

10

**Custom
Engineering**



Section 10

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Typical MDC custom chamber

- Chamber geometry
- Focal point
- Focal plane
- Focal length
- Polar angle

Drawings provided for custom fabrication must include accurate, complete data. View angles and lengths do not provide complete information — true angles and port lengths must be specified for fabrication. Descriptions of focal length, polar and azimuthal angles are given on these pages.

Chamber Wall Thickness

Chamber Diameter	Wall Thickness
≤ 10.00	.120
> 10.00 but < 24.00	.188
≥ 24.00	.250

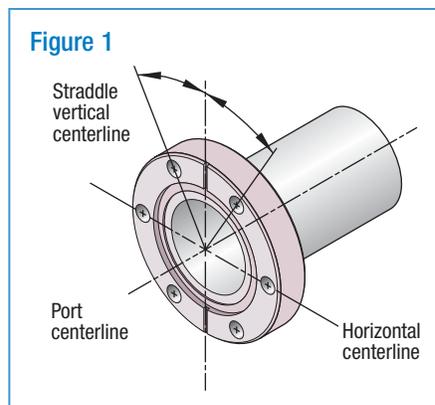
Please note that these wall thicknesses are given as reference only. Actual thicknesses may vary according to a chamber's overall design including the size and quantity of ports being fitted. Contact MDC's technical sales engineers for more details.

MDC is equipped to build custom vacuum chambers of virtually any complexity. Vacuum vessels can be built to your exact specifications from a rough hand-sketch, detailed engineering drawings or anything in-between. MDC's engineering department uses the latest AutoCAD® software and can accept drawings as electronic files in either DWG or DXF file formats. For a nominal fee MDC can supply a complete engineering documentation package on those projects for which drawings were not provided by the customer.

Unless specified otherwise the main body of custom chambers less than or equal to 10 inches in diameter will be fabricated from standard tubing. Nonstandard sizes under 10 inches and all sizes over 10 inches in diameter shall be fabricated from rolled stainless steel sheet metal. The chart below provides nominal wall thicknesses for most MDC chambers .

The accurate positioning of ports on MDC vacuum chamber is made possible with the use of sophisticated laser aligned fixtures. Five basic geometric parameters are required to define a chamber's port positions. These spherical coordinate system parameters include a port's focal point, focal plane, focal length, polar angle and azimuthal angle, figures 3 through 6 on facing page.

For the purpose of this discussion all vacuum chambers shall have a base port located on a horizontal XY base plane which is perpendicular to the chamber's vertical Z axis, figure 3 on facing page. Whenever bolt style flanges are used, bolt patterns shall straddle vertical centerline. In the case of Del-Seal™ CF metal seal flanges fitted with leak test grooves, the grooves shall be oriented vertically, figure 1 below.

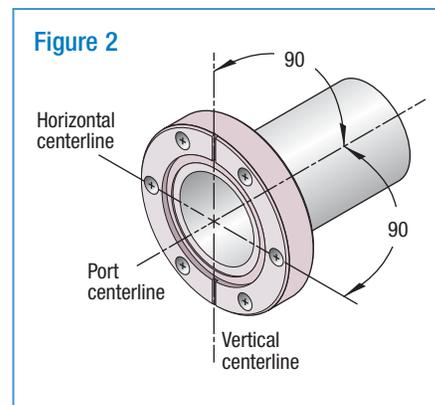


Furthermore, all port flange seal faces shall be considered perpendicular with their mating tube axes, figure 2 below.

The focal point of a port, also referred to as a port's target point, is usually a position anywhere inside a vacuum chamber where an application task is to be performed. Its location is typically defined by the vertex or convergence point of one or more ports and other chamber features. Focal points can be thought of as sphere centers from which radial ports project. Even though focal points are inside a vacuum chamber they are not necessarily at the chamber's center. Chambers can contain multiple focal points as required by an application. All focal points are located on focal planes which are parallel to the chamber's main base plane. A port's focal length is defined as an axial and perpendicular distance measured from a port's focal point to the center of its mounting flange seal face. Minimum focal lengths require the use of tapped flanges. Clearance hole flanges require a minimum 1-1/2 inch tube extension in order to fit fastening hardware.

