

How water glycol fluids affect common seal materials

Comprehensive testing revealed temperature-related issues.

By James Simpson & Eric Bucci, Trelleborg Sealing Solutions

As the oil and gas industry moves to recover more challenging reserves and enters the development of High-Pressure/High-Temperature (HPHT) fields, it is imperative that operators understand the effects of high-temperature exposure of sealing materials within water-based hydraulic fluids. Until now, these two materials have not been thoroughly tested together at high temperatures.

Water glycol fluids consist of a solution of water, ethylene or diethylene glycol, usually a high molecular-weight polyglycol and an additive package. The water-to-glycol mixture typically contains 38 to 45 percent water. These fluids usually contain red, pink or other colored dye to aid in their identification.

With water in the formulation, evaporation is ongoing and upper operating temperature limits must be considered. Water loss can cause an imbalance relative to the additives and adversely affect viscosity, pH and lubrication quality. Water content must be checked periodically and water must be added to the system if required. Added water must be distilled or soft deionized because the calcium and magnesium present in potable water will react with additives, causing them to precipitate out of the fluid and compromise fluid performance. Operating temperatures should be kept below 65°C to minimize evaporation, though in practice they can be significantly higher.

The polyglycol is a water-soluble polymer thickener that can be formulated to cover many viscosities. The resulting viscosity-temperature properties give water glycols good low-temperature, cold-start pump wear protection and they minimize cavitation. The additive package imparts corrosion resistance, metal passivation,

seal and hose compatibility, oxidation resistance, antimicrobial properties, anti-foaming agents and antiwear properties. Water glycol fluids also have better thermal transfer properties than other fire-resistant fluids.

Why use water-based hydraulic fluids?

Water-based hydraulic fluids are widely used in oil and gas, mining, hot-rolling mills and similar applications in which the potential for fire could have catastrophic consequences. They are also replacing traditional oil-based HLP fluids in applications in which environmental regulations must be observed. As a result, they have become more prevalent in many applications within offshore energy production as a means of protecting people, the environment and resources. Low-viscosity versions operate more effectively than oil-based HLP fluids over long distances, and the low compressibility of water gives faster response times.

The International Organization for Standardization (ISO) classifies fire-resistant, water-based hydraulic fluids into four categories:

- HFAE — includes oil-in-water emulsions, typically with more than 80 percent water content
- HFAS — synthetic aqueous fluids, typically containing more than 80 percent water
- HFB — water-in-oil emulsions typically containing more than 40 percent water
- HFC (also known as glycol solutions, polyalkylene glycol solutions and water glycols) — water polymer solutions, typically containing more than 35 percent water

HFC fluids are the most common hydrous, fire-resistant hydraulic fluids because they have the best fire resistance and hydraulic properties. They are used wherever hydraulic fluid escaping under high pressure can ignite on contact with hot materials. At temperatures above 600°C, these fluids should not ignite or continue to burn. They can be used at ambient temperatures of -20°C to 65°C and up to working pressures of 250 Bar.

The fire-resistant and environmentally friendly qualities of HFC fluids make them ideal for use in offshore installations, whether on surface equipment such as motion compensation cylinders or on subsea equipment when used as a control fluid to operate valves and blowout preventers. The fire-resistant properties mean greater fire safety, offering more time to initiate fire-fighting measures and bring people to safety.

Other considerations with using HFC fluids

Because they are mostly made of water, HFC fluids have vastly different lubrication properties compared to oil-based fluids. In hydraulic fluids, the interrelation between viscosity and temperature is described by the viscosity index (VI). HFC hydraulic fluids have a better viscosity temperature behavior than HLP mineral oil. In HFA hydraulic fluids, the dependency of the viscosity on the temperature is negligible. The differing viscosity temperature behavior should be taken into consideration when selecting hydraulic fluid for the required temperature range.

Owing to high vapor pressure, in comparison to a similar HLP mineral oil, the maximum operating temperature when working with fire-resistant, water-containing

hydraulic fluids must be limited. Reservoir temperatures above 50°C must be prevented in open systems because they can lead to serious water loss and accelerate the aging process in the hydraulic fluid. Furthermore, in HFC hydraulic fluids, water losses that are too high can lead to an increase in viscosity and a reduction in fire-resistant properties. The minimum operating temperature for HFA hydraulic fluids is 5°C. HFC hydraulic fluids respond well at low temperatures and have lower pour points compared to HLP mineral oils.

