Ideal® vacuum

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COMMON VACUUM FITTINGS AND CONNECTIONS

SELECTION & ASSEMBLY GUIDE

CF (ConFlat) Flanges

KF (QF) Flanges

ISO-K Flanges

ISO-F Flanges

ASA/ANSI Flanges

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1. INTRODUCTION

The design of a vacuum system includes the selection of vacuum components, fittings, and seals, appropriate for the intended application. The proper assembly of vacuum connections is crucial to how well the system performs. Poorly sealed connections allow vacuum leaks. Leaks cause a vacuum system to be slow or fail to achieve ultimate vacuum pressure. They can cause chamber contamination, botched experiments, component failures, and can be a cause of great frustration in troubleshooting efforts.

The purpose of this document is to provide the system designer or operator with general knowledge about the most common fittings used to connect vacuum equipment together. This information is useful for selecting appropriate parts when designing a new system or for identifying parts of an existing system. Flanged fittings, assembled with some combination of bolts and/or clamps, are found in every industrial vacuum system today. The four most common flange types are CF (Conflat), KF, ISO, and ASA/ANSI. For each of these, naming conventions, vacuum ranges, size ranges, and typical applications are discussed. Additionally, proper assembly techniques are presented to help the user make consistent and reliable leak-free vacuum connections.

This document does not supply a comprehensive list of all fittings and seals available, nor does it address all possible flange or seal variants. Please visit idealvac.com for specific parts. For selection or fitment questions, please contact Ideal Vacuum customer service.

When working with any vacuum equipment, read all manuals and follow all safety procedures. Only trained personnel, wearing appropriate protective equipment, should operate vacuum equipment.

2. MATERIALS - FITTINGS AND SEALS

Materials used in vacuum systems are selected for very low rates of permeation or outgassing, and for tolerance to bakeout temperatures, if needed. Materials to avoid include cadmium, zinc, brass, magnesium, paints, lead, antimony, and most plastics.

The most common material used in vacuum systems is 304 stainless steel which is corrosion resistant to many materials. Grade 316 stainless steel is used in food-grade systems since it is more resistant to chlorides (such as salt). Other materials, such as aluminum, nickel, glass, and exotic metals, are used when the process uses or creates chemicals harmful to stainless steels.

Fittings are sealed with either elastomer O-rings, or soft metal gaskets. O-rings are available in a variety of materials, each with different performance characteristics. Viton® (FKM) is the most popular O-ring seal material used in rough vacuum systems and is rated for high vacuum to 1×10^{-8} Torr. Viton is chemical and compression set resistant and has a (continuous) working temperature range of approximately -20°C to +150°C (-4°F to +300°F). The permeability of Viton and other elastomers does not allow them to be used for ultra-high vacuum applications. Kalrez® and other perfluorocarbon (FFKM) O-ring materials are used when superior chemical or temperature resistance is needed. Vacuum grease is not normally used on fixed O-rings.

Soft metal sealing gaskets may be used for high vacuum and are required for ultra-high vacuum applications. Ordinarily, copper gaskets are used and can tolerate temperatures to 450°C. Aluminum, silver- or gold-plated copper, or solid silver and gold gaskets are more oxidation-resistant gasket options.

Please also see *Technical Considerations in Selecting Vacuum Equipment for Chemical Processes.*

3. TYPES OF FITTINGS

The information provided here is for vacuum use only (atmospheric pressure and lower), even though some fittings can also be used for over pressure (pressures above atmosphere). If the system can or will be operated at pressures over ambient atmosphere, please contact Ideal vacuum customer service for solutions.

Flanged fittings are used to provide ports in chambers or anywhere semi-permanent connections are needed to join system parts and components (i.e., pumps, chambers, valves, gauges, and sensors). There are numerous, readily available flanged fittings. Sometimes it is necessary to weld flanges onto tubes to make the necessary parts. Welds must be leak free and should be tested with a leak detector.

The most common flange types used for vacuum systems are CF, KF, ISO, and ASA/ANSI. All follow strict ISO (International Organization for Standardization) standards so that similar parts can be interchanged between manufacturers. CF and ISO/KF flange types are the most widely used in today's vacuum systems.

The flange type and size needed depends on the desired vacuum level and the evacuation or pump down speed required. Each flange size has a nominal tube size to which it can be welded. The tube size dictates the maximum gas conductance and speed.

Table 1, below, shows a generalized flange selection matrix. There may be more than one flange type and size that suits a given scenario. Fittings on existing equipment, cost, availability, and ease of use might be important selection factors.

Tube Size	Maximum Vacuum Level		
	Ultra-High Vacuum (UHV) ($<10^{-8}$ to 10^{-13} Torr)	High Vacuum (HV) (10^{-3} to 10^{-8} Torr)	Medium to Rough Vacuum (760 to 10^{-3} Torr)
Small (≤ 2")	CF	KF	KF
Large (> 2")	CF	ISO, ASA/ANSI	ISO, ASA/ANSI
Seal Material	Metal Gasket	Elastomer O-Ring	Elastomer O-Ring

Table 1 - Flange type, tube size, seal material, and vacuum range

For all vacuum connections, cleanliness is vital. A clean environment, the use of gloves, proper clothing, and clean parts minimize potential leak and contamination issues. All parts should be cleaned with isopropyl alcohol (IPA) or acetone before assembly. To acheive higher vacuum faster, chambers and other parts may be heated under vacuum to remove water and contaminants (baked out). Bakeout temperature is limited by the seals and other materials in the system.

When a vacuum connection is disassembled for any reason, it is best to replace rather than reuse O-rings, even though they might be reusable. For ultra-high vacuum connections, metal gaskets must always be replaced as they will not reseal.

4. FASTENING BOLTED FLANGES

Vacuum fittings are fastened with a variety of clamps and/or bolts. The specific fastening hardware needed depends on the type of flange and the joint configuration. Specific joining methods and hardware for each flange type are described and illustrated in succeeding chapters.

Many vacuum flanges have bolt holes for fastening. Bolt holes can be smooth bored (with through holes), or threaded. This makes a difference in the length of the fastener used. For all joints with smooth bored flanges, hardware sets have bolts, washers, and nuts. When one flange has threaded bolt holes, bolts are passed through the smooth bored flange and tightened in the opposing threaded hole flange. Nuts are not used. Two threaded hole flanges cannot be mated.

For all bolted flange configurations, it is crucial to tighten bolts gradually and equally around the flange so that the flanges are brought together parallel to each other. A “star” or “cross” pattern of tightening is used. This is similar to tightening the lug nuts on a car. This simply means tightening opposing bolts while working around the flange. The higher the vacuum, the more important it is to use the proper tightening technique. When fittings are improperly tightened, seals get damaged and the liklihood of achieving a leak-proof seal is significantly reduced.

Bolts are all started and made hand tight initially. Then, using a torque wrench, bolts are each tightened by 1/8 to 1/4 turn until each bolt receives the correct torque. This can take as many as 8 or 10 “passes” around the tightening pattern. Finally, going in order one bolt at a time around the flange, each bolt is checked for proper torque. Tightening below or beyond the correct torque specification can cause an imperfect seal and create a vacuum leak.

Figures 1 and 2, below, illustrate two examples of the star tightening pattern.

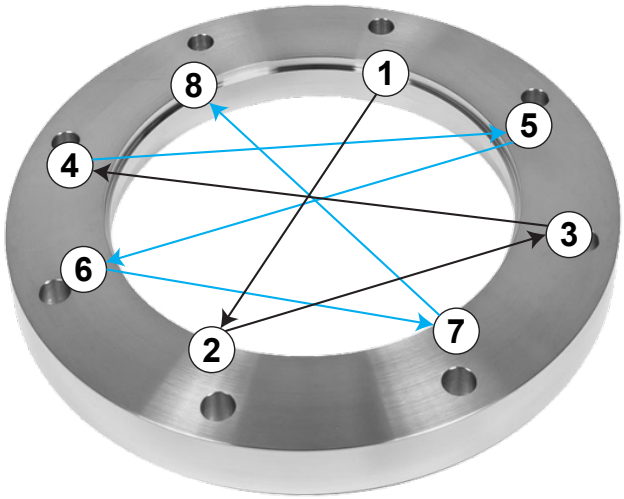

Figure 1 - 8 hole tightening pattern (ISO-F)

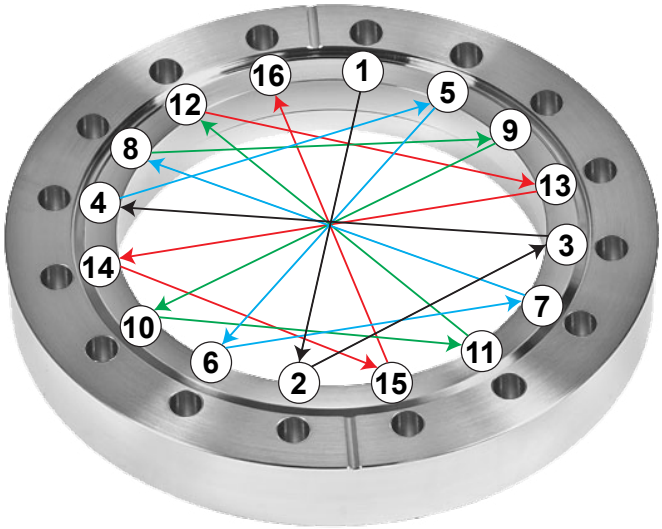

Figure 2 - 16 hole tightening pattern (CF)

5. CF (CONFLAT) FITTINGS - OVERVIEW

CF flanged fittings, also known as Conflat fittings, can be used for high vacuum (HV) and are the only available standard fittings rated for ultra-high vacuum (UHV) applications. CF flanges bolt together and have good structural strength.

CF flanges are normally sealed with soft metal gaskets (i.e., copper, silver, gold) and connections can achieve UHV as low as 1 x 10^{-13} Torr using OHFC (oxygen-free high thermal conductivity) copper gaskets and given a correctly cleaned, baked, and pumped chamber.They are commonly used when a more permanent seal is needed. CF fittings with metal gaskets can withstand temperatures as low as -196°C and bakeout temperatures up to 450°C.

