



Technical Topic

Fire-Resistant Fluids — Conversion and Compatibility

Fire-resistant fluids applications

When the possibility exists that a hydraulic fluid may come in contact with a source of ignition or the surface of very hot equipment, fire-resistant fluids may be used. This potential fire risk exists in applications such as die-casting operations, and continuous casting hydraulics in steel mills or presses that are operated near presses or ovens.

Electro Hydraulic Controls (EHC) used for governing steam supply to turbine generators are also applications in which high pressures and temperatures dictate the use of fire-resistant fluids to mitigate the potential for dangerous and expensive fires.

Phosphate esters are the most common fluid used in EHC in power turbine control systems. However, many other types of fire-resistant fluids may be used in other applications. All being not compatible with each other, special care should be taken when changing from one fire resistant fluid to another.

What is a fire-resistant fluid?

Fire-resistant hydraulic fluids are specially formulated lubricants that are more difficult to ignite and do not propagate a flame from an ignition source. Fire resistant should not be confused with fire proof, as fire resistant fluids will still ignite and burn given specific conditions.

There are several types of fire-resistant fluids and they are generally classified as follows:

- Oil and water emulsions
- Water Polymer solutions
- Anhydrous Synthetics

More specifically, the International Standards Organization (ISO) further classifies these fluids as follows:

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



- **HFDR** — synthetic anhydrous fluids composed of phosphate esters
- **HFDU** — synthetic anhydrous fluids other than phosphate esters. Examples include polyol esters and polyalkylene glycols

Changing or converting to fire resistant fluids

Detailed conversion procedures are available that cover all possible conversions. The International Standards Organization (ISO) has particularly described four main conversions:

- From a mineral oil to a water-based fluid (category HFAE, HFB or HFC)
- From a mineral oil to a synthetic anhydrous fluid (category HFD)
- From a water-based fluid (category HFAE, HFB or HFC) to a synthetic anhydrous fluid (category HFD)
- From a synthetic anhydrous fluid (category HFD) to a water-based fluid (category HFAE, HFB or HFC)

Key check points for any conversion or change are as follows:

- Compatibility of each of the components in the circuit with the fire-resistant fluid to be introduced into the circuit as a replacement (seals, packings, hoses and coatings)
- Draining and cleaning (pipes, valves, tanks, strainers, filters and cartridges, pumps, etc)
- Flushing
- Refilling and checking, including specific system and oil monitoring (potential filter clogging when converting to HFC fluids, due to their detergency properties leading to removal of previously formed deposits)

Conversion from a mineral oil to either a water-based fluid (HFAE, HFAS, HFB or HFC) or a synthetic anhydrous fluid (HFD)

A special care should be taken even when the fluids are compatible as a small remaining quantity of mineral oil can impair the fire resistance and stability of the water-based fluid (HFAE, HFB or HFC category) filled as a replacement.

Similarly, there is at least partial miscibility between mineral oils and synthetic anhydrous fluids (category HFD). Therefore a small amount of residual mineral oils will not alter the operational performance of an HFD fluid but may impair its fire resistance properties.

Change from a fire-resistant fluid to another, different fire-resistant fluid

When converting a system from a fire-resistant fluid of a given category to another fire-resistant fluid of a different category, the mixing of both fire-resistant fluids must not take place.

Summary of fire-resistant categories and applicable operating temperatures

	ISO Classification	Sub Category	Composition	Water Content	Typical Temperature Range (per ISO)	Comments
Water Based	HFA	HFAE	Oil-in-water emulsions	>80% (typ. 95%)	+5 to +50°C	Storage temperature > 0°C
		HFAS	Synthetic aqueous fluids	>80% (typ. 95%)	+5 to +50°C	
	HFB	—	Water-in-oil (invert emulsions)	>40%	+5 to +50°C	Storage temperature > 0°C
	HFC	—	Water polymer solutions	>35%	-20 to +50°C	—
Anhydrous	HFD	HFDR	Phosphate esters	None	-20 to +70°C	In some cases, used up to 150°C but at such temperatures, the fluids may be subject to rapid deterioration and shall be frequently checked (upper temperature limit for short-term only). In high-temperature circuits, i.e. above +100°C, special materials may have to be used for seals, packings, hoses, etc. Where doubt exists, clarification should be sought from the equipment manufacturer and/or fluids.
		HFDU	Synthetic Anhydrous fluids other than phosphate esters (PAG/Polyol ester)	None	-20 to +70° C	

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For example, any mixing of a water-based fluid (HFA, HFB or HFC) with a synthetic anhydrous fluid (HFDR or HFDU) will result in the formation of 2 layers system (separated water and oil phases), leading to potential pump failures.

It is also not recommended to mix fluids of the same category but from different suppliers, unless the compatibility of such mixtures have been clearly established.

Brand names may be confusing so the fluid supplier should be consulted to advise about the exact type of fluid in service in the equipment (category HFA, HFB, HFC or HFD as per the ISO classification).

Manufacturers of both the fluid and the system should be consulted for seals, metal and paints compatibility, as it may vary greatly depending on the chemical composition of all these components.

References:

- ISO 12922, First edition, 1999-10-15, Lubricants, industrial oils and related products (class L) — Family H (Hydraulic systems) — Specifications for categories HFAE, HFAS, HFB, HFC, HFDR and HFDU
- ISO 6743-4, Second edition 1999-10-15 — Lubricants, industrial oils and related products (class L) — Classification — Part 4: Family H (Hydraulic systems)
- ISO 7745:1989 and BS 7287:1990 — Guide for the use of fire-resistant hydraulic fluids
- Lubrication Fundamentals, Second edition, Revised and Expanded — D.M. Pirro and A.A. Wessol