

Multi-CF™ UHV Vacuum Chambers OVERVIEW

APPLICATIONS:

- Compact and miniature UHV vacuum chambers and housings
- Cold physics applications (where port alignment accuracy is critical)
- Portable low-cost UHV systems
- High-complexity UHV subsystems
- UHV vacuum manipulator systems
- UHV specimen transfer systems
- General UHV vacuum plumbing
- Electron gun / ion source housings
- Detector housings and subsystems
- Feedthrough clusters
- Extreme High Vacuum(XHV) using Titanium Chamber option

FEATURES / OPTIONS:

- ConFlat™ CF port diameters: 1.33", 2.75", 4.5", 6", 8" and 10".
- Precise port alignment of <0.1 degrees
- Easy internal access and port accessibility
- Grabber Groove mounting features on at all sealing surfaces (except 1.33" CF ports)
- Multiple sealing surface configurations cut directly on a hollow sphere
- Unitary stainless steel 316L construction. Titanium custom also available
- Optimized design and surface for UHV conditions

Multi-port CF MCF™ UHV Vacuum Chamber
with Internal Mounting Grooves and Groove
Grabber Mounting eV Part Prototype

Table of Contents		Page
Cover Multi-CF™ UHV Vacuum Chambers OVERVIEW		1
- Applications - Features / Options		
MCF Housings and Chambers		3-9
- Introduction - Design Features - Description - Titanium Option - CNC Fabrication - ConFlat™ Flange Sealing Surfaces	- Double Density Flange Mounting Holes - Internal Mounting (Grabber Groves) - eV Parts - External Mounting - Multiplexers	
MCF Accessories		10-17
- Flange Adapters - Thin Flanges - Close Couplers - Perimeter Weld Flanges - Weldable Clusters	- Flange Crosses - Silver Plated Bolts - CF Gaskets - Custom and Special Request Chambers	
References Notes		18
MCF™ Vacuum Chamber Product Lists		19-21
Figures		
Figure 1 Variety of MCF Chambers Figure 2 Overall Spherical Design Figure 3 Design Elements of Spherical Octagon Figure 4 CNC Fabrication Flange Features Figure 5 Stainless Steel and Titanium Spherical Cube Figure 6 Schematic Section of CF Flange and Gasket Figure 7 Internal Mounting Features Figure 8 Assortment of eV Parts Figure 9 Example of eV Part Fabricated Prototype Figure 10 Example of External Mounting Bracket Figure 11 Flange Multiplexer Figure 12 Flange Adapter Figure 13 Thin Flanges	Figure 14 Close Couplers Figure 15 Perimeter Weld Flange Figure 16 Weldable Cluster Figure 17 Four Way Flange Cross Figure 18 Silver Plated Bolts Figure 19 Silver Plate Bolts 12 Point Figure 20 Nested Copper Gaskets Figure 21 Examples of Planer MCF™ Designs Figure 22 Examples of Spherical Cube Designs Figure 23 Multi-CF™ Number System and Abbreviations Figure 24 Spherical Octagon with Pumping Port Figure 25 Custom Spherical Octagon Chamber	
Tables		
Table 1 CF Port Sizes, Hole Threads, Depths, Number, Port Code (Imperial, Metric)		5, 6
Table 2 Copper Gasket Dimension		11

Introduction

Kimball Physics UHV (Ultra-high Vacuum) Vacuum Chambers are precise, modular, multi-port fittings and housings that utilize integrated Conflat™ (CF) sealing surfaces at each port. We refer to them as MCF™ or Multi-CF™ vacuum chambers or fittings and they are available in several sizes and configurations. These compact designs are generally compatible with most other vacuum fittings in the industry with the bottom line of facilitating the efficient creation of clean reliable vacuum environments.



Figure 1. A small representative selection of Kimball Physics MCF™ chambers including Spherical Octagon, Square, Hexagon, Triangle, and Single and Double Spherical Cube geometries demonstrating the range of features and sizes available.

Kimball Physics' Multi-CF™ UHV fittings are designed as both instrument housings and as vacuum chambers, with the specific design intent to 1) conveniently support a diversity of internal apparatus, 2) permit complex port arrangements, 3) maximize interior functional volume while remaining compact to minimize their external footprint, 4) provide convenient internal access, 5) improve pumping efficiency, 6) follow a modular dimensioning system and 7) cluster together in close proximity.

In addition, the devices maintain compatibility with the existing fittings and accessories available from most manufacturers. The efficient and compact design enables improved

instrument performance, lighter systems, better structural rigidity, smaller pumping systems, easier portability, and almost always lower total cost.

With a paradigm shift in the design and manufacturing of UHV vacuum structures, Kimball Physics brings innovation, precision and quality to vacuum chambers and housings for your research, applications, and advanced technologies

Design Features

The overall shape of the chamber housing is generally based on a hollow spherical geometry, with the outer surface, excluding the ports, convex and with the inner surface generally concave (Figure 2).

The next level of structure in the chamber design incorporates various geometric configurations to provide a wide array of options for your system design. For example, the ports can be arranged in various planer geometries such as triangles, squares, pentagons, hexagons, octagons, dodecagons and three-dimensional configurations such as cubes (Figures 1, 21, 22).



Figure 2. Spherical Octagon Multi-CF™ chamber with hollow sphere overlay to illustrate the underlying spherical structure of the design.

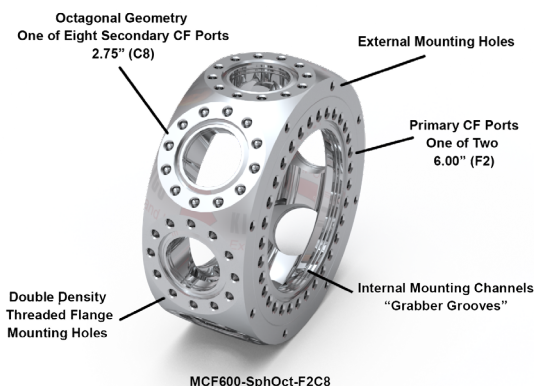


Figure 3. Spherical Octagon demonstrating planer octagonal geometry with annotations highlighting double density threaded flange holes, grabber grooves (internal mounting channels), and external mounting holes.