When maximum vacuum isn't needed, or when the connection is temporary, these flanges can be sealed with O-rings. If Viton O-ring seals are used, base vacuum levels are limited to the 10^{-8} Torr range (HV) due to O-ring permeability, and bakeout temperatures should not exceed 150°C.

CF flanges have knife edges machined slightly below the flange's flat face and same sized flanges are joined with bolts. As the flange bolts are tightened, the knife edges cut into a soft metal gasket or O-ring placed between the two flanges. This causes the soft gasket material to deform and fill minute imperfections in the flanges. This creates an extremely leak-tight seal. Once used, metal gaskets are permanently deformed and therefore cannot be reused.

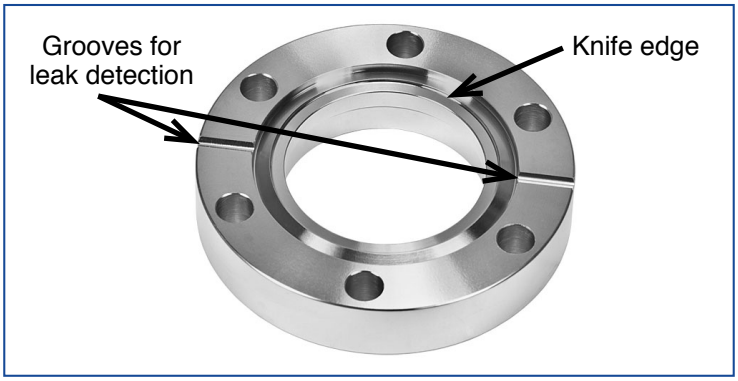

Figure 3 - Smooth bored CF flange face showing knife edge

CF flanges have either threaded or smooth bored bolt holes. Figure 4, below, illustrates the flange connection when both flanges have through holes, and when one flange has threaded holes. Flat washers are used on bolt heads and under nuts. Lock washers are not used.

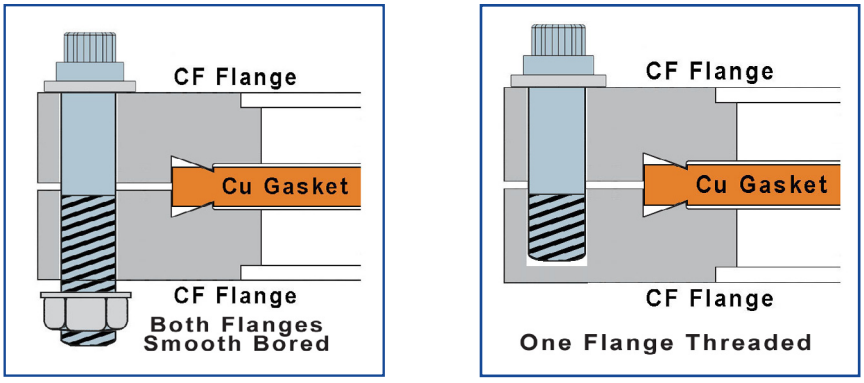

Figure 4 - CF connections with smooth bored and threaded flanges

To achieve ultra-high vacuum, CF fittings are often subjected to repeated bakeout cycles at high temperatures. Stainless steel hex or socket head screws with anti-seize compound, or 12 point silver-plated bolts are used so that they do not seize and become impossible to unscrew. Common 12 point box end wrenches are used to tighten 12 point bolts.

When joining a pair of smooth bored CF flanges, through bolts, washers, and nuts or platenuts (metal plates with two threaded holes) are used (Figure 5).

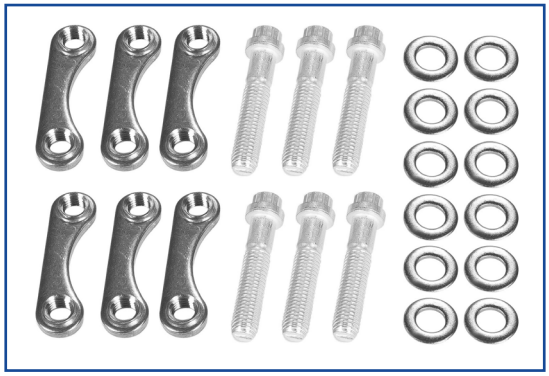

Figure 5 - CF smooth bored bolt kit with platenuts and silver-plated 12 point bolts

When possible, use smooth bored CF flanges and platenuts. Then, only one wrench is needed to tighten the bolts and platenut clearance is half that of a regular nut. Smooth bored flanges are also less expensive and more resistant to damage than threaded ones.

CF flanges are available in rotatable versions which simplify component alignment. A knife edge insert makes the seal, and the outer flange is rotated to align the bolt holes (Figure 6). Note that all CF fittings with more than two flanges (i.e., tees and crosses) have at least one rotatable flange. Also note that the flange's leak detection grooves do not need to be aligned when joining flanges.

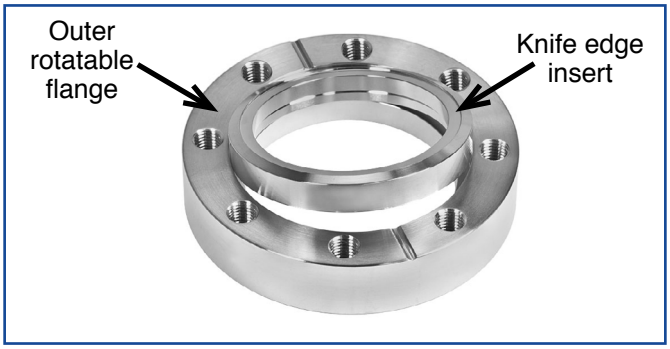

Figure 6 - Threaded rotatable CF flange

Using the proper technique and tightening to the proper torque is more critical on CF connections than on other flange types, and metal seals are less forgiving than O-ring seals.

Bolts are tightened incrementally in a star pattern using a torque wrench as described on Page 6. Bolt torque specifications are shown in Table 1, p. 7. There will be a small gap between flange faces when torqued to the correct tightness.

For high vacuum applications or temporary installations where O-rings are used instead of metal gaskets, bolts are tightened to torque in the same manner as with metal gaskets. Here, the two CF flange faces may touch before being fully torqued so that no further tightening can occur. A good seal should still be obtained.

5.1 CF FLANGE SIZES

CF flange sizes in North America are based on the outside flange diameter. Standard sizes include CF 1-1/3", 2-3/4", 4-1/2", 6", 8", and 10". Other intermediate size CF flanges, including 2-1/8", 3-3/8", 4-5/8", and 6-3/4" are available and allow other "standard" inch tube sizes to be used. Table 4, below, provides basic technical information about the most common North American sizes.

In Europe and much of Asia, CF flange size is based on the nominal metric I.D. tube size to which it can be welded. Flanges are described with either a DN or NW prefix. Common sizes are DN63, DN100, DN160, DN200, and DN250.

Threaded hole CF flanges in North America are generally tapped with inch threads. European DN CF flanges have metric threads. The number of bolt holes increases with the flange size.

Table 2, below, lists the common CF (inch) sizes and corresponding DN sizes where applicable. Also listed are some of the basic flange attributes.

Note that CF flange torque specifications are listed in **lb-in**.!

CF Size (Flange OD)	DN Size	Nominal Tube OD (in.)	# Bolt Holes	Bolt Size (inch)	Torque (lb-in)
1.33"	DN16CF	0.75	6	8-32	28
2.125"		1.0	4	1/4-28	110
2.75"	DN40CF	1.5	6	1/4-28	110
3.375"		2.0	8	5/16-24	190
4.5"	DN63CF	2.5	8	5/16-24	190
4.625"		3.0	10	5/16-24	190
6.0"	DN100CF	3.0	16	5/16-24	190
6.75"		4.0	18	5/16-24	190
8.0"	DN160CF	6.0	20	5/16-24	190
10.0"	DN200CF	8.0	24	5/16-24	190
12"	DN250CF	10.0	32	5/16-24	190
13.25"		10.0	30	3/8-24	345
14.0"		12.0	30	3/8-24	345
16.5"		14.0	36	3/8-24	345

Table 2 - CF flange basic technical information

5.2 HOW TO ASSEMBLE CF FLANGE CONNECTIONS

The example below illustrates how to join two smooth bored CF flanged fittings. It is imperative to use a torque wrench to tighten the bolts in a star pattern and to correctly torque each bolt.

