11	12	16 1/4	6 1/2	0.5	7 1/2
16	14	12	12	18 1/2	7	0.5	8
18	15	13 1/2	12	21	8	0.5	9
20	20	15	12	23	9	0.5	10
24	20	17	12	27 1/4	10 1/2	0.5	12

Notes: (1) All dimensions to ANSI B16.9.
(2) All dimensions in inches.
(3) Use E for wall thicknesses less than the "W.T. Limit for E" and E1 for wall thicknesses greater than "W.T. Limit for E".

9. Welded and Seamless Pipe, BS 1600

Nom. Bore	WEIGHT - POUNDS/FOOT							
	SCH 30	SCH 40	SCH 60	SCH 80	SCH 100	SCH 120	SCH 140	SCH 160
1/2	-	0.9	-	1.1	-	-	-	1.3
3/4	-	1.1	-	1.5	-	-	-	1.9
1	-	1.7	-	2.2	-	-	-	2.8
1 1/2	-	2.7	-	3.6	-	-	-	4.9
2	-	3.6	-	5.0	-	-	-	7.5
3	-	7.6	-	10.2	-	-	-	14.3
4	-	10.8	-	15.0	-	19.0	-	22.5
6	-	19.0	-	28.6	-	36.4	-	45.3
8	24.7	28.6	35.7	43.4	50.9	60.7	67.8	74.7
10	34.2	40.5	54.7	64.4	77.0	89.3	104.1	115.7
12	43.8	53.6	73.2	88.6	107.3	125.5	139.7	160.3
14	54.6	63.4	85.0	106.1	130.8	150.8	170.2	189.2
16	62.6	82.8	107.5	136.6	164.9	192.4	223.6	245.2
18	82.1	104.8	138.2	170.8	208.1	244.1	274.3	308.6
20	104.1	123.0	166.5	208.9	256.2	296.4	341.1	379.1
24	140.8	171.2	238.3	296.5	302.9	429.5	483.2	542.1

10. Table of Gauges

Gauge No.	Imperial Standard		Birmingham Wire & Stubs		Gauge No.	Imperial Standard		Birmingham Wire & Stubs	
	IN	MM	IN	MM		IN	MM	IN	MM
4/0	.400	10.160	.454	11.530	**23**	.024	0.609	.025	0.635
3/0	.372	9.448	.425	10.795	**24**	.022	0.558	.022	0.558
2/0	.348	8.839	.380	9.852	**25**	.020	0.508	.020	0.508
0	.324	8.229	.340	8.636	**26**	.018	0.457	.018	0.457
1	.300	7.620	.300	7.620	**27**	.0164	0.416	.016	0.406
2	.276	7.010	.284	7.213	**28**	.0148	0.375	.014	0.355
3	.252	6.400	.259	6.578	**29**	.0136	0.345	.013	0.330
4	.232	5.892	.238	6.045	**30**	.0124	0.314	.012	0.304
5	.212	5.384	.220	5.588	**31**	.0116	0.294	.010	0.254
6	.192	4.876	.203	5.156	**32**	.0108	0.274	.009	0.228
7	.176	4.470	.180	4.572	**33**	.0100	0.254	.008	0.203
8	.160	4.064	.165	4.190	**34**	.0092	0.233	.007	0.177
9	.144	3.657	.148	3.759	**35**	.0084	0.213	.005	0.127
10	.128	3.251	.134	3.403	**36**	.0076	0.193	.004	0.101
11	.116	2.946	.120	3.048	**37**	.0068	0.172	-	-
12	.104	2.640	.109	2.769	**38**	.0060	0.152	-	-
13	.092	2.336	.095	2.413	**39**	.0052	0.132	-	-
14	.080	2.032	.083	2.108	**40**	.0048	0.121	-	-
15	.072	1.828	.072	1.828	**41**	.0044	0.111	-	-
16	.064	1.625	.065	1.651	**42**	.0040	0.101	-	-
17	.056	1.422	.058	1.473	**43**	.0036	0.091	-	-
18	.048	1.219	.049	1.244	**44**	.0032	0.081	-	-
19	.040	1.016	.042	1.066	**45**	.0028	0.071	-	-
20	.036	0.914	.035	0.880	**46**	.0024	0.060	-	-
21	.032	0.812	.032	0.812	**47**	.0020	0.050	-	-
22	.028	0.711	.028	0.711	**48**	.0016	0.040	-	-

11. Decimal Equivalents of Fractions

Fraction	Decimal	Fraction	Decimal	Fraction	Decimal	Fraction	Decimal
1/64	.015625	17/64	.265625	33/64	.515625	49/64	.765625
1/32	.03125	9/32	.28125	17/32	.53125	25/32	.78125
3/64	.046875	19/64	.296875	35/64	.546875	51/64	.796875
1/16	.0625	5/16	.3125	9/16	.5625	13/16	.8125
5/64	.078125	21/64	.328125	37/64	.578125	53/64	.828125
3/32	.09375	11/32	.34375	19/32	.59375	27/32	.84375
7/64	.109375	23/64	.359375	39/64	.609375	55/64	.859375
1/8	.125	3/8	.375	5/8	.625	7/8	.875
9/64	.140625	25/64	.390625	41/64	.640625	57/64	.890625
5/32	.15625	13/32	.40625	21/32	.65625	29/32	.90625
11/64	.171875	27/64	.421875	43/64	.671875	59/64	.921875
3/16	.1875	7/16	.4375	11/16	.6875	15/16	.9375
13/64	.203125	29/64	.453125	45/64	.703125	61/64	.953125
7/32	.21875	15/32	.46875	23/32	.71875	31/32	.96875
15/64	.234375	31/64	.484375	47/64	.734375	63/64	.984375
1/4	.25	1/2	.5	3/4	.75	1	1.0