Polar angle is a port's angular displacement about a horizontal axis. This horizontal axis of rotation intersects the port's focal point and lays on the focal plane which is in turn perpendicular to the chamber's main Z axis. Polar angles are measured in a north to south direction on a 180° scale between the focal point's vertical axis and the port's center line, figures 4, 5 and 6 on facing page. The north position is 0° and the south position is 180°. A port is said to have a 90° polar angle when the port centerline lays on the focal plane, figure 4.

Azimuthal angles discussed herein shall be measured in a counterclockwise direction with a 0° starting point and a full 360°





scale. Azimuthal angle is a port's angular displacement about a vertical axis. This vertical axis intersects the port's focal point and is always parallel to the chamber's main Z axis. The azimuthal angle is projected onto the port's horizontal focal plane and measured in a counterclockwise direction beginning at the 0° or three o'clock position and ending at the port center line or center line projection. If a port has a polar angle equal to 90°, figure 4, the port's center line will lay on the focal plane. If the polar angle is less than or greater than 90°, figures 5 and 6, the port's centerline will be above or below the focal plane and must be projected onto it for a final azimuthal angle measurement.

Custom engineered chambers are designed and manufactured using state of

the art metal machining equipment as well as conventional machining and welding tools. Unless specified otherwise the typical dimensional tolerances applied to all chamber fabrications shall be as follows...

Chamber fabrication tolerances have been optimized for cost-effectiveness and reproducibility. Chambers 24 inches in length or shorter will carry a ± 0.02 inch linear tolerance. Chambers longer than 24 inches but shorter than 72 inches will carry a ± 0.06 inch linear tolerance. All chambers will carry a minimum $\pm 0.50^\circ$ angular tolerance. Deviations from these specifications must be discussed with the MDC technical sales engineers for feasibility and cost before they can be implemented.