As an example, a 6.00" Spherical Multi-CF™ Octagon vacuum chamber (MCF600-SphOct-F2C8) has two large primary 6.0" (F) CF sealing ports that are symmetrically and concentrically placed. (Please see Figure 3)

In the planer section, a series of 8 2.75" (C) CF ports are perpendicular to the plane and equally spaced to provide an octagonal geometry of CF sealing ports. Overall, the vacuum chamber includes 10 ports.

Of course, there are exceptions to this general form with numerous other design variations, and where space is available, additional smaller ports that have and can be added. We often joke that the diversity of designs is the result of physicists running amuck with advanced CAD software and CNC machines. With kidding aside, the innovation in these designs emerged from a necessity for parts that simply didn't exist. The results have led to an innovative and strategic series of UHV hardware components for chambers, housings and in-vacuum apparatus.

The Multi-CF™ structure has minimal internal welds, smooth contoured surfaces, and highly polished surfaces to provide optimal conditions for ultra-high (UHV) and with the titanium option, extreme high (XHV) vacuum conditions.

The CF sealing ports are available in standard sizes with diameters and letter designation codes of 1.33"(A), 2.75"(C), 4.5"(E), 6"(F), 8"(G) and 10"(H). (see Table 1)

Description

The Multi-CF™ chambers are typically fabricated from a monolithic or single piece of 316L stainless steel with the CF sealing surfaces directly machined into this main or primary structure.

This design approach optimizes 1) weight to structure (with high stiffness and resonant frequency), 2) the functional internal volume with minimized internal surface area and outgassing in high vacuum experiments, and 3) reduced external dimension for a given functional internal volume.



Figure 4. CNC fabrication in progress of flange features, with CF flange recess, knife edge, internal "grabber groove" channels being fabricated.

This efficient use of volume minimizes unusable internal space and allows more efficient pumping while also minimizing the components external dimension footprint.



Figure 5. Spherical Cube Multi-CF™ Stainless Steel 316L (left) and Titanium Alloy (right) Spherical Cube UHV Vacuum Chambers with six (6) 2.75" (C) ports and eight (8) 1.33"(A) additional ports.

Titanium Option

Custom chambers of similar configurations can also be fabricated from various grades of titanium (Figure 5). Titanium chambers, although more expensive, add additional benefits including very low magnetic permeability and minimized outgassing of hydrogen when pumping to extreme vacuum (XHV) levels. With titanium about half the density of stainless steel and similar in structural properties, the systems are also significantly reduced in weight.

CNC Fabrication

As previously noted, these monolithic structures

are fabricated from a single piece of metal stock using advanced CNC technology. This fabrication approach allows for the efficient use of material volume and structure in these configurations when compared to other structures in the industry that are typically fabricated from multiple component pieces that have been welded together. A high level of precision is possible with these manufacturing techniques, with port alignment typically within 0.1 degrees.

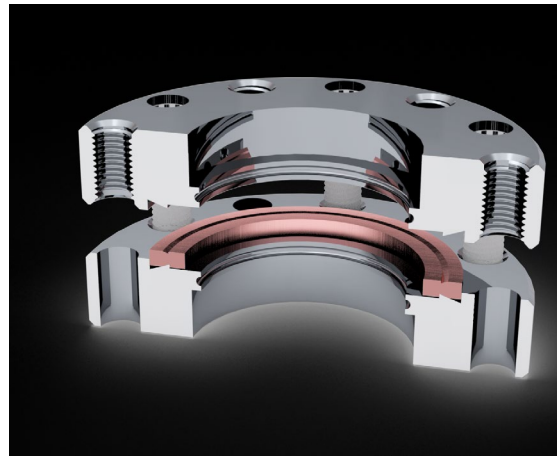


Figure 6. Schematic section view of CF flanges that were initially engaged and then separated to illustrate the sealing surfaces and the sealing groove created in the malleable copper gasket by the knife edges in the recess of the CF flanges.

Table 1 Imperial: Standard Imperial Bolt Multi-CF Chambers.

CF Port Size (inches)	*DN	**Hole Thread	***Threaded Hole Depth	Number of Holes	Port Size Code
1.33"	DN 16	#8 - 32	(0.24")	12	A
2.75"	DN 35/45	1/4" - 28	(0.42")	12	C
4.5"	DN 63	5/16"-24	(0.52")	16	E
6.0"	DN 100	5/16"-24	(0.52")	32	F
8.0"	DN 150/160	5/16"-24	(0.52")	40	G
10.0"	DN 200	5/16"-24	(0.52")	40	H

Notes:

* European and Asian Size approximation. Note that Kimball Physics' port internal bore dimension is slightly increased from conventional CF designs but are in most cases are still fully compatible.

** Hole Thread - For 1.33" flange ports, the Allen head bolt, #8- 32 (#8 or approximately 5/32 or 0.16" is the bolt nominal diameter and 32 is the number of threads per inch) is used. Twelve-point head bolts, 1/4" - 28 for 2.75" flanges and 5/16"-24 are used for the 4.5", 6.0", 8.0" and 10" flanges.

*** Hole Depth dimensions provided. Bolt length engagement into Stainless Steel is satisfactory when at least 1 bolt diameter of depth length is engaged

- Use silver plated bolts or similar lubrication to reduce friction during bolt placement and prevent thread galling.

CAUTION: User should carefully determine appropriate bolt length based on the flange (to be attached) thickness and the depth of the CF port bolt hole. It is recommended that the user confirm their anticipated bolt length on the actual parts by determining the total bolt depth with a caliper depth measurement. If the bolt is "too long", it will "bottom out" during the tightening process and strip the threads!! In some circumstances, the exact bolt length may not be available and will need to be cut to an appropriate length.

Table 1 Metric: Metric Bolt Multi-CF Chambers.

CF Port Size (inches)	*DN	Hole Thread	**Threaded Hole Depth	Number of Holes	Port Size Code
1.33"	DN 16	M4 x 0.7	6.1 mm	12	A
2.75"	DN 35/45	M6 x 1.0	10.7 mm	12	C
4.5"	DN 63	M8 x 1.25	13.2 mm	16	E
6.0"	DN 100	M8 x 1.25	13.2 mm	32	F
8.0"	DN 150/160	M8 x 1.25	13.2 mm	40	G
10.0"	DN 200	M8 x 1.25	13.2 mm	40	H

Notes:

Kimball Physics Multi-CF Chambers can be *custom* fabricated to substitute *Metric* bolt holes for the standard *Imperial* bolt hole sizes. This table provides the bolt sizes used and the depth of the flange holes in metric units.