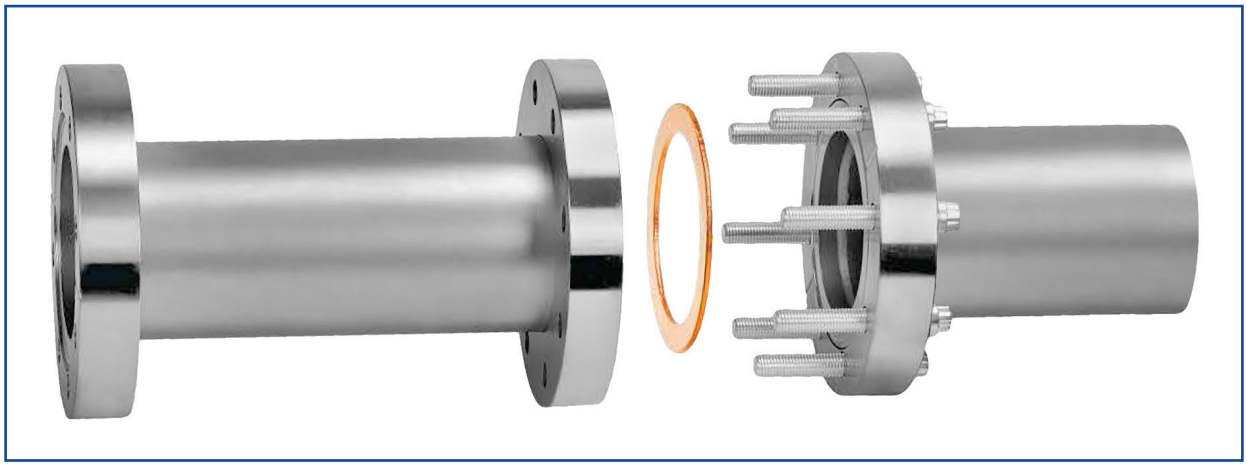

Figure 7 - Bring CF flanges together with copper gasket in between

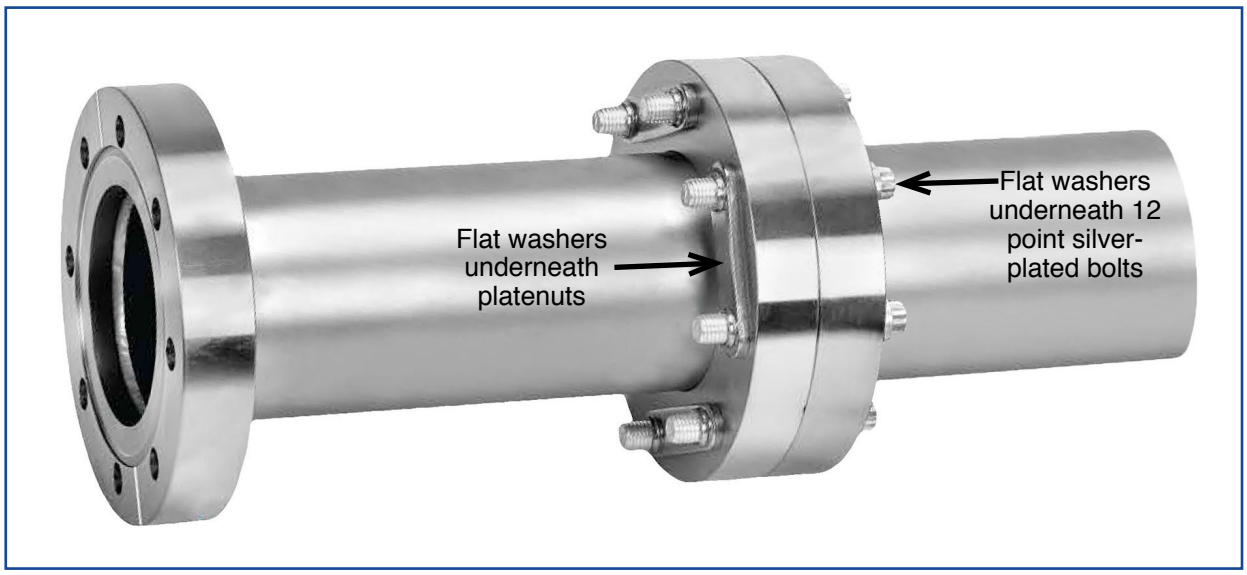

Figure 8 - Fasten CF flanges with silver-plated,12 point bolts, washers, and platenuts

To help keep gaskets (metal or O-ring) in place during assembly, gasket clips can be used. These clips fit into the leak detection slots and hold the gasket centered on the CF flange's knife edges.

Figure 9 - CF gasket retaining clips

6. KF FITTINGS - OVERVIEW

KF fittings (from the German Klein Flansche) fittings are the standard flange type used to make connections of smaller vacuum lines with up to 2" OD tubing. They are also referred to as NW, DN, or QF (for Quick Flange) because of their ease of assembly. KF flanged fittings can be used for rough and high vacuum applications down to 1 x 10^{-8} Torr. These are the easiest vacuum fittings to assemble, reconfigure, and service. Parts with KF flanges can be rotated in any orientation and no tools are needed for assembly. Undamaged KF flanges with new, clean O-rings are the least likely vacuum fittings to leak.

KF flanges have a 15° chamfered back surface and smooth, flat faces (Figure 10). They are counterbored to receive a metal centering ring which both aligns the flanges and holds an encircling O-ring in place (Figure 11 and 12).

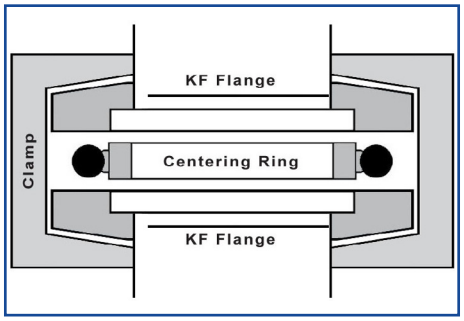

Figure 10 - KF to KF connection

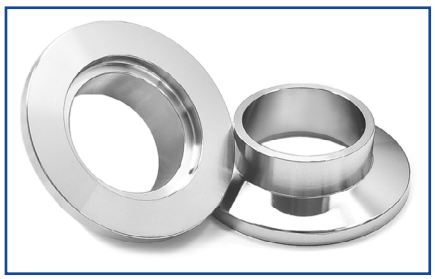

Figure 11 - KF weld stubs

Figure 12 - KF centering ring with O-ring

For standard KF-to-KF connections, a tapered, hinged, circular clamp is placed around a pair of identical flanges and made finger tight or locked (Figures 13 and 14). The two faces are squeezed together until the centering ring makes metal-to-metal contact with the flanges, which compresses the O-ring just the right amount to make a good vacuum seal. Additional clamp tightening does not improve the seal.

Figure 13 - Wing nut clamp

Figure 14- Lever/toggle clamp

A special type of KF port is found on some chambers, and particularly on some of Ideal Vacuum's interchangeable plates used on our modular Cube chambers.

The KF bulkhead port is machined flat on the chamber or plate surface with a bore sized to receive a KF centering ring. Surrounding the port are threaded bolt holes to which a standard KF flanged fitting is fastened using a special bulkhead screwdown clamp and screws.

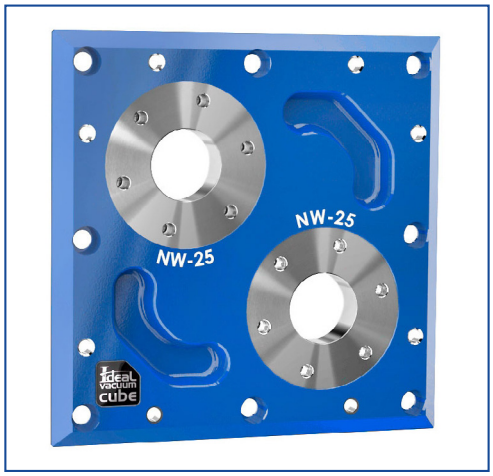

Figure 15 - Ideal Vacuum Cube plate with two KF (NW) bulkhead ports

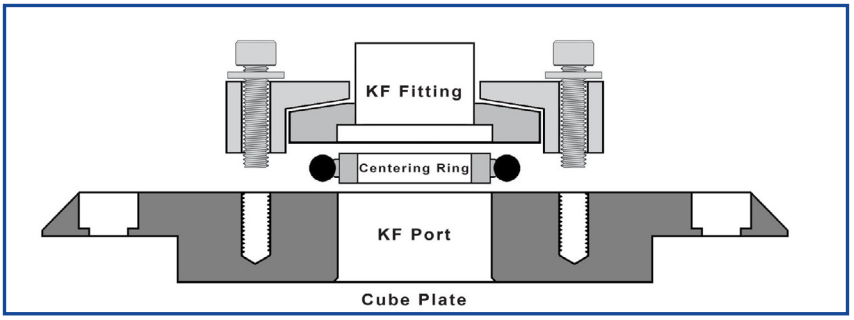

Figure 16 - KF flange to KF bulkhead connection

There are two types of bulkhead KF clamps, illustrated in Figure 17, below. The two piece split design completely surrounds the flange. The horseshoe style is a one-piece design.

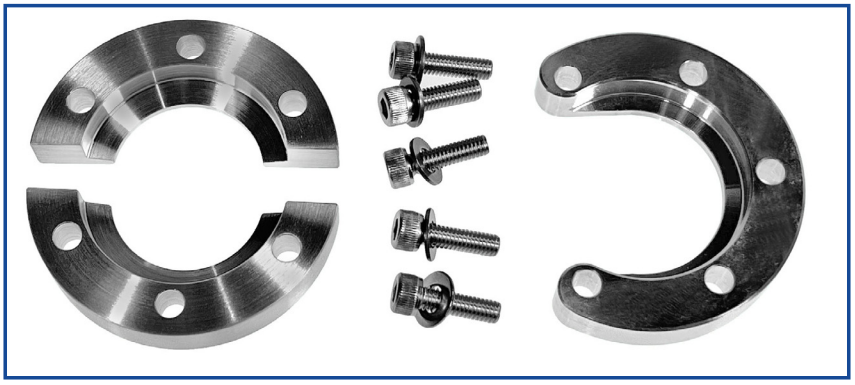

Figure 17- Two piece and horseshoe type KF bulkhead clamps

On bulkhead clamps, all screws are started and made hand tight initially. Then, using the star or cross technique described on page 6, each screw is tightened 1/4 to 1/2 turn until the clamp makes contact with the plate on all sides and the screws are tight. No further tightening can occur.

6.1 KF FLANGE SIZES

The KF flange size name is based on the nominal I.D. tube, in millimeters, to which it can be welded. Standard sizes are KF10, KF16, KF25, KF40 and KF50. In North America, KF Flanges are bored to accept inch-sized tubing. Table 3, below, lists the common KF sizes and nominal inch-size tubing sizes for each.

Flange Size	A Flange OD (in.)	B Counterbore ID (in.)	C Nominal Tube OD (in.)
KF10	1.18	0.48	0.50
KF16	1.18	0.67	0.75
KF25	1.57	1.03	1.0
KF40	2.16	1.62	1.5
KF50	2.95	2.05	2.0

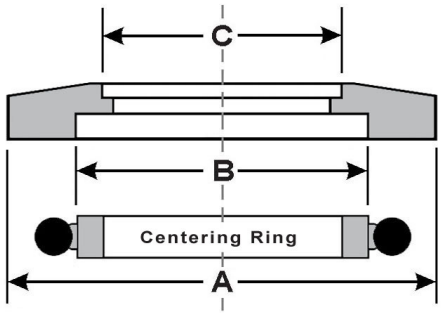

Table 2 - KF flange basic information

6.2 HOW TO ASSEMBLE STANDARD KF FLANGE CONNECTIONS

The figures below illustrate how to join two KF flanged fittings.