Figure 4

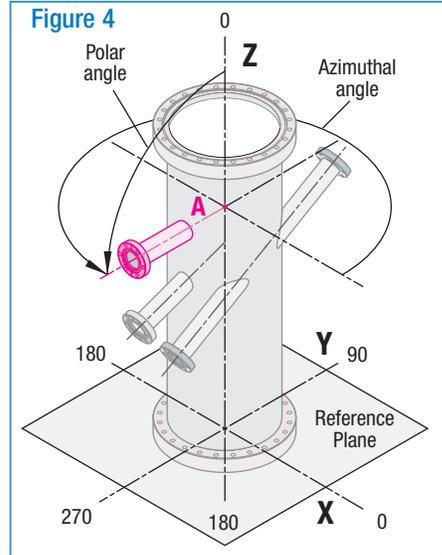


Figure 5

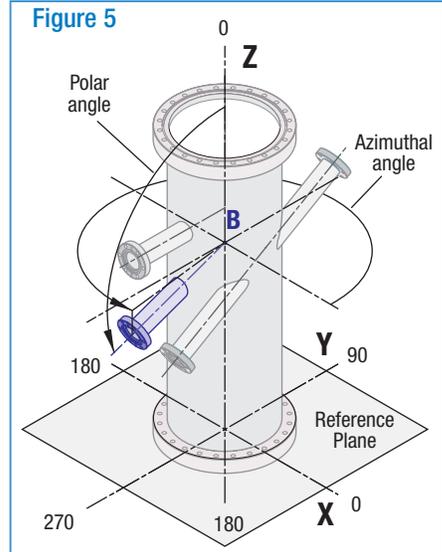


Figure 6

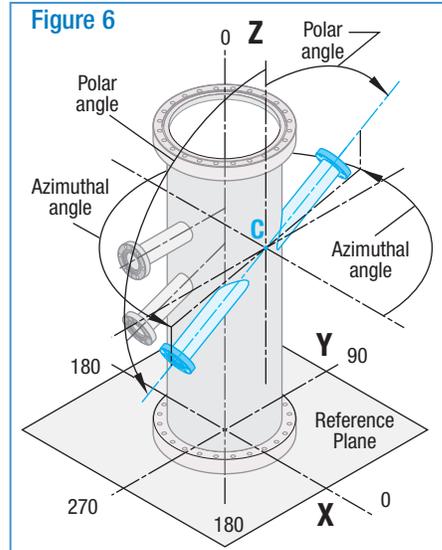
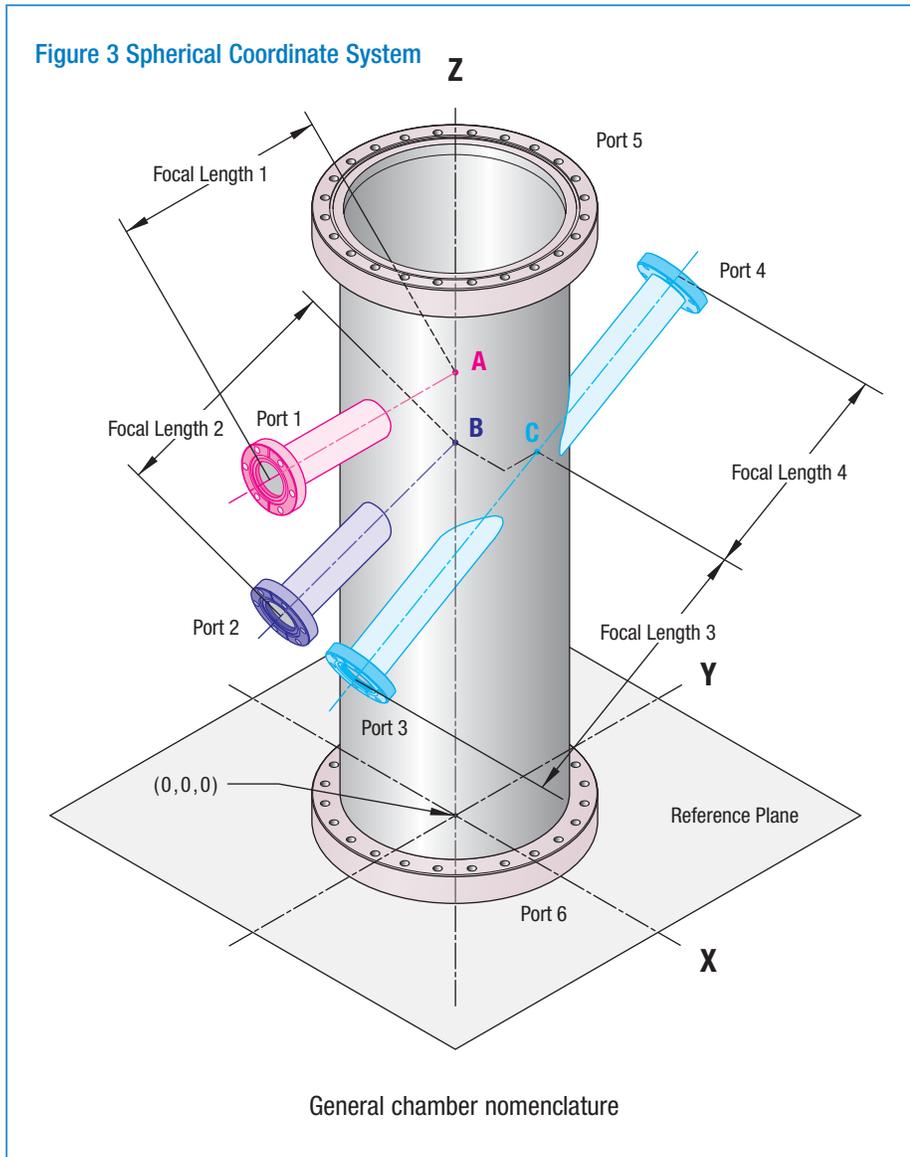


Figure 3 Spherical Coordinate System





Custom 20-inch gate valve

- Materials
- Water cooling
- Welding
- Cleaning
- Leak testing
- Shipping

MDC is equipped to build custom vacuum components of virtually any complexity. Vacuum vessels can be built to your exact specifications from a rough hand-sketch, detailed engineering drawings or anything in-between. MDC's engineering department uses the latest AutoCAD® software and can accept drawings electronically in either DWG or DXF file formats. For a nominal fee MDC can supply a complete engineering documentation package on those projects for which drawings were not provided by the customer.

