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Comparing KF, ISO, CF, ASA and JIS flanges

by Ken Harrison, President

There are numerous flanges in the world for all types of applications such as steam or liquids, but vacuum flanges have their own unique designs and designations. Vacuum flanges are unique because they need to seal better than nearly every other flange. The common acceptance criteria equates to a maximum leak of a thimble full of helium in 30 years. Vacuum flanges are used wherever an airless environment is required. This includes widely varied applications such as space simulation, semiconductor manufacturing, titanium processing and MRI machines.

The other notable aspect of a vacuum flange is that the pressure is known and the allowable pressure can never be exceeded. Therefore, the maximum differential pressure is normally full atmosphere on the outside and no atmospheric pressure on the inside. That is 1 atm, 1 bar, or 14.7 PSI. No matter how big the pump, it is never possible to go lower than 0 PSI absolute pressure. The most common vacuum flanges are the KF Flange, the ISO Flange, the CF Flange and the ASA Flange.

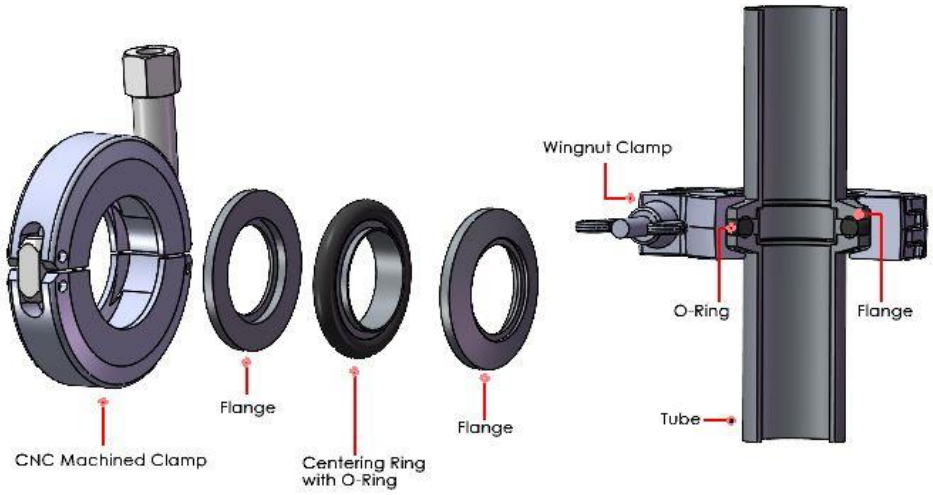
KF Flanges

The term KF comes from the German words Klein Flansche, which is translated as “small flange” into English. These flanges have a 15-degree angle (chamfer) on the back and are joined together by using tapered circular clamps. They are manufactured according to the DIN 28403/ISO 2861 standard. They are also part of the Pneurop standard. These are sexless flanges, meaning that both sides of the connection are identical and there are no O-ring grooves cut into the flanges. The flange size is based on the largest nominal I.D. tube, in millimeters, that can be welded to it. For example, the through hole of a KF25 flange is 25mm, or about one inch. In the U.S., it is common that the tubing that is welded to the flange is in a nominal inch size and it will be close, but not exactly the millimeter designation. Components manufactured outside of the U.S. will usually use tubing with a metric I.D.

The standard sizes are KF10, KF16, KF25, KF40 and KF50. Less common are the KF20 and KF32 sizes.

This flange system is also known by several other names such as NW, QF, DIN, and ISO-KF, but all of these flanges are the same.

The principle of operation is this: a centering ring holding an O-ring is placed between the two flanges and then the flanges are aligned and brought close together. The wing nut clamp (chain clamps are also available) is placed around the two flange faces and the wing nut is tightened. The two flange faces are



squeezed toward one another, thus compressing the O-ring.

These flanges are used in the pressure range from atmosphere to as low as $1x10^{-8}$ Torr or mbar. The operating and bakeout temperature range depends upon the O-ring material. The most common O-ring material is FKM (Viton-A) which is suitable for the operating temperature range of 32 deg F to 356 deg F (0 to 180 deg C) and can be exposed to short-term temperatures in the range of -15 deg F to 400 deg F (-26 to 204 deg C). The leakage and permeability rate of these flanges with FKM is $1x10^{-9}$ std cc/sec of Helium.

The most common material for these flanges is 304/304L stainless steel, but other materials such as 316L, 316LN, and 6061 aluminum are available as well.

ISO Flanges

Another metric flange that is larger than the KF flanges are the ISO flanges. Similar to the KF flanges they use a centering ring for sealing. They are manufactured according to the DIN 28404/ISO 1609 standard. They are also part of the Pneurop standard. These are sexless flanges; however, in some cases one of the two flanges will have tapped holes and then the two flanges will not be identical.