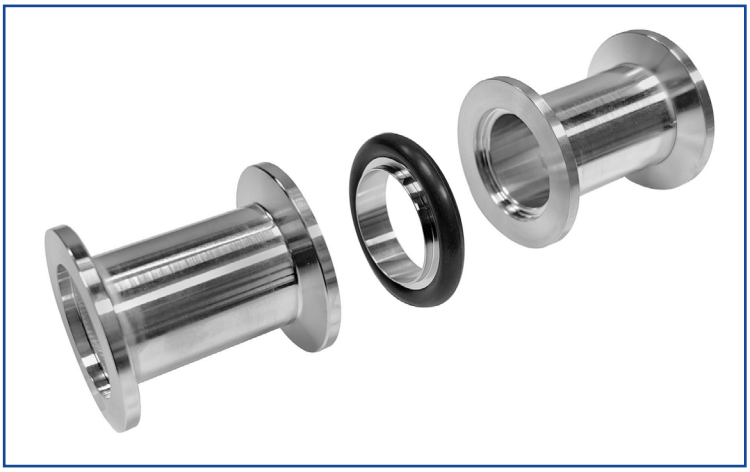

Figure 18 - Bring two KF flanges together with centering ring in between

Figure 19 - Wrap clamp around the joint

Figure 20 - Tighten the wingnut

6.3 HOW TO ASSEMBLE KF BULKHEAD FLANGE CONNECTIONS

Figure 21, below, illustrates how to mount a KF flanged fitting to a chamber or Ideal Cube plate KF bulkhead port. Start all bulkhead clamp screws. Tighten bulkhead clamp screws gradually in a star or cross patern until the clamp contacts the plate surface and all screws are tight.

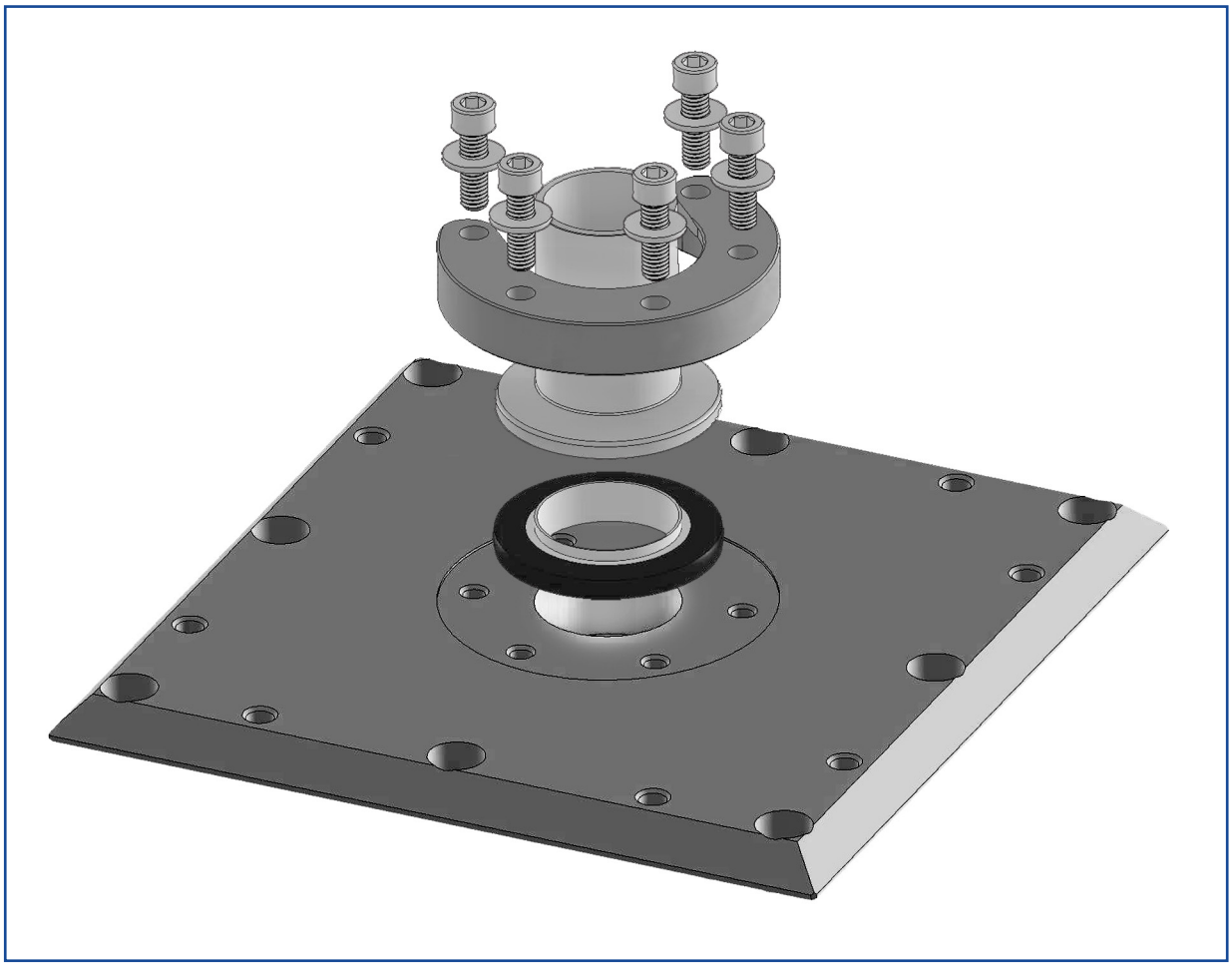

Figure 21 - KF flange to KF bulkhead assembly

7. ISO (LARGE) FLANGED FITTINGS - OVERVIEW

ISO large flange fittings are used for tubing sizes over 2 inches in diameter up to 20 inches. They are commonly found in industrial systems where high speed and conductance is needed. ISO flanges are found on chambers, roughing and high vacuum pumps, and gate valves.

ISO large flanges are like KF fittings in that they have smooth faces, are (typically) counterbored to hold a centering ring with an encircling O-ring, and are used for applications with vacuum levels up to the 10^{-8} Torr range. High vacuum levels in the 10^{-8} Torr range may not be obtainable in systems with larger diameter flanges, even under optimal conditions, due to a larger gas load from O-ring permeation.

There are two types of ISO large flanges: ISO-K and ISO-F. These two flange types look very different. ISO-K flanges do not have bolt holes. They are secured with claw clamps which grip in a groove machined into the back of the flange. ISO-F flanges have bolt holes which may be smooth bored or threaded. ISO-F threaded hole flanges have metric threads.

Figure 22 - ISO-K type flange

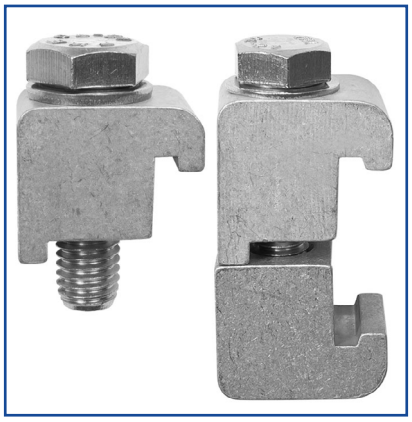

Figure 23 - Claw clamps

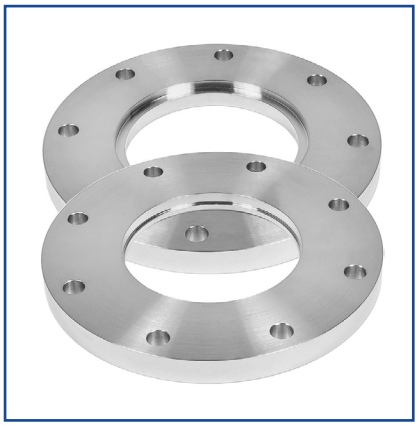

Figure 24 - ISO-F type flange

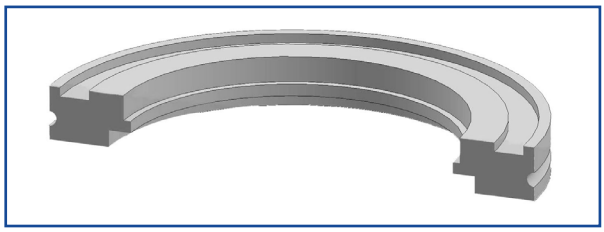

Figure 25 - ISO-K flange section

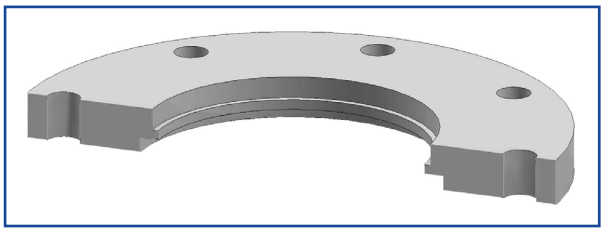

Figure 26 - ISO-F flange section

Because of their large diameter, ISO centering rings often have a spring-loaded O-ring retainer to keep the O-ring from slipping off the centering ring during installation. An ISO centering ring of the correct size can be used for any ISO flanged joint.

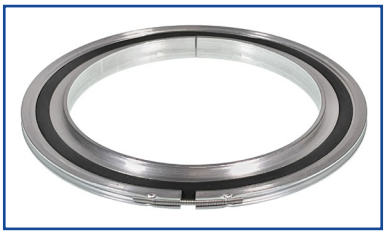

Figure 27 - ISO centering ring with spring retainer

7.1 ISO FLANGE SIZES

The ISO flange size for both ISO-K and ISO-F flanges is based on the nominal I.D. tube, in millimeters, to which it can be welded. Standard ISO flange sizes are ISO 63, 80, 100, 160, 200, 250, 320, 400, 500, and 630. Larger sizes exist. This flange system is also described as ISO LF DN XXX (where XXX is the size designation and LF is the same as ISO-K), or ISO LFB DN XXX (where LFB is the same as ISO-F).