Materials

Type 304 stainless steel is ideally suited for vacuum vessel construction because of its machining characteristics, excellent corrosion resistance and overall cost effectiveness. Unless otherwise specified all materials used in the fabrication of vacuum chambers will be type 304 stainless steel. MDC can quote the fabrication of chambers using other materials as required by a customer's application. Other materials used include 304L, 316 and 316L stainless steels. For more exotic stainless steel material types, consult with MDC's technical sales engineers. Low magnetic permeability materials such as mu-metal have also been used for the construction of magnetic shields used on conventional vacuum chambers. MDC specifies a magnetic permeability of less than or equal to 1.02μ when buying raw 304 stainless steel materials. Stresses induced during metal forming and welding operations will produce a change to this value in the proximity of an affected area, which may be significant to some applications. Distances between an application's process and the affected areas should be maximized for applications that are highly sensitive to this increase in the material's magnetic permeability.

Water Cooling

MDC can provide water cooling features on most any vacuum chamber geometry. Even though various water cooling methods for vacuum vessels have been adopted by the industry, one geometry stands out as the most efficient, reliable and cost-effective, this being the double-wall cooling method. We've been designing and fabricating watercooled vacuum chambers for over twenty years and the knowledge acquired over this period of time has lead us to recommend double-wall construction as the solution of choice for most watercooled vacuum chamber applications.

Typically, standard double-wall construction is limited to a chamber's main body and does not include any port extension tubes. Double wall cooling of port extension tubes is available on request, but significantly impacts a chamber's sale price. Double-wall chambers are fitted with water directing baffles between the walls to provide water flow over most chamber surfaces and thus minimize hot spots and water flow dead zones. Watercooled chambers are typically fitted with 1/4 inch NPT (7/16 inch nominal inside diameter) fittings. As a general point of reference, the water flow rate through a 1/4 inch NPT fitting with a total linear path of 50 inches, inlet water pressure of 60 PSI and an unrestricted outlet, will be a nominal 8-10 gallons per minute. Practical and safe water flow rates must be determined by the user by taking into account variables such as coolant path, temperature, pressure and a coolant's heat dissipating capacity.

Other less popular construction methods include tube-wrapping and half-channel geometries. Tube-wrap construction is a labor intensive hand-fitted process which provides reduced cooling capabilities. The



MDC custom spherical chamber



MDC custom chamber / system



half-channel construction comes closest to the cooling capabilities of a double-wall system, but it too is extremely labor intensive and thus not cost-effective. Of the three construction methods discussed double-wall construction also offers the most aesthetic solution, which is critical to most commercial process applications.

Customers requiring water cooling for their chamber should keep in mind that the water cooling features must be incorporated in the early stages of a chamber's design or construction. Water cooling of existing or partially constructed chambers is extremely difficult and may be cost prohibitive.

Welding

MDC employs advanced tungsten inert gas welding techniques (TIG) with high purity Argon as the inert gas medium. Manual as well as automated orbital welding machines are at the heart of all welding operations. MDC adheres to stringent UHV welding standards and practices including that of nonfiller metal, all internal fusion weld joints. External weld joints are not used unless required for structural reinforcement and then, limited to skip or span weld configurations. In the event that a weld joint can not be made internally, a one hundred percent full penetration external weld will be used. All weld joints are leak tested using a mass spectrometer leak detector with a minimum Helium sensitivity of 2×10^{-10} standard cc/sec.