The flange size is based on the largest nominal I.D. tube, in millimeters, that can be welded to it. For example, the through hole of an ISO 100 flange is 100mm, or about four inches. In the U.S., it is common that the tubing that is welded to the

flange is in a nominal inch size and it will be close, but not exactly the millimeter designation. Components manufactured outside of the U.S. will usually use tubing with a metric I.D.

The standard sizes are ISO 63, ISO 100, ISO 160, ISO 200, ISO 250, ISO 320, ISO 400, ISO 500 and ISO 630. Less common is the ISO 80 size. Although the ISO specification lists the largest size as 630 mm, the same design principle is used to make larger flanges. They are commonly (yet erroneously) called ISO 800, ISO 1000, ISO 1250 and ISO 1320 sizes.

There are two different methods to join the flanges together: 1. Bolts (ISO-F) or 2. Claw clamps (ISO-K). These two flanges look very different, yet they can be joined together by using a half-claw clamp. The naming conventions can be a little bit confusing because the KF flanges above are often called ISO-KF flanges and the two types of larger ISO flanges are ISO-K and ISO-F.

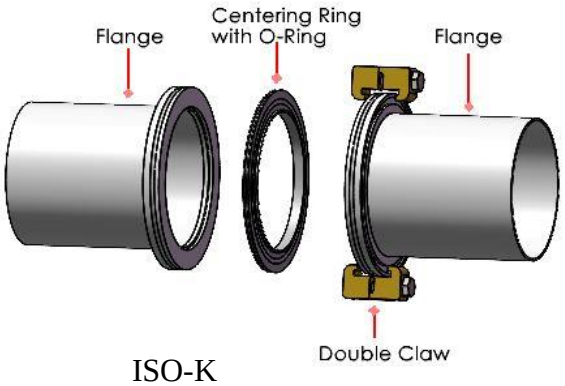
This flange system is also known by several other names such as DIN XXX ISO (where XXX is the size designation), ISO LF (the same as ISO-K), ISO LFB (the same as ISO-F).

ISO-K flanges have a groove cut into the back of the flange so that a claw clamp can grab ahold of it. Because the letter “K” sounds the same as a “C” it can be helpful to remember that ISO-K requires a Claw Clamp.

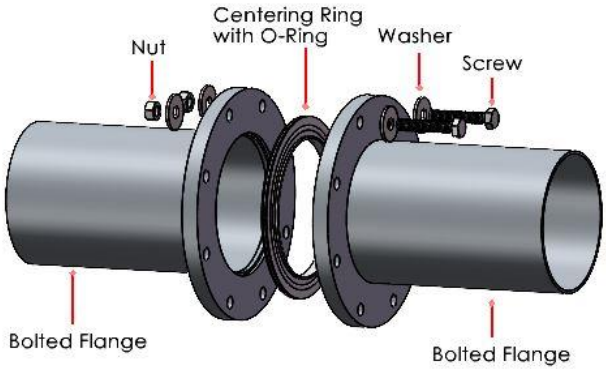
ISO-F flanges have holes into the flange that can be used to bolt the two flanges together. These holes most commonly are through holes where a bolt is placed through both flanges; however, the holes can also be tapped where there is no access to place a nut (or nut ring) behind one of the flanges. It can be helpful to remember the ISO-F flange is *flat* and there is no groove for a claw clamp.

When two ISO-F flanges are bolted together the clocking of the bolt holes can affect the alignment and leveling of the two items that are joined by the flanges. For many flanged devices such as pumps and gauges the bolt-hole-pattern straddles the horizontal and vertical centerlines of the flanges. In other cases, the bolt holes will be oriented to be on the centerlines. To solve this, rotatable ISO flanges are available. In this case, the I.D. of the flange where the centering ring sits is fixed, and. the bolt-hole-pattern is a second part that can rotate to any angle for perfect alignment. ISO-K flanges do not have this issue.

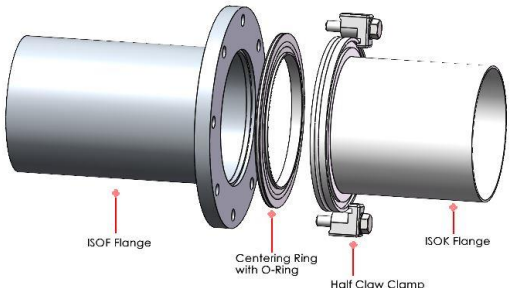
The principle of operation is this: A centering ring that holds an O-ring is placed between the two flanges and then the flanges are aligned and brought close together. The flanges are then joined by claw clamps (for and ISO-K), bolts (for and ISO-F) or with a half claw clamp (when joining an ISO-K to an ISO-F). In each case, as the bolts are tightened the centering ring is compressed making a leak-tight seal.