* European and Asian Size approximation. Note that Kimball Physics' port internal bore dimension is slightly increased from conventional CF designs but are in most cases are still fully compatible.

**Hole Depth dimensions provided. Bolt length engagement into Stainless Steel is satisfactory when at least 1 bolt diameter of depth length is engaged

- Use silver plated bolts or similar lubrication to reduce friction during bolt placement and prevent thread galling.

****CAUTION:** User should carefully determine appropriate bolt length based on the flange (to be attached) thickness and the depth of the CF port bolt hole. It is recommended that the user confirm their anticipated bolt length on the actual parts by determining the total bolt depth with a caliper depth measurement. If the bolt is "too long", it will "bottom out" during the tightening process and *strip the threads!!*. In some circumstances, the exact bolt length may not be available and will need to be cut to an appropriate length.

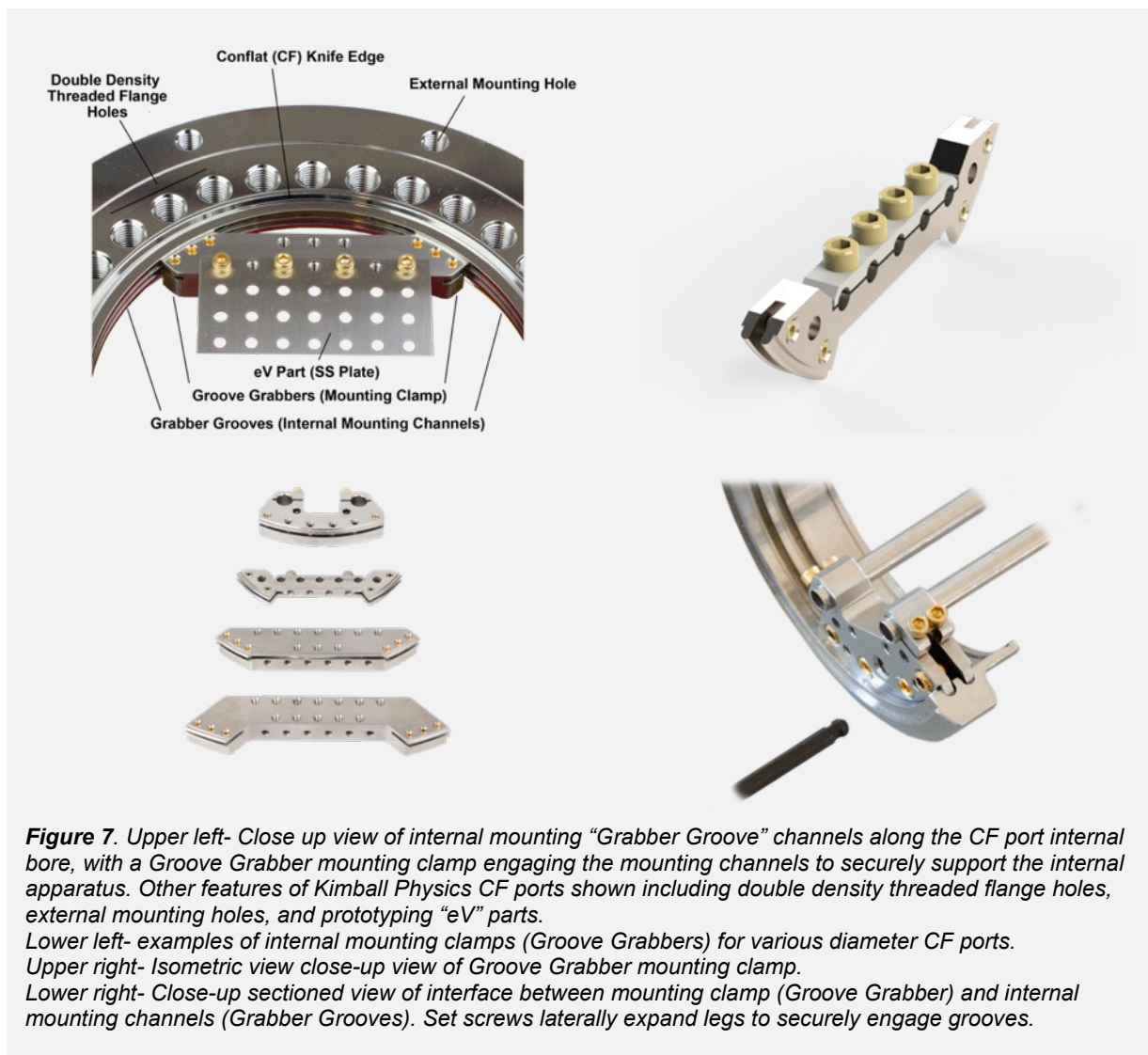


Figure 7. Upper left- Close up view of internal mounting “Grabber Groove” channels along the CF port internal bore, with a Groove Grabber mounting clamp engaging the mounting channels to securely support the internal apparatus. Other features of Kimball Physics CF ports shown including double density threaded flange holes, external mounting holes, and prototyping “eV” parts.
 Lower left- examples of internal mounting clamps (Groove Grabbers) for various diameter CF ports.
 Upper right- Isometric view close-up view of Groove Grabber mounting clamp.
 Lower right- Close-up sectioned view of interface between mounting clamp (Groove Grabber) and internal mounting channels (Grabber Grooves). Set screws laterally expand legs to securely engage grooves.

ConFlat® Flange Sealing Surfaces

The ConFlat® flange (CF) sealing surfaces are machined directly into the global structure. This sealing surface, which utilizes a knife-edge geometry, is used with an interposed malleable copper gasket, and provides both a seal and a structural and stable connection between the flanges of various components. Predictable seals for ultra-high vacuums (UHV) and even extremely high vacuums (XHV) that accompany very low pressure ($< 10^{-11}$ torr) applications can be reliably obtained over a broad range of temperatures.

The Multi-CF™ inside port diameters (bore diameter) in Kimball Physics components have been slightly enlarged from conventional

designs to allow better access to the chamber's internal volume and also increase conductance, allowing for more efficient vacuum pumping. These improved port features are still compatible with standard CF sealing surfaces while maintaining their structural and sealing integrity.