It is critical that the hydraulic fluid does not negatively affect the materials used in the components within any system that uses HFC fluids. Compatibility with coatings, seals, hoses, metals and plastics should be observed to prolong the service life and integrity of equipment.

Oil and gas hydraulic applications often involve demanding dynamic movements. For instance, sealing systems in offshore motion compensation cylinders can be subjected to significant wear because of long strokes. Compared to oil-based HLP media, the water base of HFC fluids typically produces different reactions within the traditional sealing materials used in these applications. These reactions can range from lower lubricity relative to dynamic sealing elements, to corrosion concerns of supporting metal hardware, to compatibility with sealing polymers.

Case study: Testing HFC fluids

Trelleborg Sealing Solutions and fluid producer MacDermid partnered to investigate the effects of water glycol fluids on common seal materials. In 2015, the companies developed a series of tests involving seven seal materials, six fluids and three temperatures.

The MacDermid fluids tested were ERIFON 818 TLP, COMPENOL, OCEANIC HW 525 P, OCEANIC HW 443, OCEANIC HW 740 R and OCEANIC XT 900.

The Trelleborg materials tested were XploR H9T20, XploR H9T21, XploR V9T20, XploR V9T82, Turcon T05, Turcon T46 and XploR J9513.

The details on Trelleborg materials are: XploR H9T20 — Explosive decom-

pression resistant HNBR; XploR H9T21 — Low-temperature explosive decompression resistant HNBR; XploR V9T20 — Explosive decompression resistant FKM; XploR V9T82 — Low-temperature explosive decompression resistant FKM; XploR J9513 — Explosive decompression resistant FFKM; Turcon T05 — Proprietary-filled polytetrafluoroethylene (PTFE); Turcon T46 — Bronze-filled PTFE.

The tests took place over a 90-day period in 2016 in three Trelleborg labs. Each seal and fluid combination was tested for changes in hardness, tensile strength, strain and volume. Each seal was photographed before and after the test to document all physical changes.

A series of tests were conducted on many elastomeric and thermoplastic sealing materials to investigate the effects of immersion in HFC fluids at a range of elevated temperatures up to 200°C.

As an example of the test results, the seal material property data for MacDermid Oceanic HW 740 R after a 90-day exposure at 70°C is shown in Tables 1 and 2, and 90-day exposure at 135°C is shown in Tables 3 and 4. Oceanic HW 740 R is a hybrid HFC fluid for use in subsea production control systems. It does not contain polyglycol because high viscosity adversely affects hydraulic response time.

Test results

Relative to elastomer materials, the testing highlighted that while HNBR (XploR H9T20 and H9T21) exhibits relatively small changes in hardness, volume and strain with Oceanic HW 740 R (and other HFC fluids) up to 70°C, a more pronounced change in these properties is observed when the test is performed at temperatures of 135°C. The HNBR property change from 70°C to 135°C is expected and typical because rubber materials generally lose properties as temperature increases. Therefore, the



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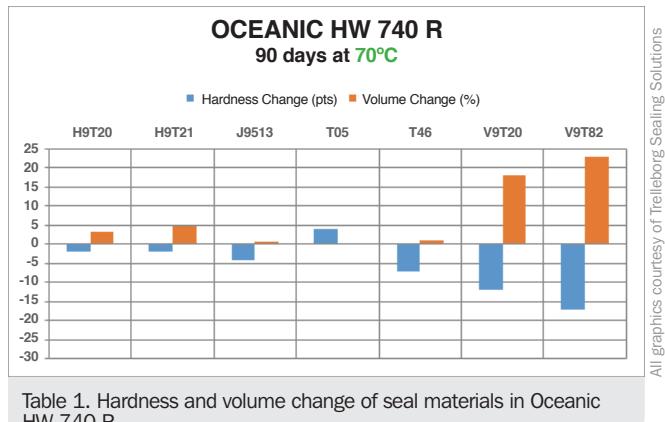


