TECHNICAL PAPER

“Effective sealing for pumps with elastomers”

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Pump engineers have a wide range of sealing options available to them which cater for the diversity of pump applications. In designing pumps and other associated equipment like compressors and valves which need maximum efficiency and long-lasting performance, the flexibility of elastomers sets them apart from other pump sealing materials available.

It is the ability of an elastomer to return to its original, undeformed shape after the removal of force (unlike rigid sealing materials like PTFE) that provides unrivalled sealing performance helping the pump designer to prevent leakage under the most demanding pressures and operating environments.

Pump users demand maximum operating efficiency from their investment and sealing solutions have to be designed to function between long service intervals. These conditions often create increased chemical, thermal and pressure related stresses on both the pump and seals, multiplying the risk of seal failure and pump leakage.

Under pressure

In many applications, pump seals are not exposed to particularly hazardous conditions or operating pressures. For most pneumatic pumps and compressors, the mix of air, water, fine oil mist and moderate heat to which they are subjected can be typically handled by mid-range elastomers such as nitrile (NBR) and EPDM. For hydraulic pumps however, operating pressures are significantly higher and as a consequence, more appropriate materials would include HNBR or the higher performing fluoroelastomer (FKM) which exhibit high strength and good oil resistance.

High pressure pumping applications present unique challenges for elastomeric seals. Since all elastomers act very similarly to high viscosity liquids, they can flow under extreme pressure conditions. In such cases back-up rings are often used to prevent the seal material extruding into the clearance gaps, while helping to ensure seal performance and preventing seal leakage once pressure is relieved. As with the elastomer itself, the chemical and thermal compatibility of the back-up ring and its ease of installation need careful consideration.

Keeping it tight

Low pressure vacuum applications are equally challenging as the performance of a vacuum system will be significantly degraded if air or other gases are allowed to enter. Different elastomer types and even different elastomer compounds within the same material family will exhibit a varying degree of gas permeability depending upon the gas and environmental conditions. Additionally, low molecular weight elements sometimes included in the elastomer formulation such as process aids or even air or gas entrapped during the manufacturing of the seal, can create a phenomenon known as out-gassing. This will negatively impact the stability of the vacuum system and seal performance over time, and can increase the time taken to achieve a full vacuum pump down.

However, new sealing materials are now increasingly available to help vacuum pump manufacturers enhance performance and prevent seal leakage and out-gassing. These materials offer exceptionally low permeability to meet the needs of vacuum processes and environmental emissions regulations. Values in helium leak-testing have indicated that specially developed self-reinforcing polymer compounds can be up to 10 times more effective in vacuum applications than standard FKM materials.

The heat is on

Elastomer sealing in both high and low temperature environments poses particular difficulties. Very often there is a compromise between elastomers which offer high or low temperature capabilities and those which offer good chemical resistance.
As pump users increase the time a pump is running and reduce cool down periods in an effort to improve output during cost cutting campaigns, the risk of seal failure due to heat damage becomes a real danger. Pumps are designed with sufficient cooling in mind, but the

heat-soak during shutdown can damage the seal or reduce the seal life. A crucial consideration is that the temperature of the process is not necessarily the highest temperature the seal will have to withstand. It could be higher or lower depending on the location of the seal and the effectiveness and use of the cooling system. It is therefore of critical importance that the correct sealing material is selected at the outset.

For pump applications, the latest elastomer materials are capable of operating in temperatures between -100°C (-148°F) for silicone up to +325°C (+617°F) for perfluoroelastomers (FFKM). A new FKM grade which can offer real benefits to pump manufacturers and users is V74C, a low compression set compound, developed by Precision Polymer Engineering (PPE). V74C has been designed to operate in high temperature pump applications up to 200°C (+392°F) and provides superior heat ageing properties combined with excellent chemical resistance. With an industry leading compression set of just 5%[i], V74C retains its mechanical properties significantly longer than conventional FKM grades, allowing extended seal service life and increased efficiency.

At the other end of the spectrum, PPE has created elastomer compounds such as V71C, a low temperature fluoroelastomer (FKM) which extends the low temperature capability of FKM below -40°C (-40°F) while still providing an upper operating temperature of +200°C (+392°F).

Both V74C and V71C present chemical engineers, pump manufactures and service organizations with the opportunity to increase service intervals, prevent leaks and generally increase the efficiency of their pumps. Moreover, the improved sealing efficiency provided by these elastomers will allow pumps to run quieter, an important consideration in enclosed environments. Both V74C and V71C exhibit the same chemical and mechanical properties as conventional FKM grades and can be manufactured into almost any sized O-ring (standard and non-standard) as well as custom designed parts.

When pressure suddenly changes

For seals that may encounter explosive decompression (ED, also referred to as RGD or Rapid Gas Decompression) forces – either positive or negative – there are a number of solutions available; groove redesign, seal redesign, use of back-up rings or choosing a specially developed ED resistant elastomer.

In the event of failure

Seal failure in pumps can be caused by many factors including accidental fitting of the wrong seal, damage through abrasion, chemical attack or heat ageing. Where a seal is compatible with the process and is correctly designed and installed, seal failure can be an early indication of mechanical problems in the pump.

The use of polymer testing techniques, using various analytical equipment, can give valuable indications as to why a seal has failed and reassurance that the specified material is suitable.

TGA (Thermo gravimetric Analysis) can be used to assess the elastomer's composition and thermal stability, DSC (Differential Scanning Calorimeter) is used to evaluate any degradation within the polymer structure and FTI (Fourier Transform Infra Red) measures any changes within the chemical structure of the elastomer. Test data obtained from these analysis techniques can then be used to fine-tune sealing materials to obtain the best possible performance.

Summary

Avoiding seal leakage or failure is a complex task for pump designers and one that must be taken seriously especially in difficult economic times when reducing down-time is critical. New developments in elastomer materials and seal design techniques means that pump engineers can avoid seal leakage and ensure optimum performance in demanding operating environments involving high and low pressures and temperatures.
By working closely with material developers and seal manufacturers such as PPE, pump manufacturers and users can increase the performance of their pumps and contribute to increased operating efficiency during these challenging times.

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[i] Compression set test ASTM D395, 24hrs @ 200°C (392°F).