THE PUMP GUY

The Revenge of Commander "O"

If you had a drop of oil on your carport floor immediately under the engine block of your Ferrari, how would you imagine the oil drop found its way to your carport floor? Would you imagine that it splashed out of the dipstick spout? Did it sweat through the engine block? What do you think? Of course you already know the answer. That little drop of engine oil leaked through a gasket seal on the oil pan.

Most square and rectangular shapes in industry require some kind of gasket material cut to seal the odd shape. Most round forms requiring a seal (shafts, sleeves, tubing, threaded joints) use the lowly and shy o-ring. We have o-ring seals all over the house and in the family car. Mechanical seals and instrumentation joints for pumps use a lot of o-rings.

About half of all pumps in the maintenance shop today, were pulled out of service because they were leaking or wouldn't hold pressure. This is most likely a leaking gasket or o-ring. The o-ring is the rubber component of most pump seals. The o-ring controls the temperature, pressure, and chemical limits of the mechanical seal.

The difference between a mechanical seal in a pump in alcohol service and a pump in steam service is the o-ring. It is not the stainless steel, or the ceramic face of the seal. The difference between a mechanical seal in ammonia service, and a mechanical seal in propane service, is the o-ring. The people who assemble seals install o-rings that are adequate to perform the static pressure and vacuum test, which is normally done with water or air. The ultimate user must verify that the seal elastomers, the o-rings, installed in the factory are adequate for the service application (temperature, pressure, and chemically compatible). If they are inadequate, they must be changed to the correct o-ring rubber compound before the installation. Because most o-rings are black and appear the same, it may be necessary to use an identification tool, or purchase individually packaged and labeled o-rings to identify the o-ring rubber compound. Once the package is opened and stapled shut, the control is lost.

There are many rubber compounds used in industry as o-ring secondary seals. Some elastomeric compounds are highly specialized, finding application only in certain industries. Here are four rubber compounds, which find broad popularity in almost any production plant. Save this information and enter it into your file of CHEAT SHEETS.

A. Fluorocarbon (Viton is Dupont's trade name) is a rubber compound that is compatible (meaning it resists without degradation) with most petroleum based liquids and gases (propane, gasoline, crude oil), some acids and other chemicals. It is used extensively in the petroleum refining and petrochemical industry. Its temperature range is good from -15º F to +400º F (-25º C to +205º C).

B. Perfluoroelastomer (Kalrez by Dupont, Parofluor by Parker, Chemraz by Greene Tweed) is a rubber compound compatible with most organic and inorganic liquids and gases and aggressive chemicals. This material finds popularity in chemical processing and pharmaceutical plants, and wherever the temperature of the application demands. Some people call it Teflon's elastomeric brother. Its temperature range is from about -20º F to +500º F (-30º C to +260º C).

C. Nitrile (Buna-N) is a rubber compound popular in most sinks and drains. It's a basic plumbers o-ring seal, and handles most household liquids and chemicals (think of laundry soap, sour milk, bleach, and fabric softener). Because industry pumps so much water, this elastomer may be the single most popular o-ring secondary seal in the world. Its service range is from -30º F to +225º F (-34º C to +115 C).

D. Ethylene Propylene (EP, EPDM) is an o-ring rubber compound that is compatible with most water-based chemicals. Its good with caustic soda, detergents, water treatment chemicals, steam, and wastewater and with food processes like milk, beer, and soups. EP rubber compound is petroleum based and for this reason it should never come into contact with petroleum based chemicals. It will dissolve. Its service range is from -70º F to +300º F (-57º C to +150º C).

For example, on a commercial passenger jet, the engine's oil and fuel lines would be sealed with **fluorocarbon** rubber. The hydraulic fluid, which is water based, would use **EP** rubber seals. The onboard drinking water, kitchen and bathrooms use **nitrile**. Inside the jet engines where it's very hot, **perfluoroelastomer** seals are popular for their temperature resistance. You can imagine what happens when someone installs the o-ring into an inappropriate application on a jet airliner. It makes the evening news.