For all ISO flanges, bolts, including claw clamp bolts, should be torqued to 7-10 lb-ft. or until the centering ring makes contact with the flanges. There will be a small gap between the flange faces when torqued to the correct tightness.

ISO-K Flange Size	Flange OD in. (mm)	Thickness in. (mm)	Tubing OD (in.)	Number of Claw Clamps
ISO-K DN 63	**3.74** (95)	**0.47** (12)	2.5	**3-4**
ISO-K DN 80	**4.33** (110)	**0.47** (12)	3.0	**4-8**
ISO-K DN 100	**5.12** (130)	**0.47** (12)	4.0	**4-8**
ISO-K DN 160	**7.09** (180)	**0.47** (12)	6.0	**4-8**
ISO-K DN 200	**9.45** (240)	**0.47** (12)	8.0	**6-12**
ISO-K DN 250	**11.42** (290)	**0.47** (12)	10.0	**6-12**
ISO-K DN 320	**14.57** (370)	**0.67** (17)	12.75	**8-12**
ISO-K DN 400	**17.72** (450)	**0.67** (17)	16.0	**8-16**
ISO-K DN 500	**21.65** (550)	**0.67** (17)	20.0	**12-16**
ISO-K DN 630	**27.17** (690)	**0.87** (22)	25.0	**20**

Table 3 - ISO-K flange basic technical information

ISO-F Flange Size	Flange OD in. (mm)	Thickness in. (mm)	Tubing OD (in.)	# Holes	Thread Size
ISO-F DN 63	**5.12** (130)	**0.47** (12)	2.5	4	M8 X 1.25
ISO-F DN 80	**5.17** (145)	**0.47** (12)	3.0	8	M8 X 1.25
ISO-F DN 100	**6.50** (165)	**0.47** (12)	4.0	8	M8 X 1.25
ISO-F DN 160	**8.86** (225)	**0.63** (16)	6.0	8	M10 x 1.50
ISO-F DN 200	**11.22** (285)	**0.63** (16)	8.0	12	M10 x 1.50
ISO-F DN 250	**13.19** (335)	**0.63** (16)	10.0	12	M10 x 1.50
ISO-F DN 320	**16.73** (425)	**0.79** (20)	12.75	12	M12 x 1.75
ISO-F DN 400	**20.08** (510)	**0.79** (20)	16.0	16	M12 x 1.75
ISO-F DN 500	**24.02** (610)	**0.79** (20)	20.0	16	M12 x 1.75
ISO-F DN 630	**29.53** (750)	**0.94** (24)	25.0	20	M12 x 1.75
ISO-F DN 800	**36.22** (920)	**0.94** (24)	32.0	24	M12 x 1.75
ISO-F DN 1000	**44.09** (1120)	**0.94** (24)	40.0	32	M12 x 1.75

Table 4 - ISO-F flange basic technical information

7.2 HOW TO ASSEMBLE ISO FLANGE CONNECTIONS

There are several ways ISO flanges can be connected. ISO-K to ISO-K, ISO-F to ISO-F, and ISO-K to ISO-F connections are possible. Different bolt/clamp hardware is needed depending on the two flanges that are to be joined. The illustrations below show the most common connections.

On the following pages, the assembly of each ISO flange configuration is presented in detail.

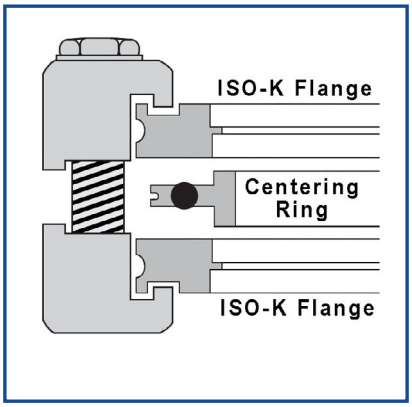

Figure 28 - ISO-K to ISO-K connection

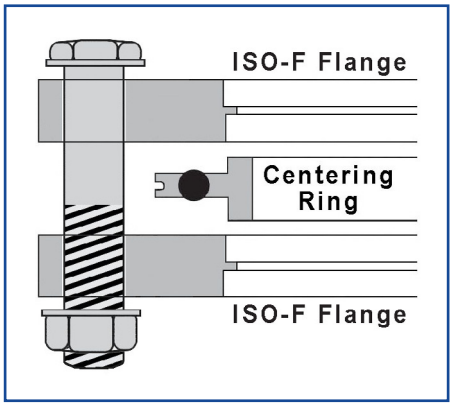

Figure 29 - ISO-F to ISO-F, both flanges smooth bored

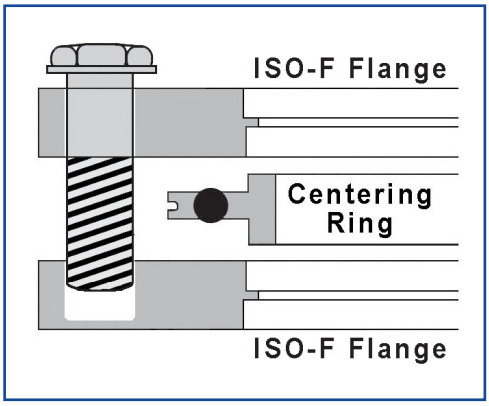

Figure 30 - ISO-F to ISO-F, one flange threaded

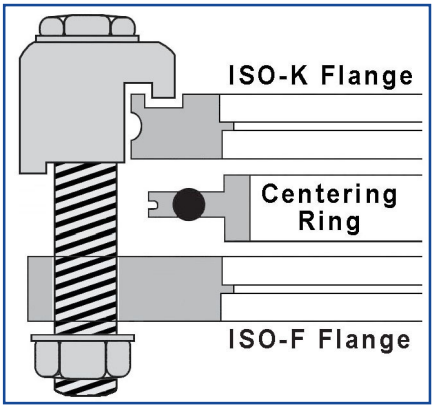

Figure 31 - ISO-K to smooth bored ISO-F

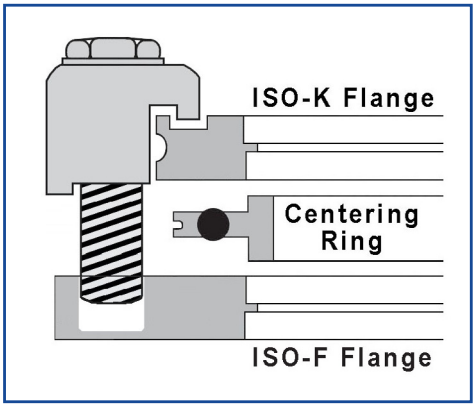

Figure 32 - ISO-K to threaded ISO-F

7.3 ISO-K TO ISO-K FLANGE CONNECTIONS

ISO-K (or ISO LF) flanges have the smallest flange O.D. for any given tube diameter. Because they do not have bolt holes, ISO-K flanged parts may be oriented in any direction. This aids plumbing alignment. ISO-K to ISO-K flanged joints are secured using double claw clamps. The claws latch onto the groove on the back side of each ISO-K flange and are tightened together. The number of clamps needed increases with the flange size, and larger flanges use bigger claw clamps (Table 3, p. 17).

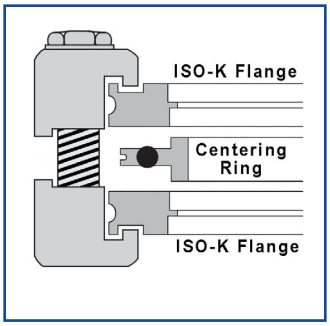

Figure 33 - ISO-K to ISO-K connections use double claw clamps

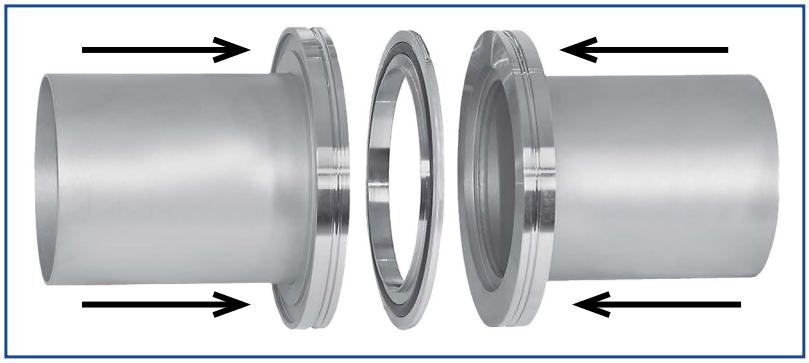

Figure 34 - Bring two ISO-K flanges together with centering ring in between

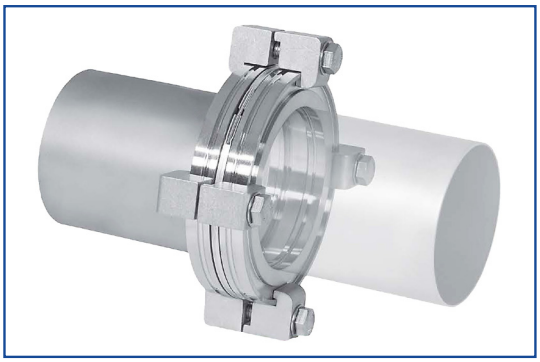

Figure 35 - ISO-K flanges joined with double claw clamps

Set the clamps equidistantly around the flanges and make finger tight. Bolts are tightened incrementally in a star pattern (page 6). Torque to 7-10 lb-ft. or until the centering ring makes contact with the flanges (Table 3, p. 17), or the double claw clamps touch in the center. There will be a small gap between the flange faces.

