Geometries & Characteristics

Vacuum chambers are built in a huge variety of shapes and sizes, limited only by application, imagination, and engineering consideration. Chambers range in volume from less than 1 cc to the “world’s largest vacuum chamber” at NASA Plumbrook, USA which is 100 ft diameter by 122 ft tall (~3.5 x 1010 cc).

The more ‘standard’ vacuum chamber shapes include: box, sphere, cylinder, D-shape, and bell jar. Additional components, used in vacuum chamber construction, include: endplates, feedthrough collars, and service wells. All are separately discussed to illustrates the strengths of the basic shapes/designs.

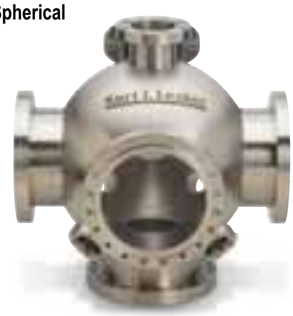
38" x 37" x 132" I.D. Rectangular Chamber

Box

The box shape chamber is available in two basic forms. One, sealed with metal wire and flat copper gaskets and often called a rectangular chamber, is designed for UHV applications. The other, called a box chamber, has one complete side hinged as an o-ring sealed door and operates at high vacuum. Since both versions are flat-sided, either thick walls or extensive bracing is used to withstand atmospheric pressure.

The box chamber’s door provides easy, fast access to any part of the internal volume. It is the platform-of-choice for any repetitive batch process such as: coating multiple substrates; product degassing; evacuation before impregnation, etc. However, its accessibility also makes it an excellent chamber for research applications where, for example, deposition sources, coating materials, and deposition geometry are frequently changed.

Spherical

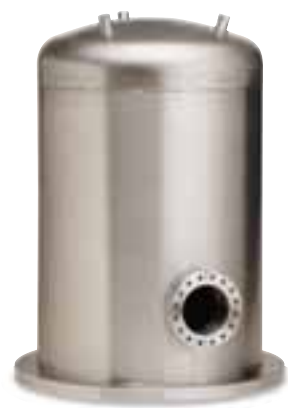


The spherical chamber equipped with CF (ConFlat®style) flanges is a popular choice for applications requiring radial component placement as in pulse laser deposition or surface sciences. These chambers have many ports for particle/radiation sources or analytical instrumentation directed at the sphere’s center or other relevant focal points. With suitable surface preparation and pumping, such chambers can reach pressures in the UHV range.

Cylindrical

While cylindrical chambers can be made with metal wire seals, most are o-ring sealed and, therefore, appropriate for high vacuum operation. The thin cylindrical walls resist atmospheric pressure well and is a commonly used shape, in either vertical or horizontal orientation. Vertical cylinders are often chosen for thin film deposition research. The interior is accessed, for changing evaporant or target, by removing the lid or lifting the whole cylinder off its baseplate. Some vertical cylinders have secondary load-lock chambers attached to a side port for substrate changing.

Horizontal cylinders are often equipped with hinged, domed, o-ring sealed end-doors the same diameter as the cylinder.



Metal Bell Jars

A metal bell jar is essentially a cylindrical chamber which has a domed top-plate already welded in place. With a metal wire seal base flange metal bell jars can reach the UHV range with suitable surface preparation and pumping. However, the o-ring sealed base flange version is very popular for high vacuum application. It is relatively simple to cool metal bell jars using an cooling-water trace welded to the outer surface. Such bell jars are often chosen for high temperature applications and because the simple design makes manufacturing easier and lowers costs.

Pyrex® Bell Jars

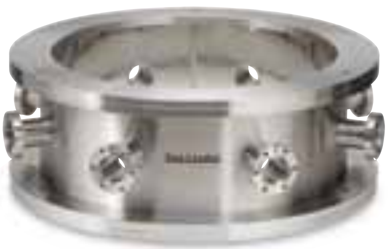
Bell jars made from Pyrex are inexpensive and transparent vacuum chambers. Using an ‘L-shape’ gasket to seal the bottom edge to a metal baseplate, they are a good choice for laboratory high vacuum applications. However, as is obvious, glass is fragile. To protect personnel (and the chamber) surround the bell jar with a metal grid guard before applying vacuum. Although wall thickness is carefully controlled during manufacture, no two bell jars are exactly alike.

Endplates

Endplates or baseplates (depending on mounting orientation) are flat metal flanges made to cap standard pyrex/metal bell jars and cylinders. Endplates usually have one large flanged port where the HV pump is attached, plus a number of smaller ports for feedthroughs and components.

Service Wells

Service wells, like endplates, act as transition stages between the pumping stack and the bell jar or other chamber. The physical distinction is that service wells are wide-bore tubes, closed at the bottom, with feedthrough flanges radially penetrating the tube walls. Because there is a much larger area for feedthrough ports and because the ports are not buried beneath the lowest surface, the service well’s primary advantages are number of feedthroughs and convenience.



Feedthrough Collars

This name sometimes misleads, as a feedthrough collar has no feedthroughs. Like the service well, it has a number of radial ports for feedthroughs, but otherwise is simply a tube with flanges at each end, used as a transition piece between a bell jar and an endplate.