Surface Finishes

Vacuum chamber finishes include internal and external glass bead blasting of all body and port tube surfaces. Flanges and machined components have a standard 63 micro-inch surface finish. Seal surfaces and

groove bottoms are machined with a 32 micro-inch concentric finish suitable for standard elastomer sealing. Optional electrochemical polishing of chambers is available at an added cost. The electropolishing process is the reverse of electroplating where the work piece is made the anode and dissolves or gives up material in the electrolytic process. The electro-polishing operating conditions are controlled so that atomic oxygen forms and reacts with the metal work piece surface. According to one theory, the high points of the metal surface are most readily oxidized and this oxidized material is thereupon dissolved in the electrolyte and otherwise removed. Selective solution of the high points of a surface tends to give a very smooth finish comparable or superior to a mechanically buffed surface. In contrast to mechanical polishing, electropolishing produces a strain free surface.

Leak Testing

MDC is dedicated to providing standard as well as custom high and ultrahigh vacuum components of the highest quality and performance. To this end all vacuum rated components manufactured by MDC and its divisions are leak tested repeatedly, as required, throughout the manufacturing process to insure these goals are met. All weld joints, braze joints and seals are leak tested using a mass spectrometer leak detectors with a minimum Helium sensitivity of 2×10^{-10} standard cc/sec.

Cleaning

Upon final machining, which uses water soluble non-sulfurous cutting oils, all components are washed in a high temperature detergent bath followed by multiple tap and deionized water rinses.

After the last rinse, parts are blown dry with dry nitrogen and packaged. Products are shipped clean and leak tested, ready for high vacuum installation and service.

Packaging & Shipping

Packaging includes the meticulous covering of all open ports with oil-free aluminum foil and the installation of protective plastic flange covers to prevent seal surface damage during transit. Where applicable components are heat-shrink skin packed, boxed or crated. For a fee MDC can ship chambers pumped and under vacuum with ports blanked-off and sealed. For this, chambers are evacuated to a rough vacuum level and sealed off by pinching a flange fitted copper roughing line. Note that this fee will include the purchase of all required port hardware including blank flanges, gaskets, fasteners and installation labor.

Pressure Rating

MDC vacuum chambers and components are constructed to maximize their high and ultrahigh vacuum capabilities. As such they are not designed for positive pressure applications with ratings above one atmosphere.



Custom multiport flanges and fittings



Custom gate valve filled with RF port shield



Custom e-Vap[®] electron beam source



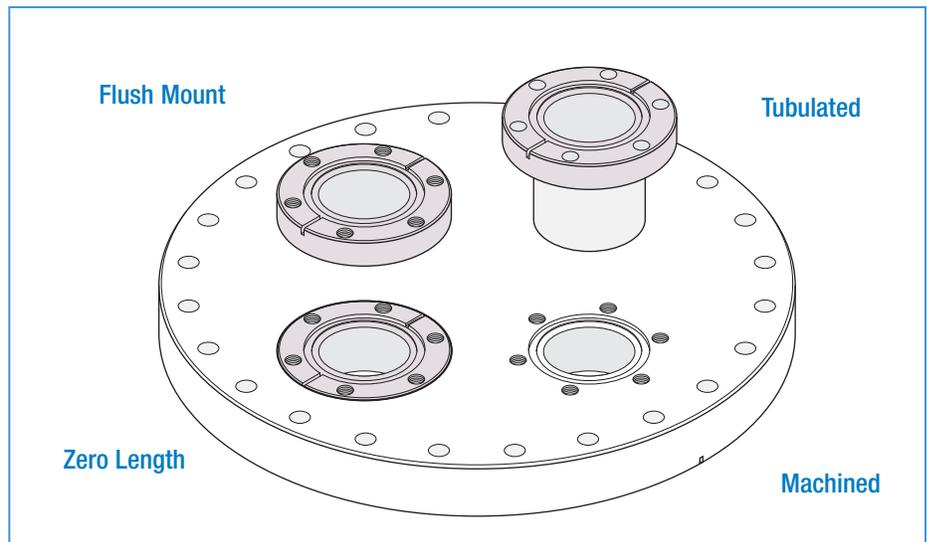
Typical MDC custom multiport flange assembly. See page 74 for similar flanges.