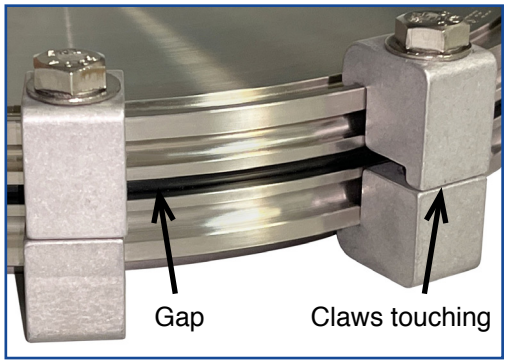

Figure 36 - ISO-K connection showing gap between flanges

7.4 ISO-F TO ISO-F FLANGE CONNECTIONS

ISO-F flanges have bolt holes which can be smooth bored or threaded. Joined with bolts, these joints have good structural strength. Tightening the bolts compresses the O-ring between the flanges to make the vacuum seal. The number of bolt holes and their size increases with the flange size (Table 4, p. 17). Lock washers are not used.

When both flanges have through holes, the bolts must be longer than the combined thickness of the two flanges, the centering ring, plus the extra length needed for flat washers on both sides of the joint, and a nut. Two wrenches are needed to tighten this flange configuration.

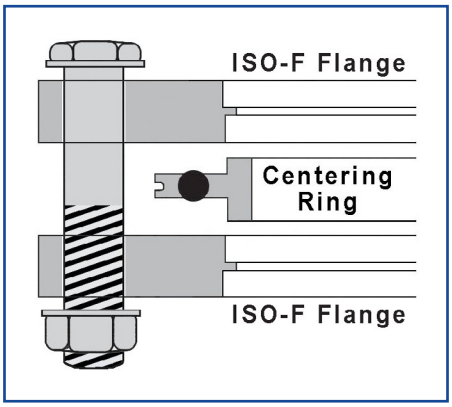

Figure 37 - Smooth bored to smooth bored ISO-F flange connection

When one flange has smooth bored holes and the other has threaded holes, the screws pass through the smooth bored flange and screw into the threaded flange. On threaded hole flanges with blind holes (the holes do not go all the way through the flange), the bolts must not bottom out before the flanges are fully tightened.

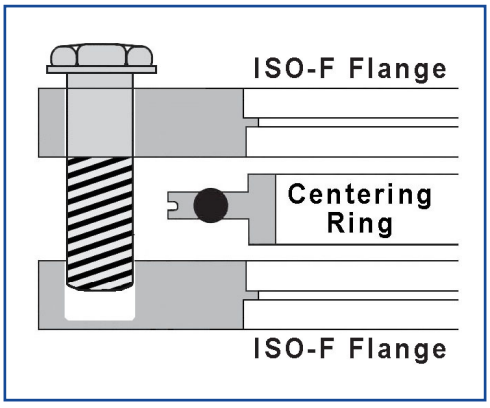

Figure 38 - Smooth bored to threaded ISO-F flange connection

Bolts are tightened incrementally in a star pattern (page 6). Torque to 7-10 lb-ft. or until the centering ring makes contact with the flanges. There will be a small gap between the flange faces.

The example below illustrates how to join two ISO-F fittings with smooth bored holes. Bolts, nuts, and flat washers are used. When one flange has threaded holes, a shorter bolt and one flat washer under the bolt head is used.

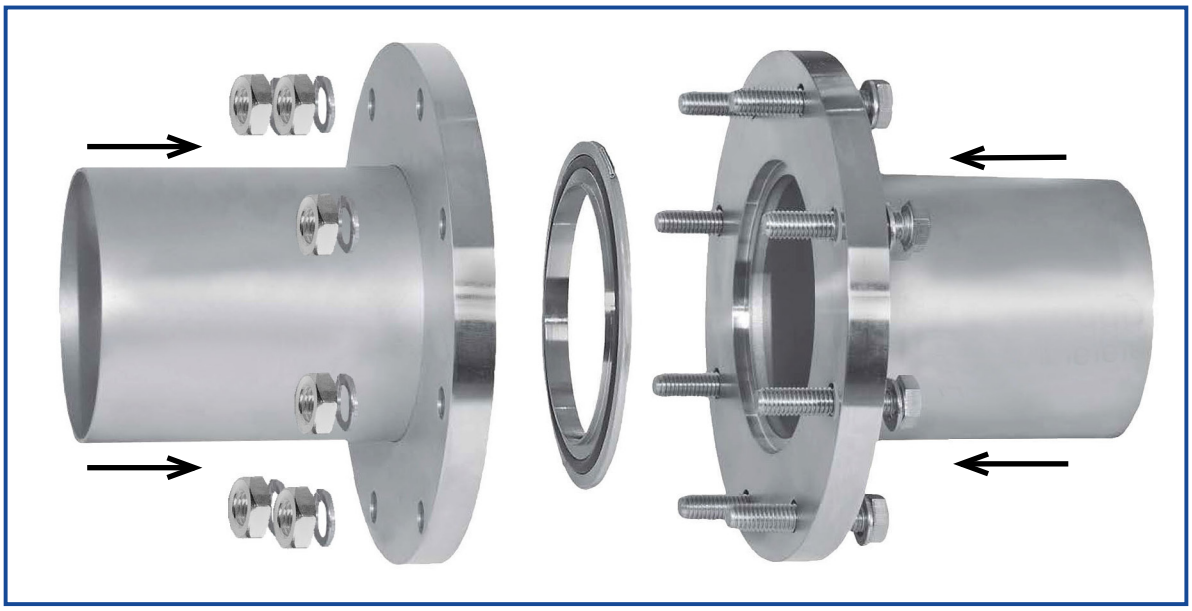

Figure 39 - Bring two ISO-F flanges together with centering ring in between

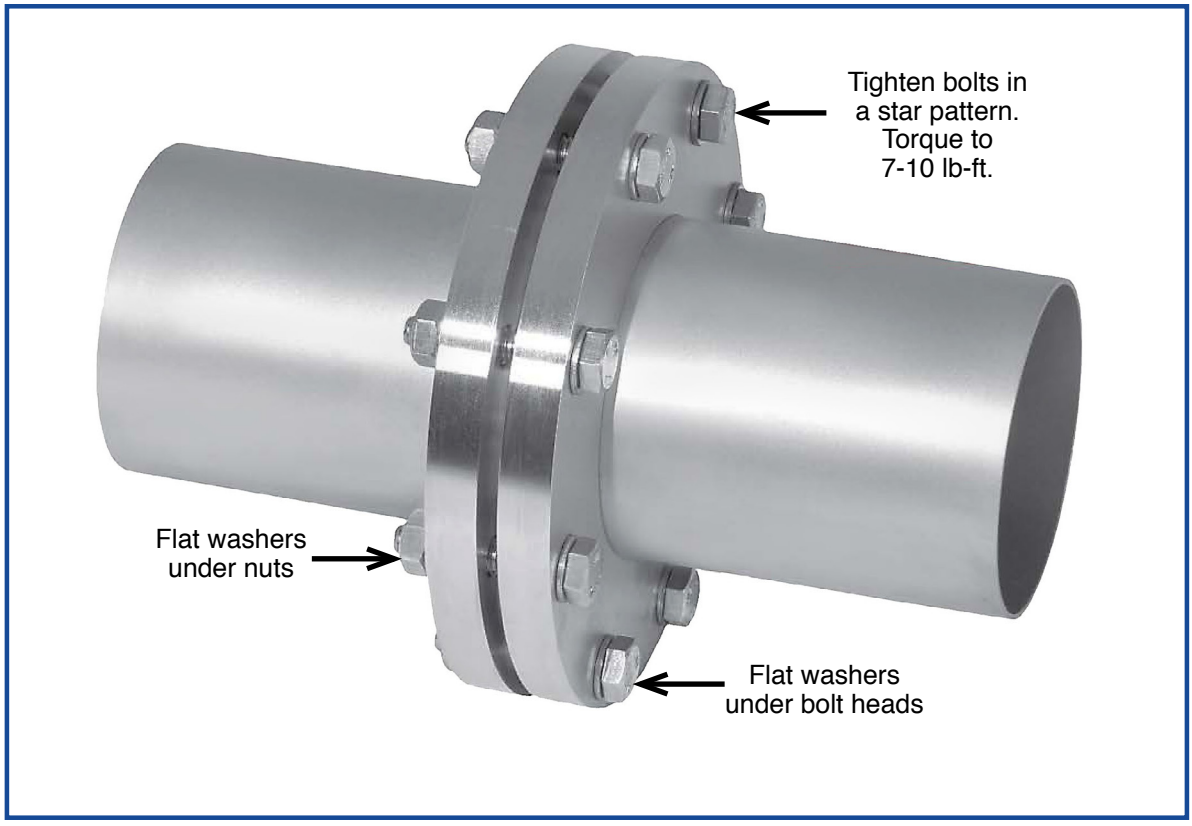

Figure 40 - Two ISO-F smooth bored flanges joined

7.5 ISO-K TO ISO-F FLANGE CONNECTIONS

ISO-K to ISO-F flange connections are commonly used to connect vacuum lines to chambers, larger vacuum pumps, gate valves, and high vacuum pumps. Single claw clamps are used for fastening ISO-K flanges to ISO-F flanges. The ISO-K flange can be rotated in any orientation regardless of the bolt hole locations of the ISO-F flange. Therefore alignment (clocking) issues are eliminated. The number of single claw clamps required is equal to the number of bolt holes in the ISO-F flange. Claw clamp size increases with the flange size (Table 3, p. 17).

When both flanges have through holes, the single claw clamps must have bolts that are longer than the combined thickness of the claw, the two flanges, the centering ring, plus the extra length for a washer and nut. Two wrenches are needed to tighten this flange configuration.

