Pumps that operate with a diaphragm have been in use since the mid-1800s because of their simplicity and effectiveness.

That isn’t to say these pumps have remained unchanged in all that time. More than 150 years of innovation and technical improvements in diaphragm profiles and elastomeric material sciences have secured their use for a wide range of pumping and reciprocating applications.

The design and utilization of diaphragms in pumping applications is a vast topic, yet it is one that Gallagher Fluid Seals’ application engineers have mastered by approaching the manufacturing and design of diaphragms with a step-by-step process.

The result is diaphragms that are expertly designed and made from the most appropriate material and crafted in a way that optimizes cost and manufacturability. Freudenberg-NOK Sealing Technologies are our vital partners in this process, and are worldwide leaders in the diaphragm field.

An elastomeric diaphragm is a versatile dynamic seal that removes many of the limitations found with other sealing methods. They do not leak, offer little friction, and can be constructed for low pressure sensitivity. With the right material consideration, diaphragms can seal over a wide range of pressures and temperatures without needing lubrication or maintenance.

**Diaphragm Design Checklist**

1. **Environmental, Functional and Material Considerations**

What is the diaphragm’s basic function? Does it act as a regulator with pressure from one side, or as a pump with pressure on either side? There are important distinctions among diaphragms for control, accumulation, switching and pumping applications. What are the environmental conditions? What temperature, humidity and media is the diaphragm exposed to?

After establishing the functional criteria, decisions can be made on the material for the diaphragm elastomer itself, based on the media being sealed or pumped. Is it a passive material like air or water, or an aggressive material like a petrochemical or a solvent?

Specifying the best material not only ensures the longest life of the diaphragm, it also saves
on cost by avoiding “over-designing.” The choice of elastomer is crucial when considering the environment in which the part will operate, and will often supersede manufacturability concerns. Relevant elements include chemical contact, abrasive hardware or medium, applied loads and health or federal regulations.

What are the pressure requirements, and does it ever veer away or reverse from them? Depending on the PSI levels, the diaphragm may need secondary materials. Typically PSI under 5 does not require fabric reinforcement. A PSI between 5 and 10 is application dependent. Anything above 10 almost always needs fabric reinforcement.

What are the maximum and minimum operating temperatures? What is the duration at the maximum? In the end, the construction and design of the diaphragm is shaped by information about the pumping volume and the cycle rate.

2. **Construction and Shape Elements**

One of the main design goals is to consider the method for building the diaphragm as early as possible.

A layer of reinforcing material molded to the elastomer, or a layer of coating on one or both sides of the diaphragm can add substantial cost to the component. The decision to use a coating depends on the pressure, media and stroke length of the piston. We should note that the relevant stroke length here is the relative stroke length of the piston head to the diameter of the diaphragm. The elastomer creates a sealing barrier between the system pressure and the porous fabric, allowing the diaphragm to turn pressure into mechanical force.

Pressure or aggressive media on one side should use a one side or even two side coated part. With pressure on two sides, one side coated part will always fail, requiring a two side coated part. A short-to-medium stroke length will allow for a one or two sided coat, but a longer stroke length must have a one-sided coat design because of the added flexibility that’s needed.

Another consideration in the construction of the diaphragm is the mating hardware finish. A rough surface will eat away at the fabric reinforcement to the point of seal failure.

The geometric profile of the diaphragm depends on the application, but stroke length is usually the key consideration. A short stroke allows for a flat or die cut diaphragm, a low convoluted or shallow draw profile. A medium stroke will typically call for a shallow draw, convoluted or drop center. A long stroke requires a deep draw or top hat.

3. **Application Properties and Hardware Considerations**
The diaphragm’s cycle rate and expected cycle life need to be determined. These values are confirmed during the prototype phase. How will the diaphragm device be assembled? Options include a bolted piston and flange, a riveted piston and flange, spin crimp or swage, or a sonic weld. The requisite hardware is made either from injected molded plastic, machined plastic or metal, or stamped or formed metal. Additional hardware considerations include the inclusion of return springs, positive stops, the design of the piston and care over time of the diaphragm.

Each of these considerations excludes various design options, allowing the optimal diaphragm design to come to pass. Other final considerations include unique specifications such as UL, or FDA compliance. These certifications are usually material in nature, but can require extensive testing and validation to achieve, thus adding significant cost to the overall diaphragm application.

**Diaphragm Inserts**

Diaphragm inserts are bonded to the diaphragm during molding and enhance connectivity, facilitating assembly and cutting costs. Benefits include ease of assembly of the diaphragm, built-in piston-area support, reduction of SKUs and a well centered attachment point. Typical metal insert materials include stainless steel, aluminum and brass, while plastic materials are usually either fiberglass-filled polyamide or PEEK.

**Product Design and Validation**

The engineers at Gallagher Fluid Seals, working with our partners at Freudenberg-NOK Sealing Technologies, design every custom diaphragm to your specifications, and validate the design before manufacturing begins. FEA capabilities allow for lower manufacturing costs and optimal design.

Testing capabilities to validate in-use performance include:

- Hot endurance testing,
- Hot steam
- Tensile strength
- Cold liquid
- Hysteresis
- Bending fatigue strength
- Permeation
- Any other customer-driven application test

These rigorous procedures give the customer the benefit of exact product design, shorter development time and lower costs.
To learn more about elastomeric diaphragms and other sealing products, contact Gallagher Fluid Seals.