Other features of our vacuum chambers that optimize UHV and XHV applications include highly polished mirror-like surfaces, with smooth rounded contour surfaces to minimize internal surface area and with few or no welds within the vacuum space (any welds present are welded from the inner surface). Our distinctive appearance is well-known throughout the

industry and attests to the highest levels of precision, quality and function.

Double Density Flange Mounting Holes

A circumferential array of double density threaded holes is typically associated with the flange port of each CF sealing surface port when size allows (Figure 6). This enables the chambers to be clocked or rotated in smaller angular increments and also provides redundancy (e.g. if there is a problem with a bolt and it damages the thread).

The holes are typically available with Standard thread (UNC, UNF), but *metric threads* are also available on request. Please see Table 1 above.

Although there are twice as many holes, only half of the holes are typically used to secure the adjacent flange. These added holes also allow for the adjacent chambers to be mounted in similar orthogonal orientations when directly connected to each other using Kimball Physics' Close Coupling Fittings. We discuss Close Couplers in more detail later in this document.

Internal Mounting

Internal circumferential channels, that we refer to as Grabber Grooves, are typically present along the inside bore of the CF aperture in ports with sealing surfaces greater or equal than 2.75" inches in diameter (Figure 7). The Grabber Grooves are used to securely attach (mount) various devices and apparatus to the inside of the chamber using Grove Grabber mounting clamps / connectors.

The Grabber Grooves typically have the same cross-sectional dimension in all flange diameters allowing for some interchange of Groove Grabber connectors as the port diameter allows.

Mounting flanges and flange adapters are also available that can be attached to other manufacturers' CF fitting to provide grabber grooves and external mounting channels when

there are no integrated mounting grooves available in the chamber structure (discussed later in this document).

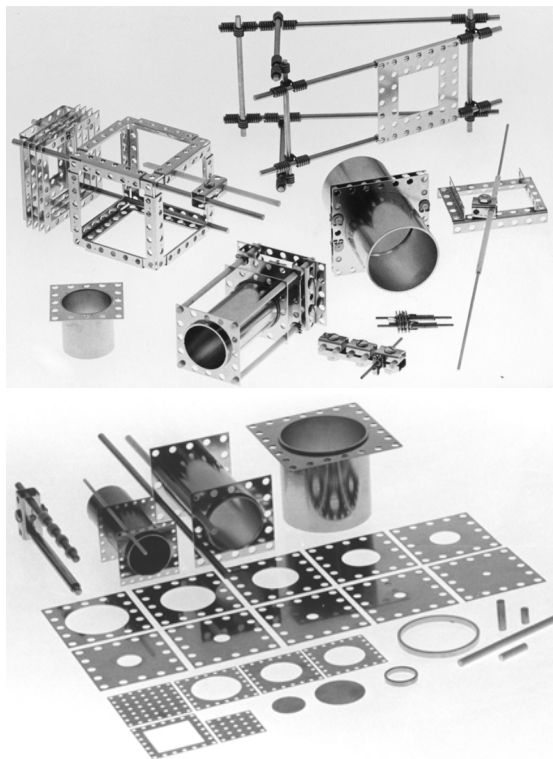


Figure 8. Assortment of various metallic and ceramic eV Parts available for mounting your apparatus or creating prototype devices.

eV Parts: Modular Components for Vacuum and Electron / Ion Beam System Prototyping and Apparatus

To provide numerous options to mount your apparatus using the internal mounting channels or grabber grooves inside the MCF chamber housing, or to construct a custom prototype or functional device, we have a complete line of "eV Parts", which are often referred to as a virtual "erector or play set" for scientists (Figures 8, 9).

eV Parts are a group of 350+ standardized parts, including ceramic and metal rods, perforated plates in various geometries, and a variety of fasteners and other parts that enable construction of all types of surface physics and

high vacuum apparatus. These versatile parts are made from high quality materials to build rigid, self-supporting, self-aligning and dimensionally stable assemblies that allow accurate alignment of lenses, slits and apertures. They interface to our mounting connectors (groove grabbers) and also enable you to create custom prototype devices, or interfaces to your own devices and securely mount them inside the chambers. These eV parts save time and money by bypassing the need to design and custom machine these parts. Please refer to our website (eV Parts Section) for a more in depth discussion of the scope and capabilities of this product.

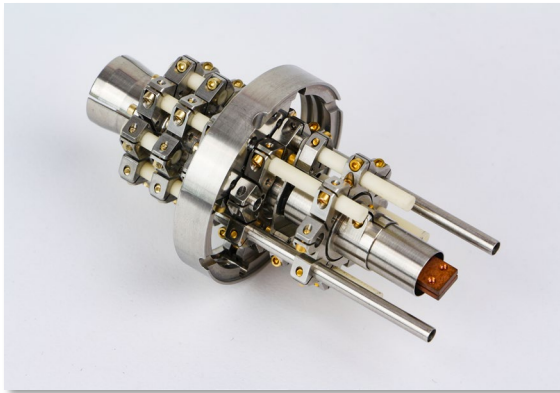


Figure 9. Example of prototype electron gun with cathode mount, anode and simple deflection optics fabricated with eV parts.

External Mounting

ConFlat™ CF fitting vacuum chambers are frequently supported or mounted to an optical bench or apparatus by placing auxiliary mounting brackets under the bolt heads of the flange gasket compression bolts. Unfortunately, the varying loads on the brackets can cause non-uniform loading on the bolts, which in turn causes variable loads on the gasket that may reduce seal uniformity and reliability.

Kimball Physics has several alternatives to enable external mounting without compromising the CF gasket seal integrity. These include 1) additional threaded holes on the external surface of MCF chambers (Figure 7), 2) external

channels on the MCF chambers to independently engage the mounting structures (Figure 10), or 3) mounting flanges with an outer diameter circumferential channel to engage mounting brackets (Figure 12).

When space is available, many of the MCF designs will have independently placed threaded anchorage points that are not involved in gasket compression. This provides an ideal solution for external mounting. Bakeout heaters can also be attached by means of these extra holes (Figure 7).