- **D-Shape**

The D-shape chamber (when viewed from above) combines the thin wall of the cylindrical chamber with the volume and large, o-ring sealed access door of the box chamber making it appropriate for high vacuum applications. The door is frequently aluminum to reduce weight. For many applications, including substrate rotation during deposition, the cylindrical rear section of the D creates no serious dimensional restrictions. The shape is often chosen for the same applications as the more traditional box chambers.

Materials

The most commonly used material for high vacuum and UHV chambers is a 300-series stainless steel—most frequently 304L (carbon content >0.03%), which is available in sheet, tube, bar, plate, and forged forms. This steel, and others such as 316L, has desirable vacuum chamber properties: mechanically strong, machinable, weldable; magnetic permeability close to 1; resistance to atmospheric corrosion; takes a high polish; and can be effectively outgassed by baking. For large space simulation chambers operating in the HV Torr range, mild steel is a cost-effective option. However, its magnetic, corrosion resistance, and out-gassing properties make it generally unacceptable.

For experiments disturbed by residuel magnetic fields or radioactive backgrounds, or which require chamber walls with excellent thermal or electrical conductivity, weldable grades of aluminum (typically 6061) are used for high vacuum and UHV. Two problems prevent the regular use of aluminum for vacuum chambers: (a) it is more difficult to weld when vacuum integrity is required and (b) its low strength means it cannot be used for CF flange knife-edges without expensive modification.

Glass is a common chamber material in educational and some research laboratories. Many types of glass have low gas permeability (except for helium) and good vacuum characteristics. The background radioactivity due to potassium 40; however, it may be high enough to preclude it for some uses. Obviously, glass is more susceptible to damage and less easily modified by the average machine shop than metal, but glass bell jars offer the benefits of low cost, transparency, and simplicity.

When the earth's magnetic field interferes with experiments, the complete chamber is sometimes made of mu-metal. However, anecdotal evidence suggest it has strange properties when used as a vacuum construction material (see **Liners** for an alternative solution).

Common materials such as brass are sometimes used, but not recommended. Less common, chemically inert materials such as Monel® and Inconel® have special applications. Zinc or cadmium-plated steels or screws should never be used inside a vacuum chamber. Their relatively high vapor pressure can cause operational adventures that are best avoided.

Water Cooling

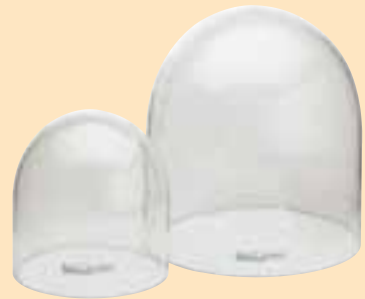
For applications with high heat outputs, double chamber walls with channeling and baffles provide the most effective method of water cooling to provide a "cold wall." For lower heat outputs, a water trace (a channel welded to the external chamber surface) is used. The trace covers a small fraction of the surface but, using data on heat input and thermal conductance, the trace pattern is designed for adequate cooling efficiency. Occasionally, copper tubing is brazed to the chamber's exterior. Although less expensive, this is never as effective as the first two methods.

Water-cooled chambers should undergo rigorous testing procedures to ensure they are free of leaks. Testing methods include stress-testing all water cavities with a pressurized gas (typically dry nitrogen) and helium leak checking all internal and external welds.

Liners

Two common applications for chamber liners are: (a) reducing the effects of magnetic fields by installing multiple mu-metal liners inside the chamber (often a better solution than a mu-metal chamber), and (b) preventing sputtered or evaporated materials reaching the chamber's surfaces using aluminum foil or thin (shaped) stainless liners.

Inspecting and Using Pyrex® Chambers



When receiving a Pyrex chamber, immediately look for shipping damage. Any Pyrex chamber will have a variety of small imperfections.

We recommend you ignore small surface scratches and blisters/bubbles (either flattened and elongated, or tiny spheres), because they are difficult to avoid in manufacturing and handling thick glass, and will not adversely affect vacuum applications.

However, do not ignore cracks, particularly those causing a distinct dark line more than an inch long in the bulk of the glass. A crack suggests shipping damage. If undamaged, re-pack the glass chamber in its original box until ready for installation. If you find damage, please contact us immediately for further instruction. We will do everything we can to rectify the situation.

During use, examine the glass chamber regularly for clouding, cracks, star formations (caused by point impact), or deep, long scratches. Clean the external surface using commercial glass cleaners. If the process clouds the internal surfaces, seek advice on the best method to remove the deposit. But remember, if you are depositing some "inert" or hard-coating material on a substrate, it will form an inert, hard layer on the glass. Do not compromise the vacuum by using cleaners that cannot wash away with water or clean solvent.

Never allow hydrogen fluoride (HF—gas or aqueous solution) near the glass chamber. It attacks glass, causing it to become opaque. Never use harsh abrasives, wire brushes, files, or metal scrapers on the glass surface. **If the glass chamber becomes cracked or starred, discard it immediately.**