MDC's technical sales engineers are available to discuss your requirements for any non-standard component. In the case where a catalog item may be close to your needs, but would benefit from a slight modification, the requirements could be easily noted using the existing catalog drawing. Locate the catalog page of the product to be modified. Provide the page number, a reference number if it's available, and a brief description of the modification requirements along with a marked up copy of the catalog drawing. Product specific drawings are available for most products depicted in this catalog and are usually presented with the table for those products.

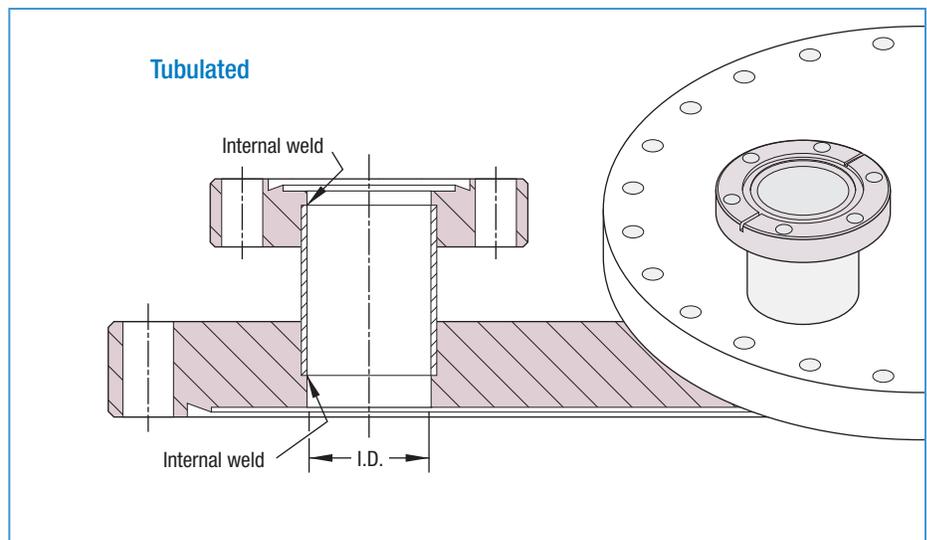
MDC is equipped to build custom vacuum components of virtually any complexity. In the case where there is no standard component close to your needs, it will be necessary to generate a drawing. Custom components can be built to your exact specifications from a rough hand-sketch, detailed computer-generated engineering drawings or anything in-between. MDC uses AutoCAD® software and can receive drawings electronically in either DWG or DXF file formats. For a nominal fee MDC can supply a complete engineering documentation package on those projects for which drawings were not provided by the customer.

One example of the multiple ways to specify a custom component

The flange assembly at right depicts four popular methods of installing flanges in to a larger flange or plate. Del-Seal™ CF metal seal flanges have been used for the purpose of this example. The methods described would apply to most any flange type and configuration. The four methods of construction are referred to as standard tubulated, top flush mounted, zero length recessed and single piece integrally machined. These are given as examples for commonly asked questions. Discussing your application with an MDC technical sales engineer will help determine the appropriate solution for your application.