Also, when space is available, externally placed channels can be integrated into the MCF surface and provide favorable structure for external mounting brackets without placing any loads on the sealing surface (Figure 10)

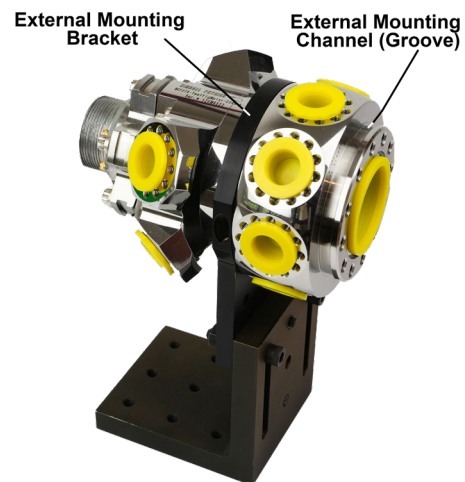


Figure 10. Spherical Octagon with bilateral mounting channels with External Mounting Bracket engaged. Temporary port covers are in place to protect CF surfaces including their knife-edges.

When the CF port sealing flanges are the only source for mounting, mounting flanges are available with circumferential channels that allow the external mounting bracket to engage the outer diameter of the flange while enabling access to the attachment bolts. The load to support the system is more evenly distributed to the entire circular flange, allowing the bolts to be uniformly tightened with more consistent compression of the flange knife-edge into the copper gasket sealing surface (Figure 12).

Multiplexers

The original multiplexer design (unpatented) was developed at Kimball Physics in 1983. The objective was to allow many smaller ports to merge and be connected to a single larger port. This requirement is frequently encountered to accommodate the several feedthroughs that are needed to connect with the apparatus within the chamber.

The Flange Multiplexer (MCF275-FlgMplxr-Cr1A5) is an evolution of our original design and includes five (5) 1.33" (A) CF ports which merge into a single rotatable 2.75" (C) CF port. The new design incorporates several new features, including: 1) a rigid unitary construction where only one weld (of previous eight) remains, 2) the inclusion of high strength Grabber Groove technology for internal mounting capability, 3) improved port alignment accuracy, and 4) better UHV cleanliness.



Figure 11. Flange multiplexers that provide additional ports that can be added to a single CF port.

Two sets of bolt holes are provided, one tapped and one clear, to allow the user to choose the mode of attachment of the base (the base may have either threaded or clear holes). The bolt ring is confined such that it cannot slide axially back from the sealing surface; thus the sealing surface is not exposed to damage (as is the case with ordinary rotatable flanges).

MCF Chamber Accessories

Flange Adapters

Flange Adaptors are available to interface with CF fittings from Kimball Physics and other manufacturers to provide 1) internal mounting capabilities (Grabber Grooves), 2) external mounting capabilities, 3) tilt of the port aperture, and 4) reduction in the port aperture diameter.

Flange Adaptors permit the Grabber Groove internal attachment system and external mounting channels to be added to ports of sizes 2.75", 4.5", 6.0", 8.0" on systems from Kimball Physics and other manufacturers that utilize CF sealing surfaces. The grabber grooves provide versatile and stable means to mount hardware within the vacuum space. The flange adapter also provides an outside diameter channel that can be used for external mounting brackets (Figure 12).

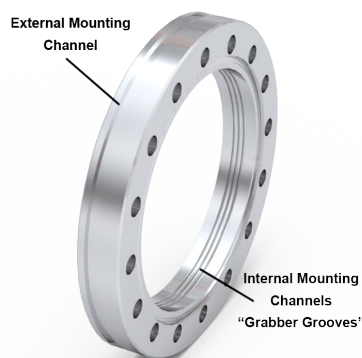


Figure 12. Flange adapter that interfaces to CF sealing surfaces to also provide additional internal and external mounting channels.

Tilt adapters are also available and were initially created for laser applications where it can be advantageous to have a viewport tilted off axis to avoid damage due to reflected beams. Angles of 2 and 4 degrees are available standard with custom angles up to 10 degrees available upon request.

Flange adapters are also available to reduce the port size diameter while providing both external and internal mounting features.

Thin Flanges

The Thin Flange is a new type of UHV CF flange designed for in-vacuum mounting to provide versatile solutions to standard Conflat™ CF ports (Figure 13). The Thin Flange can either have an open bore to 1) to bring grabber grooves to a port for in-vacuum mounting or to be used as a spacer, or 2) they can be solid and allow the flange to be custom machined to include various mounting holes or for a custom-sized apertures for various applications such as calibration of pumping speed, determining the outgassing rate of a chamber, differential pumping, and the ability to provide a platform for mounting experimental apparatus.

The Thin Flange also provides an easy method for inserting a phosphor screen RHEED screen or similar detector in front of a vacuum window.



Figure 13. Thin Flanges in various sizes, thickness, with open internal bores or solid plates.

The Thin Flange design has CF recesses with knife-edges on both sides to typically interface with the malleable copper gaskets. They can be inserted between two common CF style flanges from almost any manufacturer and are available in 1.33" CF, 2.75" CF, 4.5" CF, 6.0" CF and 8.0" CF port sizes. Two thicknesses are available: 0.175 inch and 0.400 inch. The 0.400 inch open bore flanges include one pair of

Grabber Grooves on sizes of 2.75" CF or larger. The thinner 0.175 inch flanges are not thick enough to include Grabber Grooves.

The existing system flange bases on either side of the Thin Flange provide the bending resistance necessary to have a uniform crushing force along the gasket perimeter, with even and symmetric forces on the interposed thin flange component when the bolts are tightened. The gasket crushing bolts pass through the Thin Flange clear holes without putting any force on it. Thus, the Thin Flange does not experience any bending moments, and has no minimum required thickness to prevent bending.

Close Couplers

Close Couplers are narrow two-port Multi-CF Fittings, consisting of a machined thick-wall cylinder, with opposing same-sized CF sealing surfaces (1.33", 2.75", or 4.5" for the non-rotatable couplers). The Close Coupler minimizes overall distance in joining two tapped hole flange components, resulting in the shortest possible distance between them (Figure 14).

The close coupler with non-rotatable flanges is based on the angular staggering of oppositely directed (180° reversed) bolts. By reducing the flange thickness under the bolt head while still maintaining adequate rigidity (based on the machined thick-walled cylinder), it possible to use slightly shorter bolts that can be placed into the coupler holes in alternating directions with access still available to tighten the bolts into the threaded flanges.



Figure 14. Close Couplers with various available spacing dimension to allow chambers to be joined in close proximity.

With this approach, the two CF structures can connect with a minimum interposed distance. If the structures being joined have a double

density hole pattern, as found in our Kimball Physics 2.75", 4.5", 6.0", 8.0" and 10.0" MCF ports, the angular orientation of the structures can be similar. We also include internal mounting "Grabber Grooves" in these structures.

