Consider Saniflex™ (Hytrel®) Diaphragms in place of Buna in Industrial Applications

Wilden® Chem-Fuse Integral Piston Diaphragms in Saniflex will outperform Buna-N in terms of abrasion resistance, leak prevention and overall durability

By Rob Jack and Tom Zuckett

INTRODUCTION

The air-operated double-diaphragm (AODD) pump has been a godsend for operators in the industrial space who need a cost-effective, reliable, and safe pump technology for a wide range of liquid-transfer processes. These processes can include such rough-and-tumble utilitarian applications as those found in the mining, water/wastewater, and oil and gas industries, as well as those hygienic food and beverage, pharmaceutical and cosmetic operations that require a bit more finesse.

No matter the application, though, the facility operator must take care to choose AODD pump configurations that feature high-performance, long lasting diaphragms.

Early AODD pump models – the technology has been available since 1955, or for more than 65 years – were outfitted with simple, fabric reinforced rubber diaphragms. While these rubber diaphragms have performed admirably over these many years, they have a couple of drawbacks: they must be reinforced with a stronger material, and they must be supported by inner and outer plates in operation.

Some other shortcomings of synthetic rubber diaphragm models are poor abrasion resistance and, except in the higher end of the synthetic rubber spectrum, limited temperature ranges. These can limit the application range, and shorten the diaphragm's effective service life, leading to increased maintenance, repair and replacement costs, along with the cost of cleanup and remediation should a pump develop a catastrophic leak because of a failed diaphragm.

There have been some notable advances in diaphragm design and the materials used to construct them over the years, and the manufacturers of diaphragms are always looking for ways to improve their products. This white paper will illustrate how the latest advance in diaphragm technology and the introduction of the Saniflex™ (Hytrel®) model is well on its way to setting a new standard in diaphragm performance and reliability, especially in applications typically handled with Buna.

BEGINNINGS

It was 90 years ago, in 1931, that a pair of German scientists invented a nitrile rubber compound that combined natural rubber with man-made additives that they called Buna-N, which is also known in some realms as NBR. Buna-N was an advance over traditional rubber compounds in that it offered better abrasion, tear, water and oil resistance, along with decent flex, though it did not work well in high temperatures or in operations that were conducted near an open flame.

Over time, Buna-N became a popular choice in industrial sealing applications, primarily as the main ingredient in O-rings, due to its compatibility with fuels and lubricating oils. Later, AODD pump manufacturers found great success by using Buna-N for the pump's gaskets, valve seats, valve balls, and many of these AODD pump components are still constructed of Buna-N today.

Keep in mind, though, that while Buna-N did outperform natural rubber in some significant ways, its operational characteristics did not lend itself at first to successful diaphragm construction. AODD pump manufacturers and users discovered this when they began making diaphragms out of Buna-N.

The characteristics that govern Buna-N's performance when used as a diaphragm material are its moderate abrasion resistance and low tensile strength. These combine to influence the flex life of the diaphragm.

Buna, and other synthetic rubbers, is very elastic, it can be bent and twisted into different shapes without fracture and will elongate to several times its initial length when subject to tensile loads. While the flexibility is very useful, the elongation is not desirable in a pump diaphragm. For this reason, all synthetic rubber diaphragms are reinforced with another (less stretchable) material.

Synthetic rubber is molded over a piece of reinforcing fabric mesh – most often nylon. The nylon mesh is meant to allow the rubber material to flow or "strike" through the mesh during the molding process and subsequent cross linking that cures the thermoset material. At the completion of the molding process, the reinforcing fabric is fully encapsulated within the cured rubber but is often seen at the edges of a finished diaphragm.

During operation, the rubber diaphragm flexes with the motion of the shaft it is attached to. The material also balloons or stretches during a portion of the diaphragm stroke. The net effect is to cause localized movement of the rubber and the reinforcing materials, resulting in abrasion of the rubber component. This abrasion creates voids within the diaphragm, as the rubber begins to come away from the nylon mesh reinforcement. This delamination reduces the ability of the mesh to strengthen the assembly and is a common cause of diaphragm rupture.

External abrasion plays a part in the flex life as well. From the moment an AODD pump begins operating, the diaphragm rubs against both the outer piston and liquid chamber, causing abrasive wear of diaphragm material. Worn off diaphragm particulate can be observed as a black residue in the outer piston and liquid chamber, signifying the amount of material lost to normal abrasive wear. Here's a maintenance note – inspect and polish if needed, your outer plates holding the diaphragms. Outer piston abrasive wear can be seen clearly, and you can liken this to tread wear on a pair of athletic shoes, which wear quicker if used on rough asphalt courts than on smoother surfaces.