Let's consider an industrial boiler. The wrong o-ring may not be catastrophic, but it's called a "leaking boiler". You may need at least three of these previously mentioned o-rings, and maybe all four, just to prevent leaks and drips in a simple hydronic or steam boiler. Raw water comes into the boiler room with pipes, gauges, valves and instrumentation. All these fittings would probably use **nitrile** rubber o-ring seals to give long-term leak free service.

Next, the raw water must be treated before it can be pumped into the boiler. Treating the boiler water does three things. First it controls the pH so that the boiler tubes won't corrode. Next the treatment process removes oxygen, which prevents internal boiler wetted parts from rusting. Oxygen also messes with the boiler chemistry. Third, the treatment process removes minerals from the water so that mineral scale won't form on the boiler tubes, insulating them, and causing the boiler to lose efficiency. After raw water has been treated with chemicals the raw water becomes "make-up water". The treatment chemicals and the treated water will need **Ethylene Propylene** o-rings on the mechanical seals, instrumentation, valves, connections and fittings.

If the boiler is a high-pressure boiler, the boiler's discharge valves, and instrumentation fittings may need **perfluoroelastomer** o-rings for temperatures above 300 degrees. The high-pressure boiler feed water pump may need these high temperature o-rings in the mechanical seals because of the high frictional heat generated by the seal faces. If the deaerator tank is sealed and pressurized to hold the hot water from flashing, it may need these high temperature o-rings.

If the boiler burns propane, natural gas, or fuel oil, then you'll need **fluorocarbon** o-rings on your fuel lines, valves, instrumentation and fittings. Who would have thought that an industrial boiler would need up to four different o-ring compounds just to heat some water?

Four factors affect the life of an O-ring seal:

Chemical Attack

Because the o-ring comes into contact with the fluid, the o-ring must be chemically compatible with the fluid. Chemically compatible means that the o-ring's rubber compound will resist the chemical without degradation. If the o-ring is not chemically compatible with the pumped liquid, it may swell, harden, dry and crack, soften, or even dissolve depending on the nature of the chemical attack. The surface of the o-ring may form blisters, scale, or form fissures and cracks. The cause of these symptoms generally is chemical attack. The attack may come from the pumped liquid, or from the flush or barrier fluid used with double seals. You must be familiar with the different o-ring compounds used as secondary seals in mechanical seals, and all instrumentation, connections and fittings.

The O-ring must be compatible with **all** liquids moving through the pump. I had the opportunity to go into a water bottling plant with a severe mechanical seal problem. Drinking water is mostly compatible with Nitrile rubber. Bottled water is made in batches. The health department demands that they wash and flush the equipment with caustic soda between batches to prevent transferring any bacteria or germs from one batch to another. The chemical wash and flush was not compatible with Nitrile rubber. We changed all o-rings to EP rubber and the leaks stopped.

High Temperature

Too much heat in the system may present some of the same evidence as chemical attack. As the temperature rises the o-ring seal may soften. As the temperature continues to rise beyond the o-ring's temperature limit, the rubber seal will harden and maybe crack. You must know the temperature limits (upper and lower) and the chemicals they are compatible with.

Pressure

Pressure is actually linked with the temperature and the tolerance. The pressure that an o-ring can seal is a function of the temperature of the application and the tolerance (extrusion gap) of the containment groove. You can seal 100 tons of pressure if you can control the extrusion gap and the temperature.

Shelf Life

We all know that foods last longer in the refrigerator than on the kitchen counter, but eventually they will spoil even in the refrigerator. If a secretary uses and flexes a rubber band every day, it will be good for many years. But if she puts the rubber band in the drawer for a few weeks, the rubber band will dry rot. The same thing happens with a car tire or radiator hose. If pressurized, flexed and used, they will last many years. But they'll dry rot in a few months while hanging on a nail on the wall in the garage. Likewise, rubber o-rings have a definite shelf life from their moment of curing. The manufacturers list the shelf life. It normally runs from 1 to 5 years depending on the compound. For best shelf life, the o-rings should be in an air-conditioned environment and sealed from air, humidity, and light.