ISO-K



ISO-F



ISO-F and ISO-K Flange

The operating specs are similar to the ISO-KF flanges. They can be used in the pressure range as low as $1x10^{-8}$ Torr or mbar. The operating and bakeout temperature range depends upon the O-ring material. The most common O-ring material is FKM (Viton-A) which is suitable for the operating temperature range of 32 deg F to 356 deg F (0 to 180 deg C) and can be exposed to short-term temperatures in the range of -15 deg F to 400 deg F (-26 to 204 deg C). The leakage and permeability rate of these flanges with FKM is $1x10^{-9}$ std cc/sec of Helium.

The most common material for these flanges is 304/304L stainless steel, but other materials such as 316L, 316LN and 6061 aluminum are available as well.

CF Flanges

The term CF originally came from the name Conflat Flange. However, the word Conflat was a trademark of the Varian Corporation and the flanges became so popular that many companies are making them and using them. So, while they can be referred to as a conflat flange the shortened name CF is more widely used.

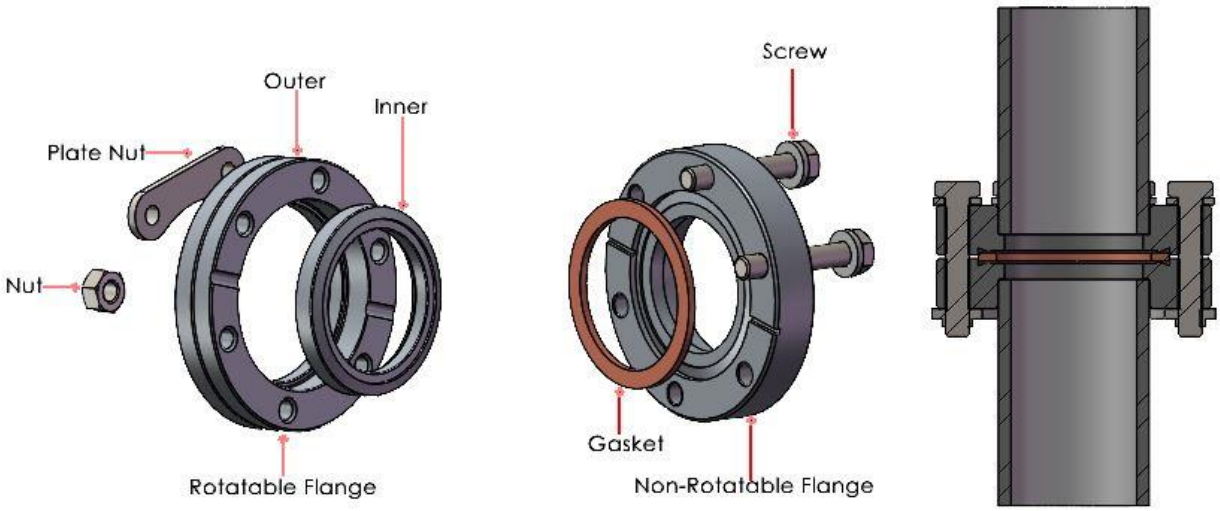
A CF flange uses a metal seal and is designed for higher vacuum applications where the permeability of an O-ring is significant to the gas load. Because all the parts are metal they can also be used when a bakeout is required at a higher temperature.

A helium molecule is 280 picometers in diameter (11 x 10^{-9} inches). This molecule can migrate through all rubber compounds and will stream through all tiny holes. A mirror-like surface that looks perfect to the human eye is 0.02 to 0.05 RA micrometers at best. At 0.02 RA the helium molecule is 71 times smaller than the roughness of this surface. In comparison, the peaks and valleys in a mirror-like surface would look like skyscrapers from the perspective of a helium molecule. As explained below, CF Flanges are designed so no gasses can pass through the flanged joint, including helium which is used for leak testing.

The flange size is normally specified by the O.D. of the flange in inches. This is very different from KF and ISO flanges. The common sizes are CF1.33, CF2.75, CF4.50, CF6.00, CF8.00, CF10.00, CF12.00, CF14.00 and CF16.50. Other sizes that are less frequently used are CF2.12, CF3.38, CF4.62, CF6.75 and CF13.25. These are manufactured according to ISO specification ISO 3669-2. Often in part numbers the decimal point will be omitted so a CF275 will actually have an outside dimension of 2.75 inches. The bolt hole sizes (or threads if the holes are tapped) are usually metric, but they are available with inch-sized holes and Imperial threads as well.

These are sexless flanges, but for design purposes it is important to pay attention as to which holes are tapped and which are through, or the flanges may not bolt together.

The principle of operation is this: A knife edge is machined into both of the mating flanges. Then, a metal gasket made from a softer material (commonly copper) is placed between the two flanges. As the bolts are tightened, the knife edges cut into copper on both sides, making a leak-tight seal. Similar to the ISO Flanges, 2-piece rotatable CF Flanges are available. The pictorial below shows a rotatable flange on the left.