Abrasive materials in the pumped fluid accelerate this wear. Abrasives will build up between the diaphragm and the outer piston and be pressed into the diaphragm material every stroke.

These are the conditions of service we find for rubber diaphragms and our industry has learned to live with our limitations. Efforts to toughen the rubber component reduce the flexibility needed, so while abrasion resistance is increased, brittle behavior is experienced.

A STEP IN THE RIGHT DIRECTION

So, while Buna-N was an evolutionary step in the development of reliable elastomer components that are used in AODD pumps, it was not the be all and end all when it came to diaphragm design, construction and operation. There is, however, a family of diaphragm materials that can be a game-changer.

Thermoplastic elastomers (TPE's) , which are often called thermoplastic rubbers, are a class of copolymers, or a physical mix of polymers, that consist of materials with both thermoplastic and elastomeric properties. These materials are often stronger than synthetic rubber, have greater temperature ranges (Figure 1) and superior chemical resistance.

Temperature Limits for Elastomers	
Wil-Flex™	–40° to 107°C (–40° to 225°F)
Neoprene	–18° to 93°C (0° to 200°F)
Buna-N	–12° to 82°C (10° to 180°F)
EPDM	–51° to 138°C (–60° to 280°F)
Viton®	–40° to 177°C (–40° to 350°F)
PTFE[1]	4° to 104°C (40° to 220°F)
Polyurethane	–12° to 66°C (10° to 150°F)
Saniflex™ TPE	–29° to 104°C (–20° to 220°F)
Geolast®	–40° to 82°C (–40° to 180°F)

Figure 1

Two widely used TPE's are Santoprene® and Hytrel®. Santoprene, manufactured by Exxon Mobile, is a physical mix of EPDM rubber and polypropylene plastic held together by a plasticizer. The combination has excellent chemical resistance to acids and bases, and is particularly useful in chemical (sodium hydroxide and hydrochloric acid for example) applications. Hytrel®, a polyether-ester copolymer, was developed by the DuPont™ Company to combine the flexibility of rubber with the strength of thermoplastics, which gives it an admirable combination of flex life, abrasion, heat and chemical resistance, along with strength and durability

Of the two TPE's, Santoprene has the higher usage throughout industry. Hytrel was first on the scene with a food grade TPE and it seems to have been a victim of its own success - pigeonholed into sanitary applications. It excels there, and Wilden® has in fact brand named it "Saniflex," but there is more utility to Hytrel than just sanitary applications, particularly for those AODD pumps that are used in industrial applications that require the transfer of non-polar materials such as acids, bases, amines and glycols, along with oils, hydraulic fluids and abrasive liquids.

A USEFUL SOLUTION

Specific to the construction of AODD pump diaphragms, unlike synthetic rubbers, TPE's do not require nylon-mesh reinforcement and they're not laminated, meaning that it cannot delaminate. TPE's are also injection molded, a much faster and economical process when compared to the hand lay-up and placement of the reinforcing fabric into a rubber transfer mold cavity.

The chemical compatibility of Santoprene lends itself to replacement of both polychloroprene (neoprene) and EPDM synthetic rubber diaphragms. The nature of the plasticizer used in Santoprene however, preclude it from handling applications typically served by Buna. The compatibility of Hytrel, though, matches many of the same chemicals that Buna is "A" rated for, especially fuels and lubricating oils, and it is this that leads us to recommend consideration of Hytrel TPE as a replacement for Buna in an AODD diaphragm.

Laboratory testing shows a near equivalence in flex life (Figure 2) of the two materials when fabricated into a standard industry diaphragm with a hole to accommodate a shaft that supports an inner and an outer plate to hold the diaphragm. Both are quite flexible and tend to succumb to abrasive wear primarily at the outer piston contact region.

A CASE FOR UPDATED TECHNOLOGY

There is another diaphragm style, however, that does not suffer from outer piston abrasion. The Integral Piston Diaphragm (IPD) has dispensed with the outer piston completely and therefore has eliminated that failure mode entirely. Additionally, the opportunity for fluid to leak past the outer piston due to torque decay or another reason, is eliminated – there is no leak path in the surface of an IPD.

