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Filters can remove H_2O from hydraulic fluid

Here is the latest component for hydraulic system filtration and contamination control

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Water is a very serious contaminant in oil hydraulic systems. Yet, water contamination is rarely identified, poorly understood, and, until recently, considered very difficult to remove. In most cases, the damage done by water is blamed on other factors. Water often works together with other contaminants to produce a combined synergistic degradation of fluid and components.

In the past, hydraulic filtration processes were designed to separate solid contaminants from the hydraulic fluid and, over the last 20 years, the hydraulics industry has made great progress in implementing and maintaining well-conceived solid-contaminant filtration on hydraulic equipment. However, the recent introduction of water-removing filters appears destined to change the focus of fluid power contamination control.

Water contamination effects

Proper maintenance of anhydrous hydraulic fluids is tantamount to eliminating the root cause of most hydraulic equipment and component failures. This cannot be overemphasized. To a hydraulic system, water is like a severe carcinogen. It destroys the fluid's base stock and critical additives. It degrades the surfaces of components and even accelerates the wear process. Damage caused by water can rarely be reversed.

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Water demonstrates its destructiveness in the following forms:

Fluid oxidation. When hydraulic fluid is heated, water combines with air (oxygen) to oxidize the fluid's base stock and additives such as antioxidants, rust inhibitors, and viscosity improvers. The result may be an increase in fluid viscosity, generation of acid products, and creation of slimes or resins. These by-products are often responsible for sticking spool valves, clogged orifices, and, of course, poor lubrication.

Loss of antiwear protection. The combination of water and high operating temperatures can quickly destroy a fluid's boundary-layer antiwear protection, which is provided by zinc dialkyldithiophosphate (ZDDP). This additive is critical to maintaining long life of pumps and motors, especially under high-pressure and high-load conditions. Without antiwear protection, wear from contaminants increases rapidly.

Silting. Valves and other components with spools and small orifices are subject to catastrophic failure due to contaminant lock and obliteration (the process of particles blocking orifices and small flow passages) or *silting*. This silting condition is greatly accelerated by the presence of moisture because moisture-laden fluid tends to cause contaminant particles to cling and stick together like wet sand — resulting in jammed and inoperative components.

Corrosion. Water etching commonly initiates severe fatigue wear, or spalling, at rolling and sliding surfaces. This corrosion process results in randomly spaced pitted areas. Tests show that spalling will occur after only 60% of rated component life when moisture is present.

In addition, water is at the root of many other corrosion-related problems. For example:

- hydrogen embrittlement of bearing steel
- etching by hydrogen sulfide and sulfuric acid (fluid/water byproducts)
- cracks caused by fatigue due to superimposed corrosion effects, and
- rust.

Fluid appearance

Typically, small amounts of water can be dissolved in a hydrocarbon fluid — up to the point where the fluid is saturated with water. Dissolved water cannot be seen in the fluid, Figure 1, and is less harmful than concentrations above the saturation point.

Once water gets into a fluid in amounts greater than its water saturation point, its presence is evidenced by a change in turbidity. These small amounts of water (less than 1000 ppm) are recognized by a slight haze in the fluid when compared with new fluid or fluid with only dissolved water. Higher amounts of moisture make the fluid appear cloudy or milky. This visible moisture is emulsified and is highly damaging.

Water-removal methods

Obviously the best place to remove moisture is as it enters or before it enters the system. This would preclude the water from doing even momentary damage to the fluid or components. Because the most common ingression point is the reservoir opening, desiccant- or bladder-style breathers should be used where possible. One desiccant-style breather design is shown in Figure 2. Worn wiper seals and corroded heat exchangers are also common entry points for water and should be serviced frequently.

Various methods have been used over the years to remove moisture from mineral-based hydraulic fluids. Some are clearly effective, at least to a degree, while others should be avoided. The following are common methods for removing water:

Gravity separation. Moisture that enters a system from condensation will collect on the inside top of the reservoir and eventually run to the bottom. This free water will not become emulsified until it passes through the pump. As free water, it is already separated from the oil by gravity and can be removed easily by purging through the sump. For equipment exposed to wide temperature changes, this purging should be done regularly.

Centrifugal separation. By increasing gravitational forces even emulsified water can be removed effectively from fluids. However, centrifugal separators are expensive and bulky.

