Analyzing Hydra-Cell Pro Pump Diaphragm Damage

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Hydra-Cell pump diaphragm damage is caused by one of the following four conditions: 1. Incompatibility (Chemical or temperature), 2. Over-pressurization, 3. Mechanical interference and 4. Cavitation.

This article will cover the causes of diaphragm damage, corresponding physical damage characteristics and aspects to review to prevent reoccurrence of diaphragm damage. It will also describe pump performance with damaged diaphragms and outline the recovery procedure to restore pump performance.

How Long Do Diaphragms Last?
With the exception to the PTFE version, Hydra-cell Pro pump diaphragms do not have a certain number of "strokes to failure". This is due to their hydraulically balanced nature along with the physical design having a built-in convolute to facilitate a stress-free flexure. As a result, the diaphragms are not considered a wear item.

PTFE Diaphragms
PTFE diaphragms usually due have a "wear life" because the design consists of PTFE bonded to an neoprene substrate (required to provide sufficient flexibility). When initially released in 1994 they were limited to about 2000 hours of service (120 million cycles). The PTFE layer is more susceptible to physical wear compared to the other homogeneous diaphragm materials and the inherent stiffness of the PTFE layer results in material fatigue over time. Since 1994 the PTFE diaphragm design has evolved to extend service life and operation at higher RPMs. The additional failure modes applicable to PTFE diaphragms are cracked and worn away sections of the PTFE layer.

Chemical or Temperature Incompatibility
Diaphragm materials for Hydra-Cell Pro pumps include Aflas, EPDM, FKM, PTFE, Neoprene and Buna-N. Each material has an acceptable temperature range (from the low end 30-80F and at the high end from 120-250F). Operating outside of the recommended temperature range may enable deformation of the material leading to a cracked or melted appearance. The visible damage caused by temperature and chemical incompatibility looks similar, so it requires reviewing your process to determine which is more likely. A rough surface or stiffness with a crack are likely related to chemical incompatibility whereas extreme temperatures are associated with deformation. Diaphragm material is chosen with liquid compatibility in-mind, a straight-forward process of consulting chemical compatibility charts. When the liquid has a blend of chemistries determining which diaphragm material is most compatible can be nuanced, requiring soak testing or trial-and-error. It is possible that there is no 100% compatible material for a given application and thus a preventative maintenance schedule is required to periodically change the diaphragms prior to failure.

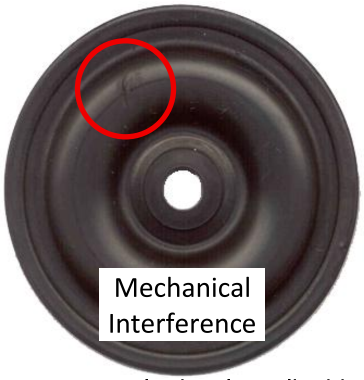
Remedies: Ensure chemical compatibility and operation within the design temperature range, be wary of upset conditions which may cause temperature spikes.

Over-Pressurization
Hydra-Cell Pro pumps have maximum discharge pressure ratings from 1000 to 5000 PSIG depending upon pump model. Operating the pump beyond the design pressure can result in damage to the diaphragms, o-rings and hydraulic components. Diaphragms which have failed due to over-pressurization usually have a frayed circumference caused by pinching between the valve plate and pump housing. Perimeter bolts hold the pump manifold and valve plate to the pump housing however during over-pressurization these bolts can "stretch" just enough for the diaphragm and o-rings to extrude out of their sealing grooves. Once the pressure is relieved the valve plate and housing pinch the edge of the diaphragm. A common situation involves a worn pressure regulating valve (PRV) which is bypassing too much liquid resulting in lower pressure, so somebody tightens down on the PRV resulting in higher pressure required to bypass flow and this temporarily solves their problem, however pressure spikes attributed to spray wands or fast acting valves will now exceed the design pressure – and that quick over-pressure pulse can cause enough movement between the sealing faces to pinch the diaphragms and o-rings. Over-pressurization does not typically result in sudden catastrophic diaphragm failure, rather sealing surface across the circumference of the diaphragm gradually degrades. Actually, the pump manifold o-rings will typically fail before the diaphragms do, so if o-rings are frayed or pinched it is important to examine and replace the diaphragms also.