Figure 2 lays out the relative flex lives of these diaphragms, normalized on the measured life of Buna diaphragms, Saniflex and Saniflex Chem-Fuse are reported as multiples of Buna life. The IPD doubles the flex life of Buna in the 1" and 1.5" pump sizes. The life increase is substantially more in the larger 2" and 3" sized pumps.

These relations were noted during the development of Wilden IPDs targeted at the sanitary market. The absence

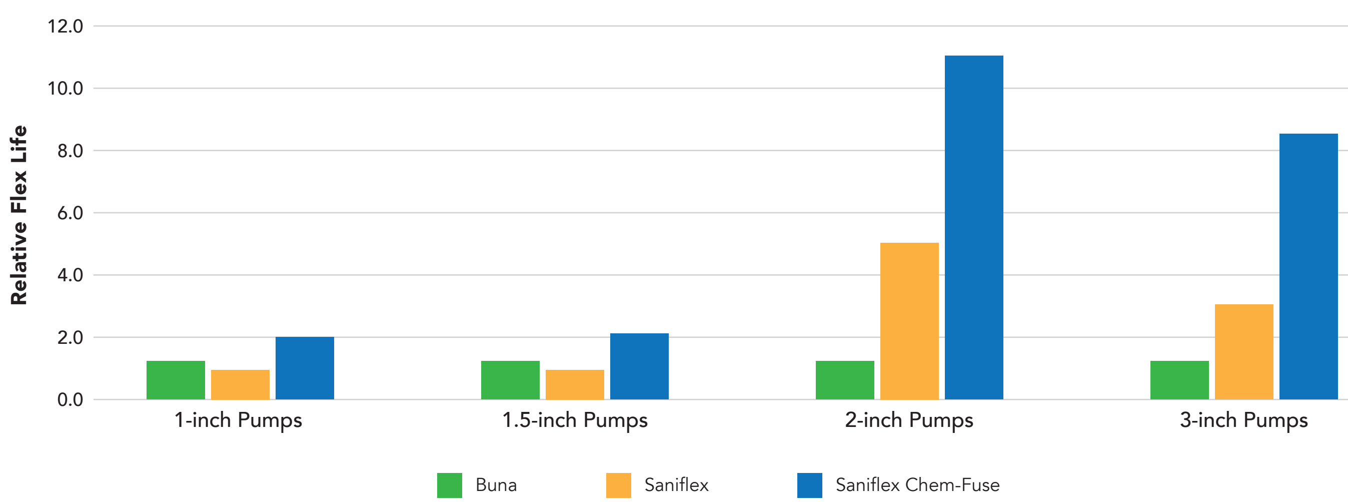

Figure 2

of the outer piston means there is no need to tear down the shaft – diaphragm assembly for cleaning, a major plus for sanitary users, and a requirement for those utilizing clean-in-place (CIP) processes.

The increased flex life was eagerly accepted, given the nature of most mechanical wear on diaphragms. When this technology was applied to non-food applications, in paint and polishing industries for example, the extended diaphragm life was a welcome bonus to existing diaphragm pump users.

Chem-Fuse Integral Piston Diaphragms are manufactured in both Santoprene and Hytrel materials, currently available for use on Wilden's 25 mm (1"), 38 mm (1.5"), 51 mm (2") and 76 mm (3") Pro-Flo® SHIFT and Pro-Flo® metal and plastic pump models.

Given the suitability of Hytrel as a stand in for Buna and having seen the flex life improvements of the Chem-Fuse design, Wilden suggests consideration of the Hytrel Chem-Fuse, for applications previously tied to Buna. We think your process will experience a noticeable increase in operational uptime.

CONCLUSION

There's little question that advancements in diaphragm design and materials of construction have helped keep AODD pumps a first-choice technology for non-food-grade product-transfer applications that feature abrasive liquids. In that realm, Buna-N has been a noteworthy addition to the evolutionary cycle. Though while popular, Buna-N's shortcomings – chief among them moderate abrasion resistance, flex life and durability – left the door open for a more advanced thermoplastic elastomer (TPE) compound to move to the head of the class.

That compound has arrived in the form of Saniflex/Hytrel, which Wilden is now incorporating into its full line of Chem-Fuse IPDs. By combining the advantages of Saniflex – better abrasion resistance, reduced risk of leaks occurring past the outer piston and ease of cleaning with Hytrel – wider operating temperature range – Chem-Fuse outshines Buna-N in industrial applications. Chem-Fuse IPDs also provide the highest level of durability, reliability and safety, even when used in the most difficult pumping conditions.