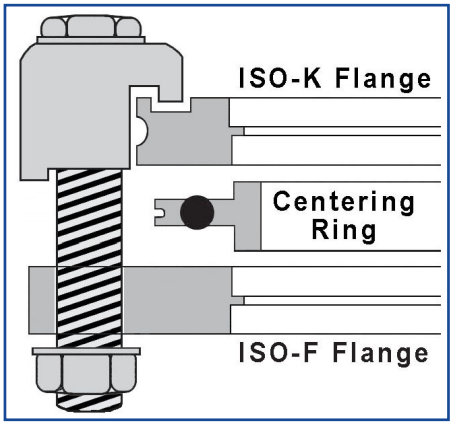

Figure 41 - ISO-K to smooth bored ISO-F flange connections

When the ISO-F flange has threaded holes, a washered machine screw goes through the single claw and is screwed into the threaded flange. On ISO-F threaded hole flanges with blind holes (the holes do not go all the way through the flange), the bolts must not bottom out before the flanges are fully tightened.

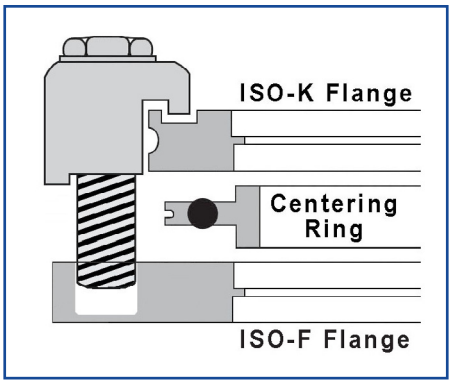

Figure 42 - ISO-K to threaded ISO-F flange connections

Bolts are tightened incrementally in a star pattern (page 6). Torque to 7-10 lb-ft. or until the centering ring makes contact with the flanges. There will be a small gap between the flange faces.

The example below illustrates how to join an ISO-K flanged bellows fitting to an ISO-F gate valve with (blind) threaded holes using single claw clamps. The single claw clamp screws thread into the flange without bottoming out.

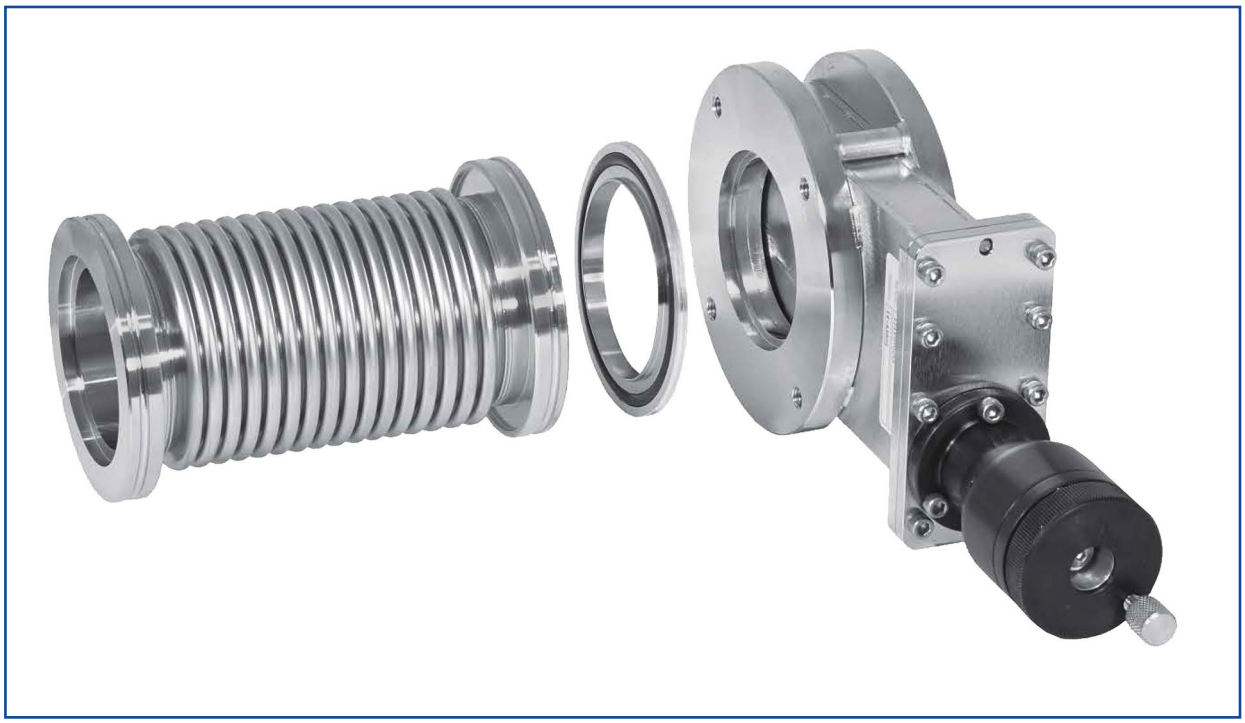

Figure 43 - Bring ISO-K and ISO-F flanges together with centering ring in between

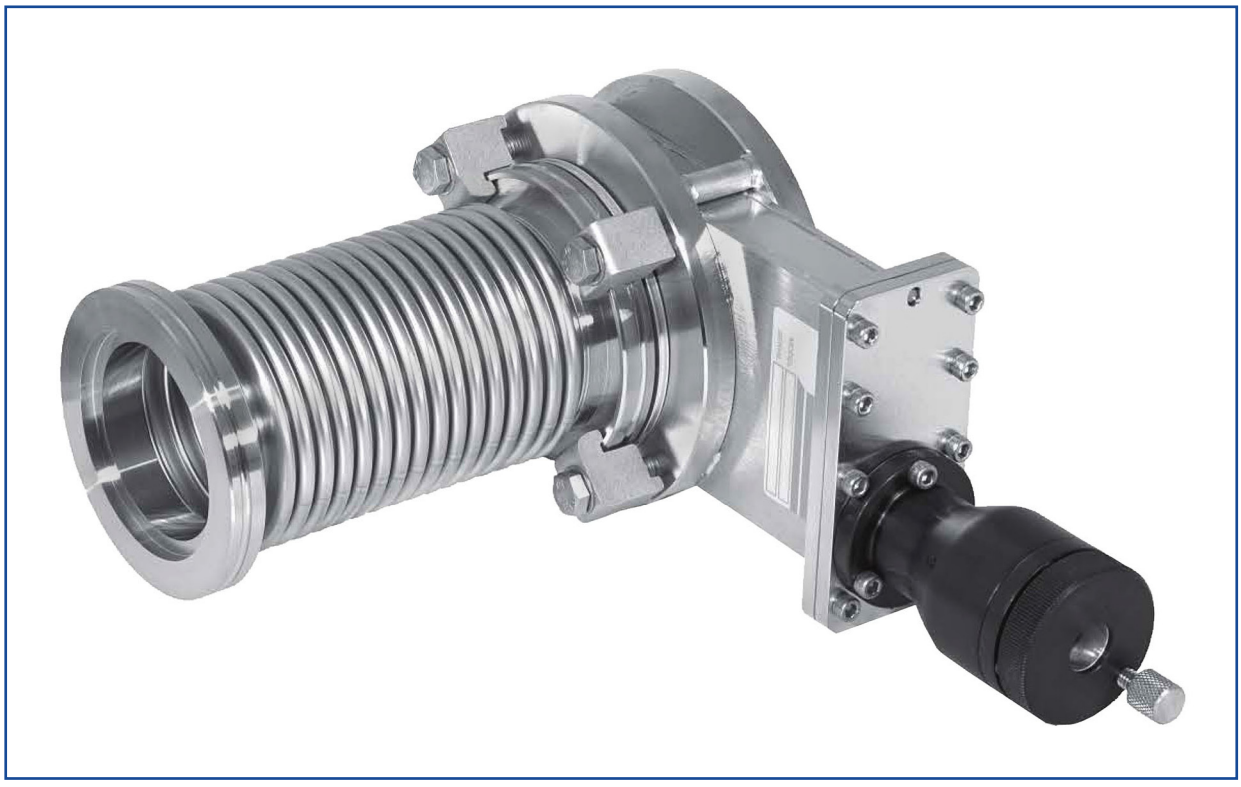

Figure 44 - Fasten ISO-K to threaded ISO-F flanges with single claw clamps

7.6 ISO-K TO NON-COUNTERBORED ISO-F FLANGE CONNECTIONS

Some large roughing pumps have threaded hole ISO-F flanged inlets, but their faces are not counterbored for a centering ring. Their faces are completely smooth.

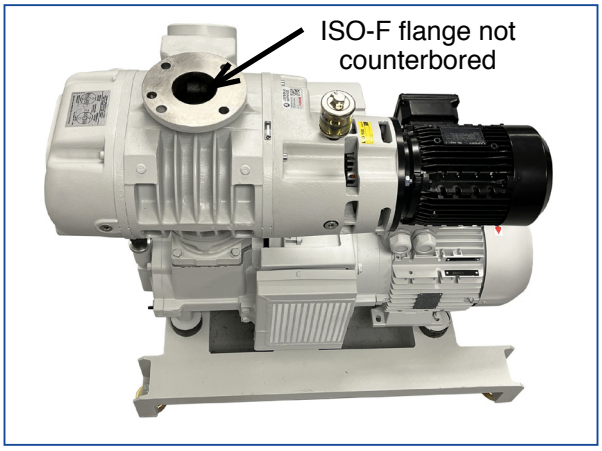

Figure 45 - Leybold WAU-501 Roots blower pump with smooth ISO-F inlet

Even so, an ISO-F smooth bored flange can easily be connected to the inlet using a single sided centering ring. An ISO-K flange can also be attached to the pump inlet providing a rotatable bolt ring adapter fitting and a one-sided centering ring are used to properly align the flanges.

The bolt ring adapter fits around the ISO-K flange, secured with a split ring that fits into the circumferential groove in the side of the ISO-K flange. Now, bolt holes for fastening the two flanges are provided. Note that the rotatable bolt ring adapter is often provided by the pump manufacturer. Also recognize that this special type of ISO-F to ISO-K connection is NOT a structural joint.