If your application requires joining two structures that have the conventional hole pattern (not the double density pattern), the structures will be rotated with respect to each other one-half the angular spacing between the bolts in the pattern unless they have rotatable flanges.

If it is preferred that the two adjacent structures with conventional bolt patterns and with no rotatable flanges are to be joined in the same angular orientation, this can be accomplished with Kimball Physics Rotatable Close Coupler, which provides the ability to rotate one of the flange surfaces and allows for increased flexibility in placing the bolts, assembling fittings and in adjusting systems after assembly.



Figure 15. Perimeter Weld Flange which includes double density hole array and both internal and external mounting channels.

Perimeter Weld Flanges

Perimeter Weld Flanges are weldable UHV CF flanges available at Kimball Physics. The flange contains the CF sealing surface with a circular double density tapped hole array. (Figure 15). The circular base is typically welded to spherical chamber's surface to provide a prefabricated port sealing surface. However, they also may be welded to tubes, cones, ellipsoids, plates, and other shapes. By placing the weld lip on the outer perimeter of the flange, it is possible to significantly improve access to the interior of a system, while simultaneously reducing overall size. Each 2.5" or larger flange has one or more pair of internal mounting Grabber Grooves. They also include external outside diameter channels for external mounting capability.

Weldable Clusters

Weldable Clusters provide the option of attaching a multiple CF sealing surfaces to an instrument housing or vacuum chamber (Figure 16).

The structure is CNC machined from a unitary piece of 316L Stainless Steel and provides exceptional internal volume and access. The base consists of a 6" weldable port on the structure's main axis that can be attached to a 6" tube or a 6" CF flange (with some preparation). The port transitions to a 4.5" port on the original axis and there are two options for additional ports, 1) two angled 2.75" CF ports or 2) four angled 2.75" CF ports. The 2.75" and 4" ports include double density holes and circumferential internal mounting channels (Grabber Grooves). These structures provide a

Table 2-. Copper Gasket Dimensions

Copper MCF™ High Clearance Gasket	Part #	Thickness	Outside Diameter	Inside Diameter
1.33"	50-100019 (pkg 10)	0.080" +/- 0.003"	0.838" +/- 0.002"	0.640" +/- 0.003
2.75"	50-120009 (pkg 10)	0.080" +/- 0.003"	1.895" +/- 0.002"	1.530" +/- 0.003
4.5"	50-130019 (pkg 10)	0.080" +/- 0.003"	3.243" +/- 0.002"	2.910" +/- 0.003
6.0"	50-140019 (pkg 10)	0.080" +/- 0.003"	4.743" +/- 0.002"	4.310" +/- 0.003
8.0"	50-150019 (pkg 10)	0.080" +/- 0.003"	6.743" +/- 0.002"	6.310" +/- 0.003
10.0"	50-160019 (pkg 10)	0.080" +/- 0.003"	8.743" +/- 0.002"	8.310" +/- 0.003

versatile solution to add multiple port CF access to your instrument housing or vacuum structure



Figure 16. A Weldable Cluster with prefabricated CF sealing ports that can be welded to a system to provide compact multiport access.

Flange Crosses

Two way and four-way flange cross fittings are a compact solution to provide multiple ports in a small region, in essence a miniature vacuum chamber (Figure 17). The fittings are CNC fabricated from a unitary 316L SS structure and are available with either 4 CF sealing ports (2- 2.75" and 2-1.33") or 6 CF ports (2- 2.75" and 4- 1.33"). The 1.33" ports contain double density threaded bolt holes and all 2.75" ports include internal mounting channels or Grabber Grooves.



Figure 17. Example of a Compact Four Way Flange Cross fitting with mounted accessories including a viewing port and flange port covers in place.

Silver Platted Bolts

Low friction silver plated machine bolts, with 12-point heads (12-point flange head cap screw),

are typically used on ports of 2.75" and greater and allow wrenches with smaller head dimensions to be used in limited spaces to advance the bolt in smaller angular increments to torque the bolts (Figures 18 and 19).

It is essential that the correct bolt diameter, thread pitch and length are chosen to prevent the screw from unintentionally "bottoming out". Low friction silver surface bolts are used to minimize the chance of the screw inappropriately binding (galling) or breaking.



Figure 18. Low friction silver plated bolts with 12-point heads.

Three basic bolt sizes (diameters and thread pitches) are typically used with Kimball Physics' vacuum hardware (Table 1). For 1.33" flange ports, the Allen (Hex Head Cap Screw) head bolt, #8- 32 (#8 or approximately 5/32 or 0.16" is the bolt nominal diameter with 32 threads per inch) is used. Twelve-point head bolts, 1/4"- 28 for 2.75" flanges and 5/16"-24 are used for the 4.5", 6.0", 8.0" and 10" flanges.

Silver plated bolt lengths are available in various sizes from Kimball Physics and other manufacturers. It is important to carefully calculate the total bolt length required by first measuring the thickness of the flange(s) being attached to the sealing surface, and then adding the estimated depth of the bolt entering the threaded hole. As a first estimate, it is recommended that at least 1 bolt diameter in length engages the stainless steel threaded hole. The total depth of the flange holes are approximately two "bolt diameters". Please refer to the specifications of the flanges for more detailed information and use a digital caliper to confirm the thickness dimensions of flanges, the

depths of threaded holes, and bolt lengths.



Figure 19. Silver plated bolts (#8-32, 1/4"-28 and 5/16"-24) used to secure flanges in a typical vacuum system. Allen hex heads with #8-32 bolts, and 12-point heads (1/4"-28, 5/16"-24) are present. Wrench in place to finish tightening 1/4"-28 bolt in limited space of a close coupler flange.

Please note that metric bolts, used for specially requested metric MCF™ systems, are not available with 12 point heads, whereby the user may encounter more limited tool access to the socket head cap screws on metric bolts, especially notable in Close Coupler fittings.

CF Gaskets

Malleable copper gaskets provide the sealing surface between the CF flanges of a vacuum system. Diametrically opposed knife-edges create a clean fresh groove into the gasket to provide a durable and high vacuum seal. (Figures 6, 20).