Coalescing separation. Coalescers have been used for years to separate free and emulsified water from many

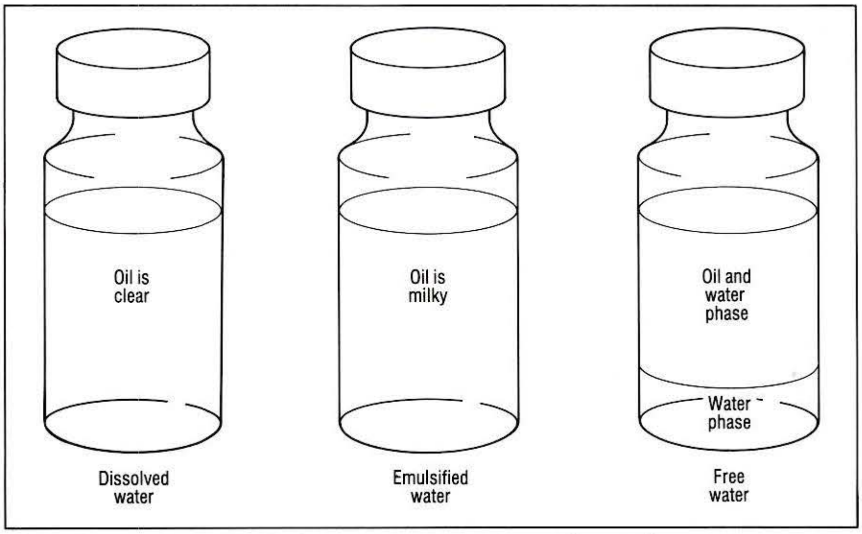

Fig. 1. Water in a hydraulic oil may be dissolved, emulsified, or free.

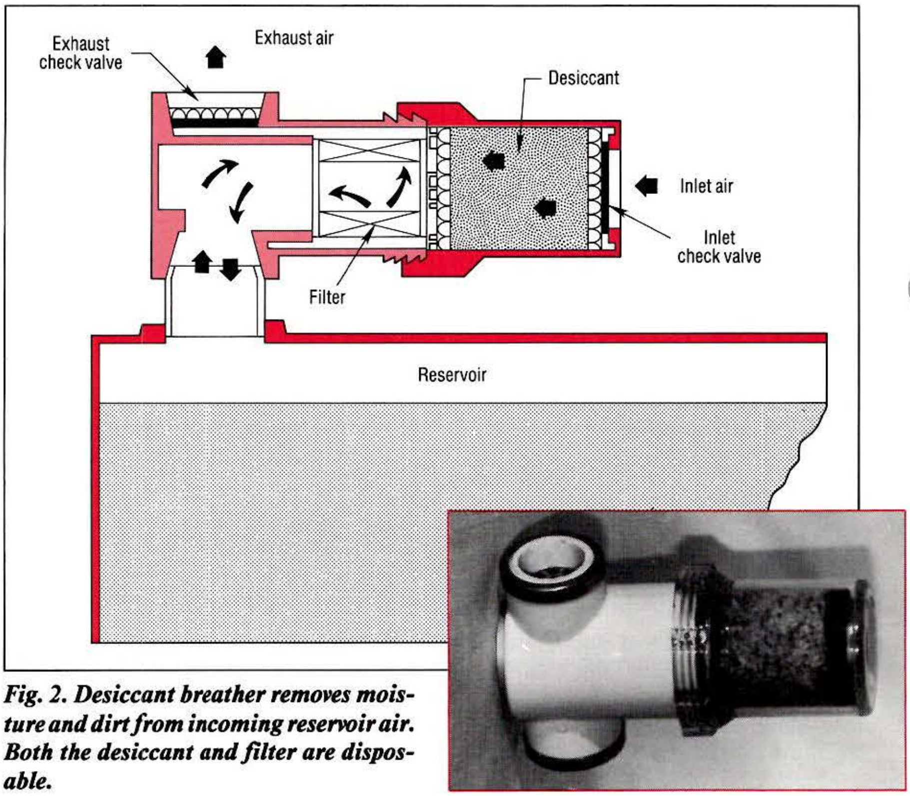

Fig. 2. Desiccant breather removes moisture and dirt from incoming reservoir air. Both the desiccant and filter are disposable.

types of fuels. In coalescing separation, water droplets are forced to collide with each other and combine (coalesce). As the process continues, the water droplets become large enough to separate from the fluid by gravity. Interfacial tension between the fluid and water is the operative separation mechanism. However, the attractive forces associated with oil/water emulsions are usually too difficult to break by coalescence.

Vacuum dehydration. Vacuum dehydration has been broadly used to remove dissolved, emulsified, and free water from all types of mineral-based hydraulic fluids. Its operation is based on two principles. Both involve creating large fluid surface area — such as by thinly dispersing the oil through a column of porous media — while exposing the fluid to a vaccum. With the first principle, ambient air is metered into the vacuum chamber. Under high vacuum this air has a very

Fig. 3. New filters employ a super absorbent polymer to remove both water and dirt from hydraulic fluids.

