How to design with INFLATABLE SEALs

Seals are central to the design of medical equipment with moveable, interlocking parts that must be secured for sanitary, thermal, or radioactive reasons.
Designing with inflatable seals requires the inclusion of a source of compressed gas, which is used to inflate seals in the medical device industry and is often already available on the plant floor, in a laboratory, or medical environment. It is also possible to inflate with liquids rather than gas in demanding applications, and water would be an acceptable inflation media in this sector, although not common. For low-temperature applications, a seal can be inflated with a blend of glycerine and water.

**Designing with inflatable seals**

Seals used on doors and openings should be selected early during product design. In some cases, contact seals may be effective, but they often require substantial force be applied to load the seal, which impacts product design and increases manufacturing cost. Inflatable seals enable more cost-effective fabrication for two main reasons:

Inflatable seals are more forgiving because the seal can inflate to close a gap between structural members and achieve equal sealing pressure around the flange if the gap falls within a broad tolerance. For example, an inflatable seal will work whether the gap spans 3mm or 10mm. A compression seal or other contact seal will not be effective unless the seal and flange contact each other with great precision, which is difficult to achieve on new equipment. Even a robust and precision-manufactured machine with well-designed flanges will lose some of its geometric integrity as hinges and other components deform or bend over years of use. Throughout the course of the equipment lifecycle, a contact seal will become problematic and may exhibit leakage.

Inflatable seals enable lighter and more affordable methods of equipment fabrication. The force exerted on the chassis of a piece of equipment means doors and related components must be thicker, perhaps machined instead of welded. These components are typically made of stain-

less steel, and inflatable seals might be attractive due to lowered material costs.

**Standard vs. advancing materials**

Seals are often exposed to temperature extremes and mechanical stresses, and a well-machined elastomer inflatable seal will maintain its structural integrity and flexibility throughout millions of duty cycles. While silicone is the standard material for inflatable seals, new advanced products include materials innovations designed to prolong life and mitigate operational risk. Silicone rubber impregnated with a silver ion helps the material resist bacteria growth.

Another new technology is designed to make silicone rubber less permeable. Silicone is not porous, but has the highest permeability of all rubber compounds. If it is immersed in water long enough, there will be some gas that escapes, forming bubbles. Treatments are now available that decrease the permeability of silicone used in an inflatable seal, preventing absorption of foreign substances, prolonging the life of the seal, and

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**Which equipment needs INFLATABLE SEALS?**

- Isolators – where a leak-tight enclosure can be critical for environmental health protection due to hazardous substances of processes – can secure glove boxes, access gates, transfer systems, and filtration systems that handle toxic or sterile components
- Sterilizers – which may rely on heat, chemicals, irradiation, or filtration – may be suitable for desktop autoclave sterilizers, sterilizing tabletop autoclaves, and static air depyrogenation sterilizers
- Dryers, freeze dryers used to sterilize everything from machine components to glassware
- Material handling functions, to raise, lower, or grasp objects
seals

preventing cross-contamination. The treatment may also result in a seal with a better friction co-efficient, ensuring that the seal moves easily in its groove and avoiding any sticking between the surface of the seal and the flange.

**Advanced design**

Once a machinery designer chooses an inflatable seal, they must also choose a cross section that is right for the specific application. Sometimes, the customer seeks high pressure on a large extent to close a wide gap, expects the highest performance, and wants to use a rough, grippy seal face, even though the application in the pharmaceuticals industry requires a polished face. The elements of this design would place the seal under stress, and consulting a seal manufacturer during the early product design process will ensure the design conforms to the requirements of the industry, the performance characteristics of the material, and the sealing system.

The location of the seal is also important. In washing machines, for example, bottles, vials, or other glass objects can break and cut the seal so proper location of the seal can mitigate against damage. In other cases, improper seal location can cause retention of product or other material in the groove of the seal, even if it is a lip seal with a smooth surface. Avoiding retention becomes important when using a cross-section like an accordion seal, where designers need to avoid retention of material, water, or even drops of liquid or condensation in the seal itself.

**More than just closure**

Inflatable seals are most often used to seal openings, but they can also be used in designs such as an airlifting bag or in other settings to initiate or halt motion. In a surgical theater, for example, lights extending from the ceiling need to be positioned and repositioned securely by the surgeon, and a manufacturer may use an engineered length of an inflatable seal to lock the light in place. The surgeon can press a handle to deflate the seal, and as soon as he or she releases the handle, the seal will re-inflate and lock the light into position. This also offers a cushioning action because the seal absorbs vibrations in the building that may be caused by foot traffic, equipment on the floor above, or nearby vehicle traffic.

**Conclusion**

Inflatable seals should be at the top of the medical designer's list for a broad class of equipment. Reduced pressure
requirements allow for lower cost fabrication methods because the equipment can be less robust and need not hold precise flange tolerances throughout its lifecycle. They work as equipment falls out of specification during its lifecycle, and new innovations in silicone material design can help reduce risk of contamination and meet regulator demands. Involving the sealing system manufacturer in the early stages of design is crucial to ensuring optimal performance of the equipment, and the supply chain management practices of the vendor should be subject of careful due diligence.

Regardless of the application, supply chain integrity and traceability for the processes and components that go into the seal should be a primary focus during selection and specification. Each seal should include a laser marking that allows the manufacturer to reverse-engineer the raw material batch, extrusion, mixing, installation of the fitting valve, manufacturing batch, and the lot of stainless steel used for fitting the valve.

3 INFLATABLE SEAL CONSIDERATIONS

1. Specify the seal early, as it can allow you to value-engineer the design, saving cost. Early consultation will also help you specify the correct seal profile.

2. Consider the new innovations in silicone sealing materials, including silver ion impregnation, which prevents microbial growth.

3. Ask hard questions about supply chain integrity and traceability. The seal is only as trustworthy as the silicone it is manufactured from and the processes that go into it.

About the author: Bruno Rouchouze is a senior product manager with the Technetics Group, a unit of EnPro Industries Inc. He has been with the company for 37 years, where he has been involved in the design and development of inflatable seals and rubber sealing devices. He can be reached at bruno.rouchouze@technetics.com.

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