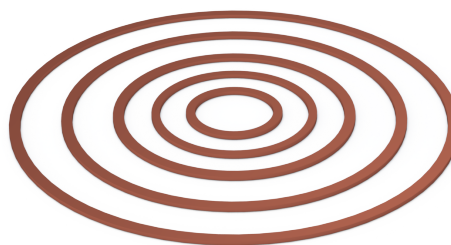


Figure 20. Nested copper gaskets for CF ports of 1.33", 2.5", 3.75, 4.5", 6.0", 8.0" and 10.0" are shown for size comparison of CF port apertures. The gasket thickness, 0.080" remains constant.

The copper surface is clean and free of contaminants and UHV compatible with high vacuum conditions over a broad temperature range. Table 2 gives an overview of the typical copper gasket dimensions that are used. Using Kimball Physics MCF™ vacuum chambers with expanded port internal diameter (ID) dimensions (for improved physical access and pumping conductance), "high clearance" gaskets that include a slightly expanded inside diameter (ID) dimension is recommended and available at Kimball Physics.

Custom and Special Request Chambers and Instrument Housings

If you don't see the MCF™ vacuum chamber or housing that you need for your application, please reach out to Kimball Physics to engage our specialists if you may need a custom design for your specific application. A significant portion of our MCF™ chambers and instrument housings are designed and manufactured for the specific needs of our customers.

And although our MCF™ chambers and accessories come with Standard Imperial CF port dimensions and bolt threads, metric sizes are also available upon request.

Figure 21. Examples of MCF™ Designs: Triangle, Square, Pentagon, Hexagon, Octagon, Dodecagon, Pumping Port

		
Spherical Triangle MCF275-SphTri-A5	Spherical Square MCF600-SphSq-F2C4A8	Spherical Square with Rotatable Port MCF450-SphSq-E2C3r1A4
		
Spherical Pentagon MCF600-SphPent-F2C5	Spherical Hexagon MCF275-SphHex-C2A6	Spherical Octagon MCF450-SphOct-E2A8
		
Double Spherical Octagon MCF600-DbISphOct-F2C16	Spherical Octagon with Pumping Port MCF600-SphOct-F2E1C7	Spherical Dodecahedron MCF1000-Sphdodecagon-H2C12

Notes:

- 1) Images are not to scale. Please see Figure 23 for translation of Product Code to Port Dimensions
- 2) Designs shown are only a limited representation of the possible geometries and sizes available.

Figure 22. Examples MCF™ 3D Designs: Spherical Cube, Double Spherical Cube, Expanded Spherical Cube

		
Spherical Cube <i>MCF133-SphCube-A6</i>	Double Spherical Cube <i>MCF133-DbISphCube-A10</i>	Spherical Cube <i>MCF275-SphCube-C6</i>
		
Expanded Spherical Cube <i>MCF275-SphCube-C6A8_Exp</i>	Expanded Spherical Cube <i>MCF450-SphCube-E6A8</i>	Expanded Spherical Cube <i>MCF450-SphCube-E6C8A12</i>
<p>Notes:</p> <p>1) Images are not to scale. Please see Figure 23 for translation of Product Code to Port Dimensions</p> <p>2) Designs shown are only a limited representation of the possible geometries and sizes available.</p>		

Figure 23. Multi-CF™ Numbering System and Abbreviations

MCF
Multi-Port ConFlat™
(CF) Vacuum
Chamber

MCF XXX-TYPE-ZZZZ

XXX
Largest Port Size:
133 = 1.33"
275 = 2.75"
450 = 4.50"
600 = 6.00"
800 = 8.00"
1000 = 10.00"

TYPE

Abbreviation	Full Description
ClsCplr	Close Coupler
FlgAdpr	Flange Adapter
FlgCross	Flange Cross
FlgMplx	Flange Multiplexer
GrvGrb	Groove Grabber
PWeldFlg	Perimeter Weld Flange
SphCube	Spherical Cube
SphHex	Spherical Hexagon
SphOct	Spherical Octagon
SphPent	Spherical Pentagon
SphSq	Spherical Square
SphTri	Spherical Triangle
SphDodecagon	Spherical Dodecagon
SphDecagon	Spherical Decagon
ThnFlg	Thin Flange
WeldClstr	Weldable Cluster
ExtOct	Extended Octagon
DblSphCube	Double Spherical Cube
DblSphOct	Double Spherical Octagon

ZZZZ

Port Code	Port Size
A	1.33"
C	2.75"
E	4.50"
F	6.0"
G	8.0"
H	10.0"

Other Codes	Feature
r	rotatable
c	clear

Examples



	MCF1000-SphOct-H2C8	Spherical Octagon (2) 10.0" (H) CF Ports (8) 2.75" (C) CF Ports
	MCF450-SphCube-E6C8A12	Spherical Cube (6) 4.50" (E) CF (8) 2.75" (C) CF (12) 1.33" (A) CF



Figure 24. 6.0" MCF™ UHV Spherical Octagon with (2) 6.0" ports, (1) 4.5" high conductance welded, non-rotatable pumping port and additional (7) 2.75" ports. External mounting bracket capable with (8) threaded holes on each 6.0" flange face. Grabber grooves for internal mounting are present on all ports.



Figure 25. Custom 12" MCF™ Spherical Octagon vacuum chamber with 1) enlarged ports with increased conductance for better pumping efficiency and 2) offset port surfaces for specific design requirements.

References

For more information about Multi-Port CF (MCF™) Vacuum Chambers and Accessories, visit our website at: Multi-CF Hardware

Other References:

MCF Vacuum Chambers Overview (Vacuum Chambers and Accessories)

MCF Design Theory and Part Numbering System- Multi-CF Hardware

Spherical Octagon- Multi-CF Hardware

Spherical Cube- Multi-CF Hardware

Spherical Hexagon- Multi-CF Hardware

Thin Flange- Multi-CF Hardware

Close Coupler (non-rotatable)- Multi-CF Hardware

Several of the design features in our MCF™ products are covered under Kimball Physics U.S. Patents: 5,593,123; 5,625,947; 5,660,418; 5,671,956; 6,270,945; 6,678,937; 7,216,899; 8,191,901; 8,695,987

Notes:

