# Engineering a Better Vacuum Chamber

by Ken Harrison, VP of Engineering for the GNB Corporation,
www.gnbvalves.com

Vacuum chambers have been built in nearly every shape and size. Designs vary from simple to "What were they thinking?" However, it is possible to design and build superior chambers for less cost, by considering the following:

## Controlling Deflection

If deflections are controlled, then a chamber will seal reliably and last a very long time. Deflections can be controlled by selecting an intrinsically strong shape, or by using a weaker shape then adding stiffeners.

### Chamber Shapes

The best shape to minimize both material and deflection is a sphere. It is also the best shape for evacuating air and maintaining cleanliness because there are no corners. The limitation to this shape is that some applications do not readily fit in it. The forming costs of the hemispheric halves can also be expensive for larger chambers.

**Fig 1: This large, cylindrical chamber with domed ends saves materials because the shape is very strong.**

The next best shape is a cylinder with domed ends. This is one of the most common shapes, and the rigidity is almost as good as a sphere.

Rigidity of Shapes

***More Rigid***

Sphere
Ellipsoid
Cylinder with domed ends
Cone
Geodesic ball (triacontrahedron)
Diamond (octahedron)
Cylinder with flat ends
Pyramid (tetrahedron)
Box

***Less Rigid***

Box chambers, while common, offer the least rigidity.

<u>Doors, Ports and Feed-throughs</u>

A chamber's integrity is difficult to maintain if major structural sections are removed to add doors, ports and feed-throughs. Flanges and stiffeners can be added to compensate for the loss of rigidity.

For ease of handling, doors should be made as light as possible. A common way to make doors strong, yet light is to combine a sealing flange with a dished head, or curved plate.

**Select the Best Materials**

Stainless steel plate is the material of choice for many applications. Aluminum, mild steel, titanium, inconel, monel, glass, Teflon®, and polycarbonate can also be used. Avoid porous and dirty materials; common castings can be particularly problematic. An excellent cost compromise is to use stainless steel for the components that are exposed to vacuum and mild steel or aluminum for other components. For example, the chamber, chamber door and ports can be made from stainless steel; and the hinges, external stiffeners and other hardware could be made from mild steel.

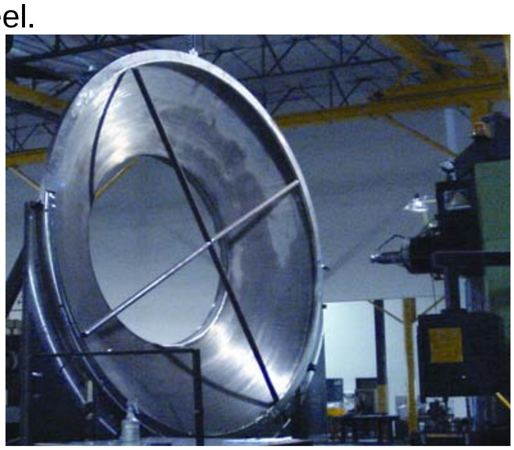

**Fig 2: This 15-ft diameter dished head costs much less when made from mild steel rather than stainless steel.**

Gasket materials deserve special consideration. Viton®-A (fluorocarbon) is the most widely used material, but butyl, Buna-N, EPDM, Silicon (lower vacuum levels), Chemraz and Kalrez are also used. For ultra-high vacuum applications (less than $7.5 \times 10^{-10}$ Torr), metal seals such as copper and aluminum are often used.

**Use Proper Surface Preparations**

Cleanliness is essential. This means that a chamber must have a clean, non-porous surface wherever it is exposed to vacuum. To achieve this requirement, one of the following processes is employed:

1. Machined/ground all over
2. Bead blasted
3. Grained
4. Electro-polished

These processes can increase the cost of a vacuum chamber. Do not over specify—and only finish the surfaces that are exposed to the vacuum.

**Design the Structural Components**

Structural components should not be an afterthought because these items may significantly impact the cost and reliability of the chamber. Some of the components that must be considered are:

1. Stands
2. Lifting points
3. Hinges
4. Fasteners
5. Stiffeners

Although these can be made from the same material as the chamber, the use of stronger and/or less expensive materials (such as mild steel) can be an advantage.

**Fig 3: The painted, mild steel stand minimizes material costs.**

## Engineer the Heating, Cooling, and Shielding

Some chambers will require heating, cooling or shielding. When the internal process is very hot, a double walled (jacketed) chamber is required. This design will have channels that are sandwiched between the inner vacuum chamber and an outer water jacket. Water is then circulated between the two walls for cooling. It may also be necessary to have jackets around the ports or water channels machined into the flanges to circulate water.

**Fig 4: This box chamber is covered with water traces to provide cooling.**

For moderately hot applications, a water channel is welded in a zigzag fashion all around the outside of the chamber. A stream of water flows through the channel, and heat is conducted from the hot sections between the channels by the flowing water.

## Final Recommendations

Many companies over-design thinking that if they make it thick enough it will be indestructible. However, quality is not measured by the pound. To engineer a better vacuum chamber, all of the above factors must be considered.

## About the Author:

Ken Harrison is the Vice President of Engineering for the GNB Corporation. GNB specializes in the manufacturing of vacuum products including: chambers, gate valves, angle valves, baffles, traps and large fittings. For more information visit www.gnbvalves.com or call 916-395-3003.