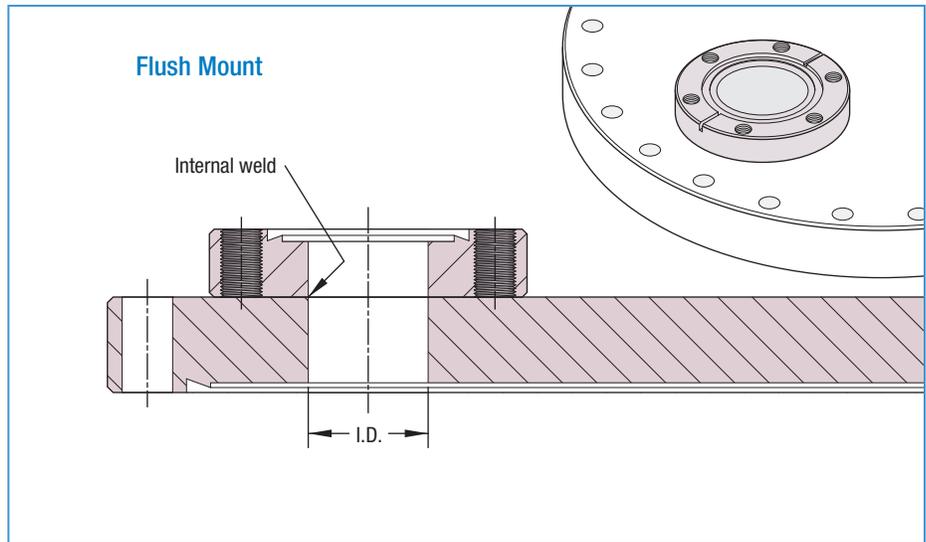


The tubulated method of construction would be one in which a standard or custom half-nipple is welded to the larger flange at the tube end. The larger flange or plate is counter-bored to match the tube's inside and outside diameters. The tube to flange transitions are welded in the same fashion along the bore's inside diameter. This method of construction allows the use of clearance hole, bolt and nut fasteners, and is the only configuration that would allow the use of a rotatable flange.

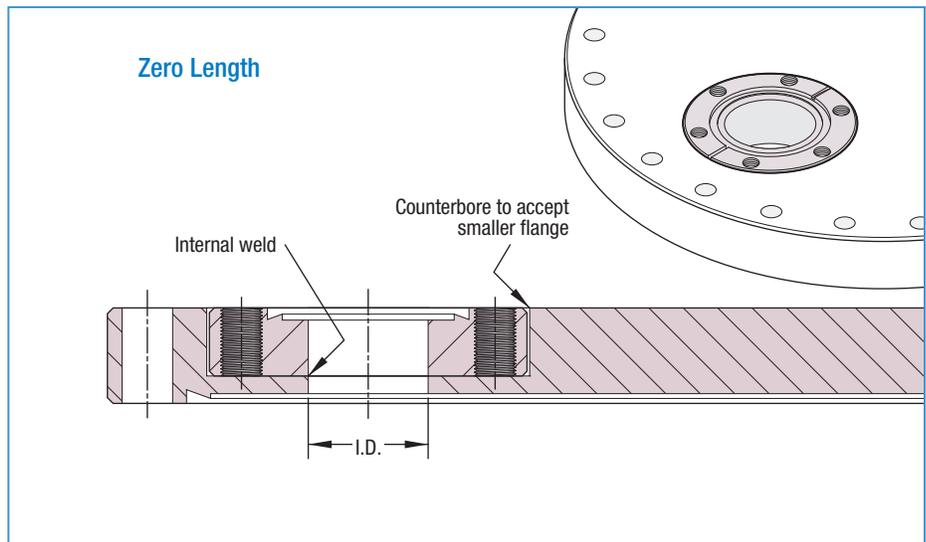




The most economical method of installing a flange would be to use standard off the shelf components requiring the minimum amount of modification and fabrication or in other words a top mounted method. In this method the larger flange or plate is bored to match the bore size of a smaller flange. Both are then joined by fusion welding internally along the interface between the two bored pieces. In some cases, external skip welds are provided for additional mechanical strength. This is the most economical method of construction.



The zero length method of installation is similar to the top mount method with one exception, the larger flange or plate is counter-bored to a depth that matches the thickness of the smaller flange. The counter-bore is used to reduce the overall thickness of the completed assembly and thus provides a zero length recessed profile. The flanges are welded in the same fashion along the bore inside diameter. This approach provides a more aesthetic look at a reasonable cost.



An integrally machined method eliminates all weld joints, but requires the most amount of machining. Special machining steps include the use of blind-tapping for all bolt holes and off-center turning of the knife-edge seal geometry as well as through bore operations. In some instances it may even be desirable to use helical thread inserts, since these would be easy to replace in the event a thread is damaged. Conventional threads would be very difficult to repair. This type of fabrication is the most aesthetic, but also the most expensive of the three choices.