Would you be surprised if I said that many o-rings are installed into equipment long after their shelf life has expired? Here's how this happens. The manufacturer may sit on an o-ring for a few months before shipping the o-ring to a wholesaler or distributor. It might be on the wholesaler's shelf for up to three years before a requisition is issued to deliver the o-ring to an end user's plant. Then it may sit on the storeroom shelf for up to another three years if it were bought in quantities. If it were a rare or odd size, the storeroom tech would order two o-rings…one for immediate installation…and another for the next unplanned failure. Eight months later when the mechanic reaches for that spare o-ring, it's probably rotted. As a pump consultant, I go into a lot of un-air conditioned storerooms. I see a lot of o-rings hanging on nails or loose in bins and drawers. This is gonna leak when you pressurize the system.

When a pump is hauled out of service for a leaking seal, the mechanical seal should be disassembled and the o-rings inspected. They will exhibit certain signs and evidence of damage and degradation. The o-rings may suffer from extrusion, or hardening, or compression setting or nicks and cuts. Let's look at these:

Extrusion is deformation under pressure. An o-ring extrudes when the pressure is too high. Maybe the o-ring needs back-up rings to tighten tolerances. Maybe the design of the o-ring groove is inadequate. Some o-ring compounds get softer as the temperature rises so temperature-linked-to-pressure is also a factor to consider. An o-ring also may soften if under chemical attack. This should also be checked as a possible source of the extrusion.

Although an o-ring softens with temperature, too much heat will **harden** the o-ring. Too much heat is the usual cause, but chemical attack may produce the same result. The o-ring must deal with the temperature of the application and also from the heat generated between the mechanical seal faces. Many mechanical seal designs place the o-ring where it receives a lot of heat. A good idea is to find a mechanical seal with the o-rings and other secondary elastomer seals placed away from the heat of the faces.

Compression Setting is a good indicator that the O-ring was exposed to too much heat. Compression setting means that the round cross-sectioned o-ring came out of its groove with a squared cross section. The heat caused the o-ring to re-cure in the groove, taking the shape of the groove.

Ozone attacks o-rings, especially Buna-N (Nitrile compound). They should be stored away from fluorescent lighting and electric motors. These are sources of ozone. Ozone causes a general degradation of these elastomers. Remember the o-ring's shelf life. They should be stored in a cool environment or refrigerator, and sealed from air, humidity, and light.

Nicks And Cuts indicate that someone isn't providing the proper protection for the o-rings either in storage or upon pump assembly. This failure is mostly evident on start-up as immediate leakage. Extreme care should be taken to prevent damaging the o-rings as the mechanical seal is slid down the shaft at installation. The o-ring grips the shaft to withstand the seal's maximum pressure rating. The shaft o-ring must slide over the impeller threads, key way grooves, steps on the shaft, and marks made by previous setscrews. O-rings damage easily. They need protection and care upon assembly.

When I was a young steel mill mechanic in Birmingham, Alabama back in the 1960s, I installed a lot of mechanical seals with EP o-rings onto some treated water pumps for the hydrostatic pipe-testing machine. My supervisor had told me to protect the o-rings by greasing them before sliding the seal over the pump shaft. We changed seals every week. Our seal salesman loved us. My supervisor was questioning my ability to install the seals because they failed constantly. And I was doing what he told me to do. You **DO NOT** put petroleum based grease onto an EP o-ring to help it slide over the shaft. (Go back to the beginning of this article and re-read the info on EP rubber.) CHEAT SHEET!!

Remember, most pumps don't come out of service because they break. Most pumps go into the shop because they're **leaking**. Every day all over the world, too many $2,000.00 mechanical seals are thrown into the recycle bin or thrown away because of an 11¢ o-ring (Commander "O"). Put this information into your CHEAT SHEET file and store the info with your other notes from previous articles.

The book on operating and maintaining pumps is finished in both English and Spanish languages. The next step is the copyright and publisher search. One chapter of the book is entitled Common Sense Pump Maintenance. It was such a delight to write that it inspired us to write another book on common sense general maintenance. It will be about more than just pumps. We promise not to let common sense maintenance become reduced to three letters, ala RCM, TQM, and others. You won't have to subscribe to any philosophy of life, say a daily mantra, attend any more meetings, or take any more BS. We promise that it won't get you downsized. It will just make you feel good about what you're already doing and maybe give you some ideas on how to make your work easier in maintenance.