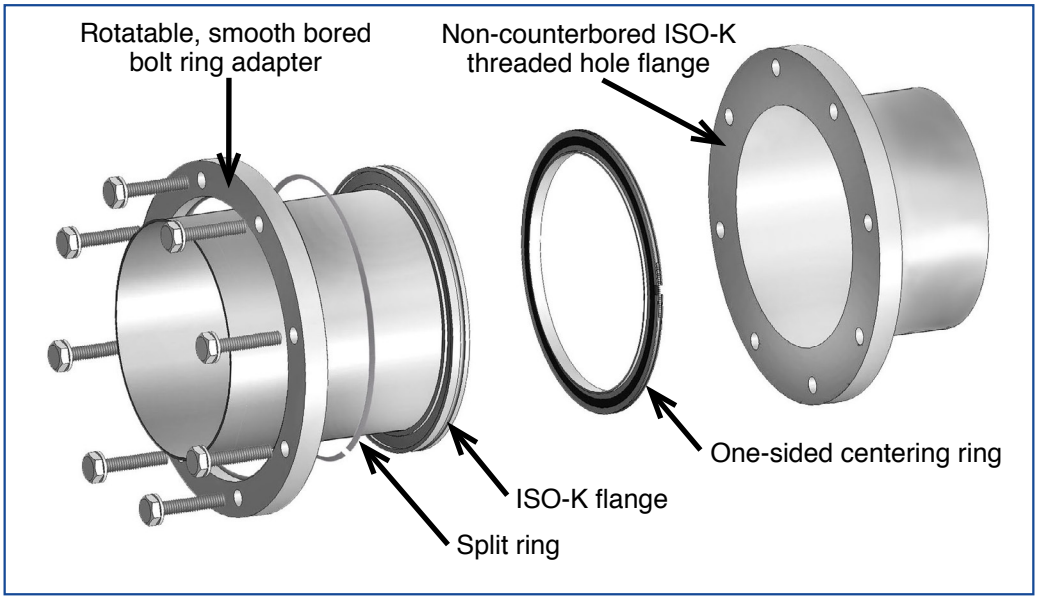

Figure 46 - Rotatable bolt ring adapter assembly

As with all ISO flange joints, bolts are tightened incrementally in a star pattern (page 6). Torque to 7-10 lb-ft. or until the centering ring makes contact with the flanges. There will be a small gap between the flange faces.

8. ASA/ANSI FITTINGS - OVERVIEW

ASA/ANSI (large) flanges, were originally created for use with (pressurized) steam pipes, and later adapted for vacuum system use. As a result, for a given tube diameter, ASA/ANSI flanges have larger outside diameters and larger bolt hole diameters than other large vacuum flanges (i.e., ISO-F flanges) for the same tube size.

Like other vacuum flange types that use O-rings, ASA/ANSI flanges may be used for rough and high vacuum down to 1 x 10^{-8} Torr. High vacuum levels in the 10^{-8} Torr range may not be obtainable in systems with larger diameter flanges, even under optimal conditions, due to a larger gas load from O-ring permeation.

Unlike other types of vacuum flange connections where the mating flange faces are identical (i.e., CF and KF), a sealing pair of ASA/ANSI flanges consists of one flange with a smooth face, the other with an O-ring groove machined into its surface.

ASA/ANSI flanges always have through holes. Bolts, nuts, flat washers, and lock washers are used to compress the O-ring to make the vacuum seal.

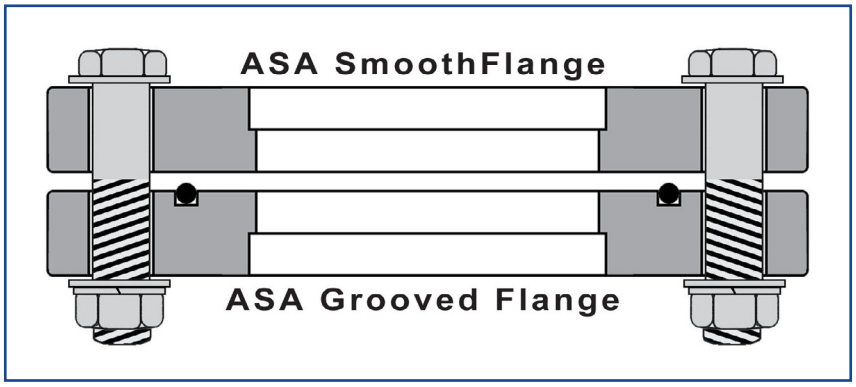

Figure 47 - ASA/ANSI flange connections

ASA/ANSI flanges are available in fixed and rotatable versions which simplify component alignment. Rotatable flanges with either a grooved insert for an O-ring, or a smooth insert makes the seal. The outer flange is rotated to align the bolt holes (Figure 48).

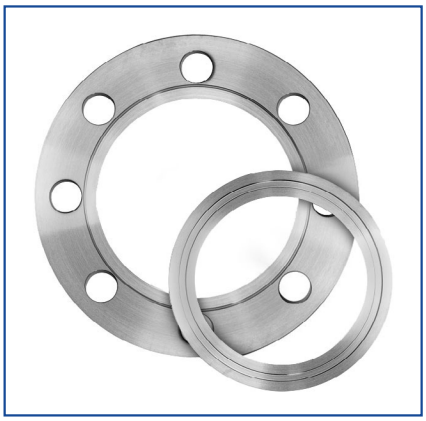

Figure 48 - ASA/ANSI rotatable flange with grooved insert

Bolts are tightened incrementally in a star pattern using a torque wrench as described on page 6. Bolt torque specifications are shown in Table 5, on the next page.

8.1 ASA/ANSI FLANGE SIZES

The American Standards Association (ASA) was renamed The American National Standards Association (ANSI) in 1969. Since then, the older ASA and the newer ANSI naming conventions for the same sized flanges have caused much confusion.

The ASA naming convention uses the flange's outer diameter, in inches, for the flange size.

The ANSI naming convention for the same flange uses the largest nominal I.D of the tube, in inches, to which it can be welded.

For example, a flange with an outer diameter of 4.25 inches accepts a maximum 1" diameter tube.

Common ASA flange sizes for vacuum use range from 4.25 to 19 inches, corresponding to ANSI flange sizes of 1 to 12 inches. Larger sizes exist.

ASA Size	ANSI Size	OD (in.)	Bore (in.)	# Bolt Holes	Bolt Size	Torque (lb-ft.)
4.25	1	4.25	1.0	4	9/16-12	14
5.0	1.5	5.0	1.5	4	9/16-12	14
6.0	2	6.0	2.0	4	5/8-11	14
7.5	3	7.5	3.0	4	5/8-11	14
9.0	4	9.0	4.0	8	5/8-11	14
11.0	6	11.0	6.0	8	3/4-10	24
13.5	8	13.5	8.0	8	3/4-10	24
16	10	16	10.0	12	3/4-10	24
19	12	19	12.0	12	7/8-10	24

Table 5 - ASA/ANSI flange basic technical information

8.2 HOW TO ASSEMBLE ASA/ANSI FLANGE CONNECTIONS

The example below shows a pair of ASA/ANSI to KF50 adapter flanges and illustrates how to join ASA/ANSI fittings. There must be one smooth and one O-ring grooved flange. Two similarly faced flanges cannot be joined. Use a torque wrench and a backing wrench. Bolts have flat washers on either side of the flanges and use lock washers. Tighten the bolts in a star pattern and tighten each bolt to the proper torque.

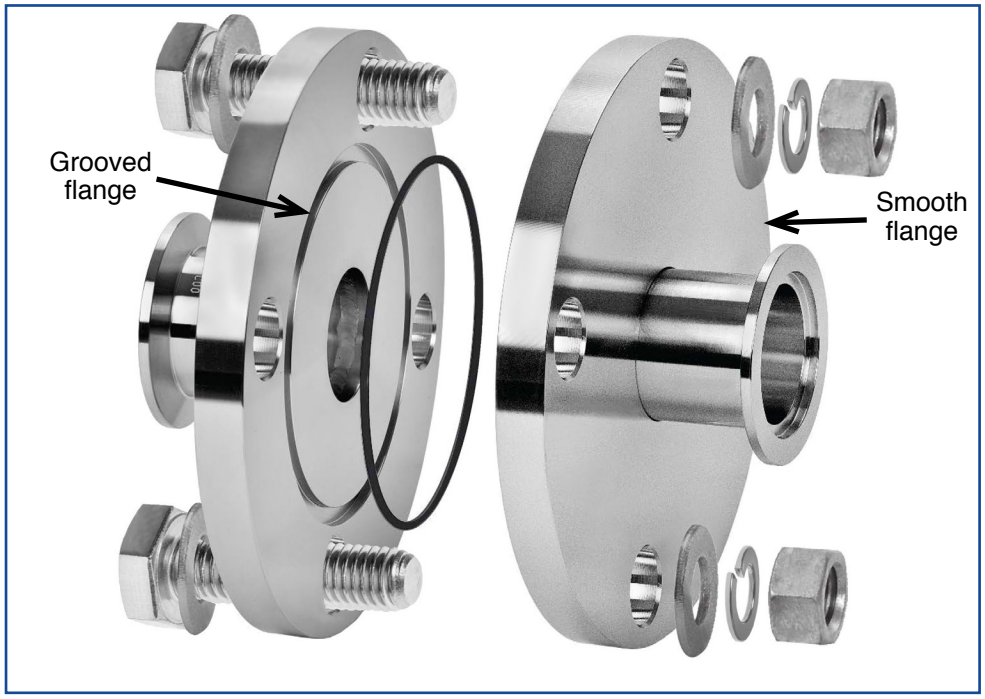

Figure 49 - Bring unlike ASA/ANSI flanges together with an O-ring in between

Figure 50 - Fasten the flanges with bolts, nuts, flat washers, and lock washers

Ideal Vacuum Products, LLC.
5910 Midway Park Blvd NE
Albuquerque, NM 87109

Phone: (505) 872-0037
Fax: (505) 872-9001
Web: idealvac.com