Remedies: Use a quality pressure gauge or transducer to monitor discharge pressure and be careful to ensure the PRV is set properly, rebuild or replace worn PRVs.

Mechanical Interference

Uncommon but it is possible to damage a diaphragm with material caught within the pump chamber. Its uncommon because the maximum free passage area of the pump chamber check valves inadvertently restrict oversized material from entering the pump chamber and normally such material fouls the check valves and does not damage diaphragms. The most common example involves liquid freezing in the pump chamber and running the pump with either the entire chamber filled with frozen liquid or a sizable piece of frozen liquid entrapped in the pump chamber. In such cases the diaphragm cannot physically expand into the chamber, resulting in physical damage.



Other forms of mechanical inference include precipitation of entrained solids when the pump is not in use. If precipitation occurs and the material tends to clump together or resist becoming re-entrained once the pumping action restarts, this can result in physical diaphragm damage.

Remedies: Prevent liquid within the pump head from freezing by running the pump dry and using the pump manifold drain plug. To prevent precipitation and agglomeration of material within the pump head without running the pump dry, flush the pump head before shutting down.

Cavitation

As relates to Hydra-Cell Pro pumps, cavitation is caused by attempting to displace more liquid than available within the pump chamber. This situation is often created by a fouled inlet filter element, insufficient inlet pressure or some other restriction within the inlet plumbing such as a collapsed flexible hose or closed valve. The issue at hand is that the diaphragm has a fixed volume displacement, thus when the liquid within the pump chamber is less than this displacement a vacuum is formed resulting in a violent flashing of liquid.

The diaphragms of current generation of Hydra-Cell Pro pumps are not immediately damaged by inlet cavitation. Beginning in June 2003 with the model D/G10 pumps, almost all current Hydra-Cell Pro pumps are protected from cavitation damage. Prior to 2003 and for some models that were not upgraded until >2004 it was possible to immediately damage a diaphragm via cavitation. The issue at hand was that the resulting vacuum within the pump chamber allowed the hydraulically actuated diaphragm to "over-fill" with oil resulting in mechanical interaction with the outlet check valve leaving a crescent shaped cut along the diaphragm convolute.

I included this failure mode for diaphragms even though all the modern Hydra-Cell Pro pumps are impervious to cavitation damage because there still many pre-2003 pumps in operation where such damage may occur, although with each passing year this population of outdated Hydra-Cell pumps decreases.

Diaphragm Failure

A damaged diaphragm reduces pumping efficiency; pulsation is pronounced and pumping sound increases. Degradation in performance is easily noticed if the flow rate or discharge pressure is monitored.

A cut, cracked or severely frayed diaphragm will likely result in loss of hydraulic oil from the back end of the pump; usually some oil enters the pump head and some process liquid will migrate into the hydraulic end. If not caught soon enough, insufficient lubrication of the bearings and hydraulic pistons will accelerate wear and could result in complete destruction of these hydraulic components. As long as the liquid pumped is not aggressive to the hydraulic components, recovery involves replacing the diaphragms, draining the hydraulic end, flushing with new oil, replacing with new oil and removing the air from behind the new diaphragms.

Pump Repair Kits

There are three kit configurations: elastomer, valve and complete kits. The elastomer kits contain the diaphragms and manifold o-rings. The valve kits contain the check valve assemblies which includes the o-rings/tetra seals and dampening washers as applicable. The complete kit is simply a combination of the elastomer and valve kits.

Although check valve wear is normally the driving factor for pump maintenance, most customers will elect to change the diaphragms also, just because it doesn't increase the cost of the kit very much nor significantly increase the labor time.

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