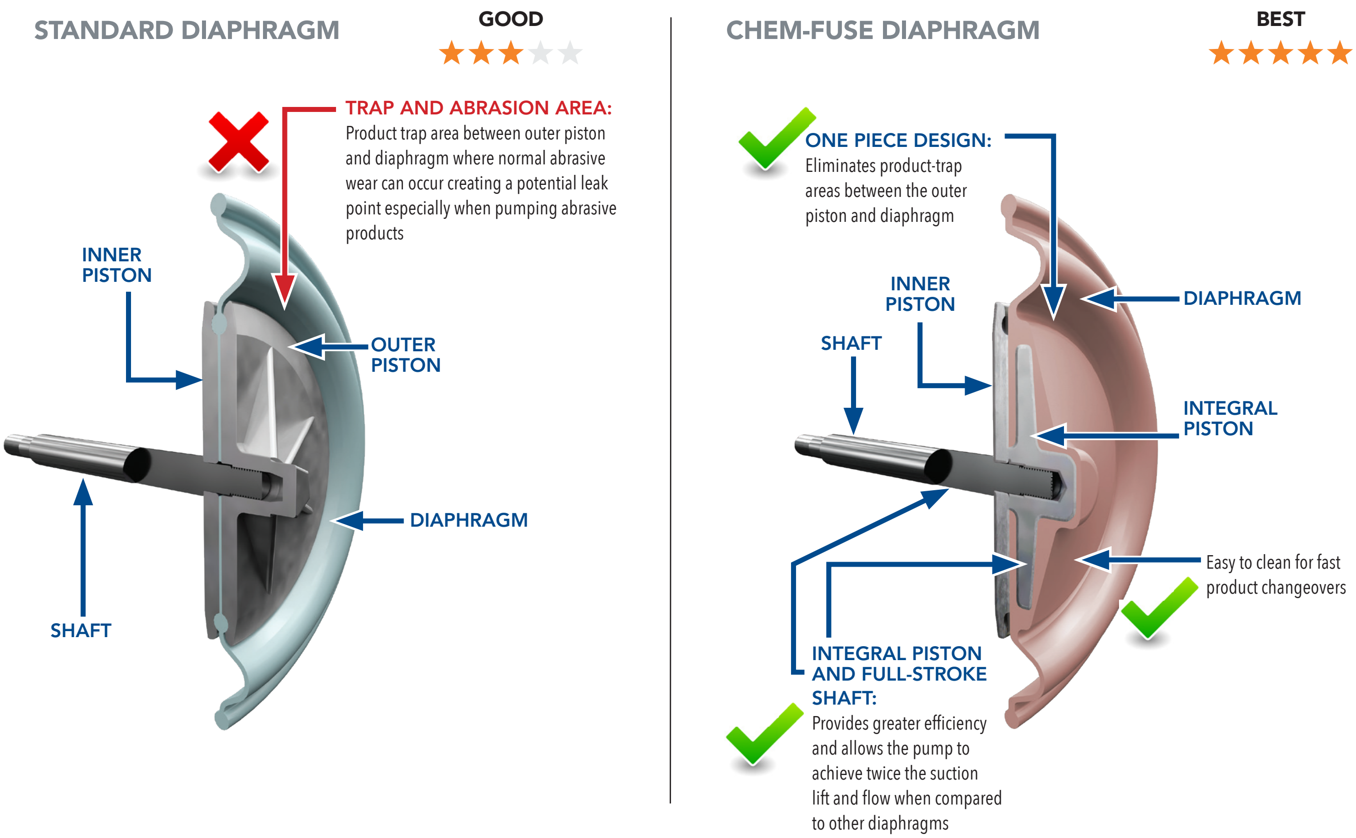

Figure 3 - The Integral Piston Diaphragm (IPD) design of the Chem-Fuse diaphragm encases the shaft connection within the diaphragm material. This eliminates notorious wear and product-trap areas that are inherent in traditional diaphragm design, as well as the outer piston and its attendant abrasive wear during normal operation. The result is a diaphragm that is longer lived, safer and more leak-resistant, which is a critical need when handling dangerous or hazardous non-food-grade oils, abrasives, and solvents.

ABOUT THE AUTHOR:

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