Table 1. Hardness and volume change of seal materials in Oceanic HW 740 R

All graphics courtesy of Trelleborg Sealing Solutions

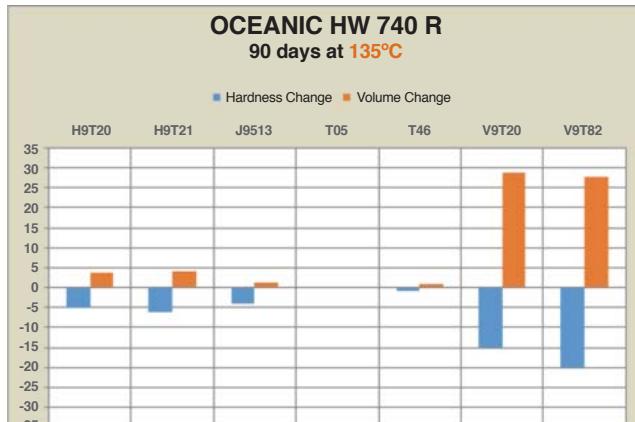


Table 3. Hardness and volume change of seal materials in Oceanic HW 740 R at 135°C

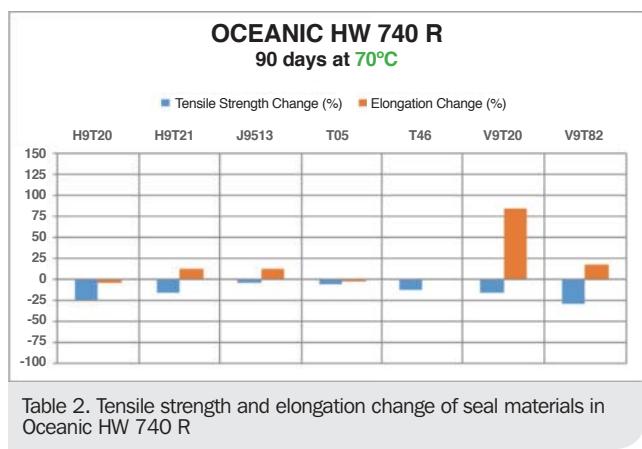


Table 2. Tensile strength and elongation change of seal materials in Oceanic HW 740 R

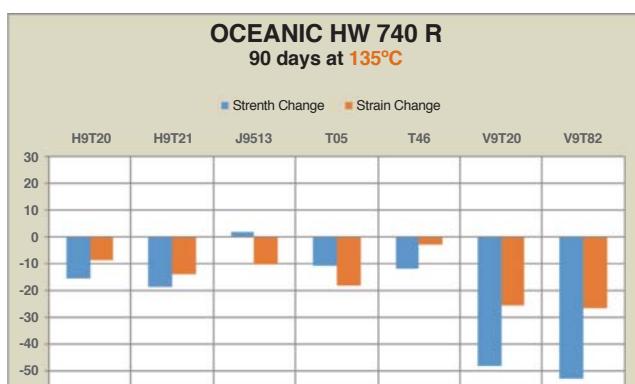


Table 4. Tensile strength and elongation change of seal materials in Oceanic HW 740 R at 135°C

90 days at 135°C in Oceanic HW 740 R	
	H9T20
Strength Change (%)	-15.7
Strain Change (%)	-8.7
Hardness Change (pts)	-5

test results for HNBR are within acceptable seal performance and operational limits and suggest the best combination of compatibility and material property retention at temperatures up to 135°C.

In applications with temperatures above 135°C, professionals typically look to Fluoropolymer (FKM) materials for a solution. However, testing illustrates that water-based HFC fluids significantly change the properties of FKM at 70°C and 135°C. As a result, FKM would not typically be recommended for applications involving these fluids.

Tests show relatively small changes in perfluoroelastomer Isolast J9513 and Turcon PTFE materials' properties. At temperatures above 135°C, these materials offer a potential solution when dealing with high-temperature applications that involve HFC fluids. More deep sea wells are reaching temperatures up to 200°C and additional Trelleborg testing shows Isolast J9513 and Turcon materials

retain a significant portion of their material properties in high-temperature water glycol fluids like MacDermid Oceanic XT900.

The testing reveals the importance of fluid type and seal material choice in ensuring optimal seal performance and service life. Traditional sealing materials, such as FKM, often inert in most fluids, are exhibiting disadvantageous behavior in HFC fluids.

The material compatibilities mentioned may not automatically result in success. Offshore operators can add extra additives to suit their particular applications, and extra additives were not included in the case study test. Extra additives may lead to seal material incompatibilities and could have dramatic adverse effects on sealing materials. Material incompatibilities may accelerate the hydraulic fluid aging process and increase wear and degradation of the sealing components. Each application must be reviewed to optimize the seal materials with the HFC fluid. Seals must be proved in specific applications with specific fluids and under actual operating conditions to ensure seal performance and life. **FC**

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