These flanges are used in the pressure range from atmosphere to as low as 1x10^{-12} Torr or mbar, and the maximum bake out temperature is 842 degrees F (450 degrees C) with the standard copper gaskets.

The most common material for these flanges is 304/304L stainless steel, but other materials such as 316L, and 316LN are available as well. GNB also sells bi-metal CF flanges. The typical application is to have a CF flange with a stainless steel knife edge to be welded onto an aluminum chamber.

ASA Flanges

ASA flanges are vacuum flanges that were adopted from the 150# (150 psi rated) steam-pipe flanges. Eventually the American Standards Association changed its name to ANSI (American National Standards Institute), but the ASA name has stuck in reference to the flanges.

ASA Flanges have an O-ring groove cut directly into the flanges. These are sexed flanges, meaning that when the two flanges are bolted together only one of the two can have an O-ring groove and the other side must be flat with no O-ring as a sealing surface.

Because they were originally designed to withstand 150 PSI and vacuum is at most 15 PSI these flanges are thicker and have a lot more material than other vacuum flanges. They are more common on machines in the industrial vacuum market rather than the scientific or high-purity systems.

The size of the flange is roughly the size of the I.D. of the opening in the flange. Common sizes include: ASA1, ASA1.5, ASA2, ASA3, ASA4, ASA6, ASA8, ASA10, ASA12, ASA14, ASA16, ASA18, ASA20 and ASA24. In accordance with the ANSI B16.5 Class 150 specification, the opening in the flanges is a little bit larger than the nominal size in inches, ranging from about 1/8 to 3/4 inches larger. However, in the vacuum industry because there is so much extra material it is common to open up the I.D. of the flanges to achieve increased vacuum conductance. It is also the norm that the I.D. of the flanges has been increased to match the next size up of vacuum pump. For example, many ASA6 flanges actually have an opening of 7.9 inches (200mm pump size) and an ASA10 flange can have an opening of 12 inches (12-inch pump size).

Although the ANSI B16.5 spec only covers flanges up to 24 inches in diameter, the same configuration has been used on much larger flanges. Consequently, in the vacuum industry ASA flange size designations of ASA30, ASA36, ASA40, ASA48 and ASA52 are available.

The principle of operation is this: An O-ring groove is cut into one of the two mating flanges. Often, it is a single or double-bevel, dove-tailed groove in order to capture the O-ring and hold it into place. The surface finish of the mating, flat flange must be 32 micro inches RA (0.8 micro meters RA) or better. Then the two flanges are bolted together with the O-ring compressed in the groove between the two.

These flanges are used in the pressure range from atmosphere to as low as $1x10^{-5}$ Torr or mbar, when made from mild steel or $1x10^{-8}$ Torr, or mbar when made from stainless steel. The most common O-ring material is FKM (Viton-A), but Buna-N and Silicon are also available. The leakage and permeability rate of these flanges with FKM is $1x10^{-9}$ std cc/sec of Helium.

The most common material for these flanges is mild steel such as A-36 carbon steel, but 304/304L stainless steel is also popular.

JIS Flanges

The final type of vacuum flange is the JIS flange. JIS stands for the Japanese Industrial Standard. In many ways they are similar to ASA flanges. Visually it can be difficult to tell the difference between a JIS flange and an ASA flange. The way to tell the difference is to check the dimensions against the specification.

The size of a JIS flange is based on the I.D. of the pipe that connects to the flange. Most JIS flanges are metric sizes, but it is possible that a close, similar inch-sized pipe could be welded to the flange. Specification JIS B2220 shows that the flanges range in size from 10mm to 1500mm (approximately 3/8 inch diameter to 60 inches in diameter).

Like ASA flanges, these are based on steam and liquid requirements. They come in operating pressures such a 2 kg/cm^2 (28.5 PSI), 5 kg/cm^2 (71 PSI), and 10 kg/cm^2 (140 PSI). Often these will be referred to as 2K, 5K and 10K flanges. Even a 2K flange is rated for double the operating pressure as compared to

vacuum. In industrial applications there is often a flat rubber gasket that is placed between the two flanges faces; however, for vacuum flanges an O-ring grove is often cut into one of the two flange faces making these a sexed flange coupling.

These flanges are used in the pressure range from atmosphere to as low as $1x10^{-5}$ Torr or mbar, when made from mild steel; or $1x10^{-8}$ Torr, or mbar when made from stainless steel. The most common O-ring material is FKM (Viton-A), but other options are also available. These flanges are commonly made from carbon steel or stainless steel.

For more information on these flanges, or for valves that come with one of these flanges please visit the GNB website at www.gnbvac.com.

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