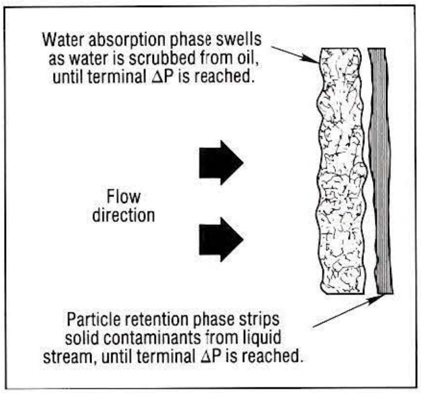

Fig. 4. Two-stage water and dirt removing filter media.

low relative humidity and draws the water out of the fluid (mass transfer). With the second method, fluid enters the chamber at a temperature around 150°F. Under vacuum this temperature is above the boiling point of water and induces vaporization. With both methods the vapor is expelled by the vacuum pump and is either condensed or released to the atmosphere. The primary drawbacks of vacuum dehydration are large equipment size and high cost.

Desiccant adsorption. Desiccants such as activated alumina, fuller's earth, and molecular sieves are commonly used to remove dissolved water from mineral-based fluids. Although these desiccants are very efficient, their capacity for holding water is insufficient to be used effectively to remove emulsified or free water.

Super-absorbent elements

A new super-absorbent polymer, developed originally for agricultural uses, has gained prominence recently for removal of moisture from hydraulic fluids. Several hydraulic filter manufacturers have introduced products that employ one or more variations of the polymer directly in the filter element itself. The primary benefit is that standard spin-on and canister filters with these elements will remove both water and dirt, Figure 3. No additional filtration equipment is required.

The polymer consists of a cross-linked, starch-based molecule which is refined to a coarse powder. This molecule can absorb between 100 and 1000 times its weight in water, depending on the water's purity. (Some filters, sized about 6-in diameter by 18-in long, are capable of removing more than a liter of water.) During manufacture, the powder adheres to the fibers of a loose, open-mesh depth media, typically fiberglass. This media comprises the first stage of the filter, Figure 4. The second stage employs cellulose or micro fiberglass filter media for particle retention and to restrict migration of the polymer.

As moisture-laden oil enters the filter's first stage, the polymer reacts with the water and turns it into a gel. This immobilizes the water in the media while allowing oil to pass freely. As more moisture is absorbed, the gel particles grow, causing the media to expand. Eventually the swollen gel seals off flow, creating a high pressure drop, Figure 5, and signalling the need for an element change.

Note that water-removing filters will typically have a higher pressure drop than a filter of the same size that removes solid particles only.

The advantages of a single filter for removal of both water and particles are obvious. Most importantly, these elements remove moisture as it enters the system, before harm is done to the fluid and components. Or these filters can be employed downstream after moisture is observed while still providing dirt-removing capability.

Finally, maintaining cleanliness in a hydraulic system is at best a difficult process. The presence of water severely compounds the housekeeping problem. Hydraulic equipment users should employ the latest advances in fluid contamination control — removing both water and solid particles — in the interest of extending their equipment's life and reliability. HP

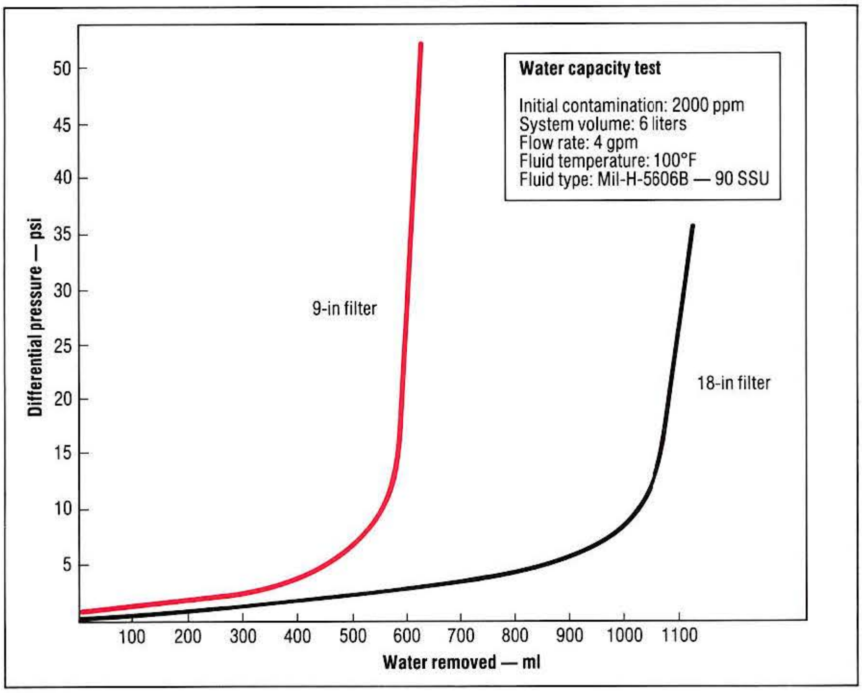

Fig. 5. Plot of water-removal capacity test.

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