1. Tables show typical dimensions and parameters, data is for guidance only.

2. Specifications Subject to Change Without Notice.

3. DE Altobelli, DT Taylor 03/27/2024; DE Altobelli 1/29/2025

Document: MCF_Vacuum_Chambers_Overview_2025_0129

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MCF™ Product Lists

Category	Product Description	Model	Other Features	Port Code, Dimension (inches) and Number of Ports					
Spherical Cube				A 1.33"	C 2.75"	E 4.5"	F 6.0"	G 8.0"	H 10.0"
	1.33" Spherical Cube	MCF133--SphCube-A6		6					
	1.33" Spherical Cube Double	MCF133--DblSphCube-A10	Double	10					
	2.75" Spherical Cube	MCF275-SphCube-C6			6				
	2.75" Spherical Cube Alt Config 1	MCF275-SphCube-C5A4	Alt Config 1	4	5				
	2.75" Spherical Cube Alt Config 2	MCF275-SphCube-C4A8	Alt Config 2	8	4				
	2.75" Spherical Cube Expanded	MCF275-ExpCube-C6A8	Expanded	8	6				
	2.75" Spherical Cube Double	MCF275-DblSphCube-C10-A	Double		10				
	4.5" Spherical Cube	MCF450-SphCube-E6				6			
	4.5" Spherical Cube	MCF450-SphCube-E6A8		8		6			
	4.5" Spherical Cube Expanded	MCF450-SphCube-E6C8	Expanded		8	6			
	4.5" Spherical Cube Expanded	MCF450-SphCube-E6C8A12	Expanded	12	8	6			
	6.0" Spherical Cube Expanded	MCF600-SphCube-F6	Expanded				6		
	6.0" Spherical Cube Expanded	MCF600-SphCube-F6C8	Expanded		8		6		
	6.0" Spherical Cube Expanded	MCF600-SphCube-F6C8A24	Expanded	24	8		6		
	8.0" Spherical Cube Expanded	MCF800-SphCube-G6C8			8			6	
Notes	-Background Image: MCF450-SphCube-E6C8A12								

Category	Product Description	Model	Other Features	Port Code, Dimension (inches) and Number of Ports					
Spherical Octagon				A 1.33"	C 2.75"	E 4.5"	F 6.0"	G 8.0"	H 10.0"
	2.75" Spherical Octagon	MCF275-SphOct-C2A8	Ext Mnt Cap	8	2				
	4.5" Spherical Octagon (Clear Holes)	MCF-450_SphOct-Ec2A8	Clear Holes	8	2				
	4.5" Spherical Octagon (Tapped Holes)	MCF-450_SphOct-E2A8	Tap Holes	8	2				
	6.0" Spherical Octagon	MCF-600-SphOct-F2C8			8		2		
	6.0" Double Spherical Octagon	MCF600-DblSphOct-F2C16	Double		16		2		
	6.0" Spherical Octagon Pumping Port	MCF-600-SphOct-F2E1C7	Pumping Port		7	1	2		
	8.0" Spherical Octagon	MCF800-SphOct-G2C8			8			2	
	8.0" Extended Spherical Octagon	MCF800-ExtOct-G2C8	Extended		8			2	
	8.0" Extended Spherical Octagon	MCF800-ExtOct-G2C816	Extended	16	8			2	
	10.0" Spherical Octagon	MCF1000-SphOct-H2C8			8				2
Spherical Triple Octagon									
	2.75" Spherical Triple Octagon	MCF275-SphTrpOct-c18			18				
	2.75" Spherical Triple Octagon	MCF275-SphTrpOct-Cr2A16	Rotatable	16	2 (r)				
Notes	-Background Image: MCF600-SphOct-F2C8 r = rotatable								

Category	Product Description	Model	Other Features	Port Code, Dimension (inches) and Number of Ports					
Spherical Square				A 1.33"	C 2.75"	E 4.5"	F 6.0"	G 8.0"	H 10.0"
	4.5" Spherical Square	MCF450-SphSq-E2C4			4	2			
	4.5" Spherical Square Rotatable	MCF450-SphSq-E2C3r1A4	Rotatable, Pumping Port	4	3+1r	2			
	6.0" Spherical Square	MCF600-SphSq-F2C4A8		8	4		2		
	6.0" Spherical Square	MCF600-SphSq-F2E4A4		4		4	2		
	6.0" Spherical Square	MCF600-SphSq-F2E4A8		8		4	2		
	8.0" Spherical Square	MCF800-SphSq-G2E4				4		2	
	8.0" Spherical Square	MCF800-SphSq-G2E4C4			4	4		2	
	8.0" Spherical Square	MCF800-SphSq-G2E4C4A16		16	4	4		2	
	8.0" Spherical Square	MCF800-SphSq-G2F4					4	2	
Notes	-Background Image: MCF600-SphSq-F2C4A8								

Category	Product Description	Model	Other Features	Port Code, Dimension (inches) and Number of Ports					
Spherical Triangle				A 1.33"	C 2.75"	E 4.5"	F 6.0"	G 8.0"	H 10.0"
	1.33" Spherical Triangle	MCF133-SphTri-A5		5					
	2.75" Spherical Triangle	MCF275-SphTri-C5			5				
Spherical Pentagon									
	6.0" Spherical Pentagon	MCF600-SphPent-F2C5			5		2		
	6.0" Spherical Pentagon	MCF800-SphPent-F2C5A2		2	5		2		
Spherical Hexagon									
	6.0" Spherical Square	MCF600-SphSq-F2C4A8		8	4		2		
	6.0" Spherical Square	MCF600-SphSq-F2E4A4		4		4	2		
	6.0" Spherical Square	MCF600-SphSq-F2E4A8		8		4	2		
Spherical Decagon									
	8.0" Spherical Decagon	MCF800-SpDecG2C10			10			2	
Spherical Dodecagon									
	10.0" Spherical Dodecagon	MCF1000-SphDoDecagon-H2C12			12				2
Flange Multiplexers									
	2.75" Flange Multiplexer-Instrument Housing	MCF275-FlgMplxr-C1r2A4	Multiplexer Rotatable	4	1+2r				
	2.75" Flange Multiplexer-Instrument Housing	MCF275-TestFlgMplxr-C2A4	Multiplexer	4	2				
	2.75" Flange Multiplexer-Instrument Housing	MCF275-FlgMplxr-Cr1A5	Multiplexer Rotatable	5	1r				
	2.75" Flange Multiplexer-Instrument Housing	MCF275-FlgMplxr-C1r1A4	Multiplexer Rotatable	4	1+1r				
Notes	r = rotatable flange								