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Hydraulic fluid power — Fire-resistant (FR) fluids — Requirements and guidelines for use

Transmissions hydrauliques — Fluides difficilement inflammables — Exigences et principes directeurs pour leur utilisation

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 7745 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 4, *Classifications and specifications*.

This second edition cancels and replaces the first edition (ISO 7745:1989), which has been technically revised.

Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. The most widely used liquid for hydraulic power systems is mineral oil which has advantages of excellent lubricity, availability in a wide range of viscosities and reasonable cost.

While not readily ignited in bulk, mineral oil is nevertheless flammable, and the high pressures associated with hydraulic systems can lead to a release of fluid which is easily ignited. In circumstances where ignition is likely, such as in a steel mill, or where released fluid cannot be allowed to propagate a fire, as in a coal mine, an alternative, fire-resistant, fluid must be used. Fire-resistance and physical properties such as viscosity and lubricity vary widely among the several types of fluid available. It is important therefore to select a fire-resistant fluid to match its proposed application and the perceived hazards in use.

Hydraulic fluid power — Fire-resistant (FR) fluids — Requirements and guidelines for use

1 Scope

This International Standard specifies the operational characteristics for the various categories of fire-resistant fluids defined by ISO 6743-4. This International Standard details the factors to be considered when selecting a fluid from these categories for a proposed application.

This International Standard identifies difficulties which might arise from the use of such fluids and indicates how they may be minimized. Appropriate procedures are given for replacing one fluid with another from a different category. Health and safety aspects when handling and disposing of fire-resistant fluids are also covered.

This International Standard does not apply to fire-resistant fluids used in the hydraulic systems of commercial or military aircraft. The appropriate aviation standards are also usually applied where aircraft hydraulic fluids are filled into ground-based systems.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
fire-resistant hydraulic fluid
hydraulic fluid that is difficult to ignite and which shows little tendency to propagate flame

[ISO 5598:2008, definition 3.2.271]

3 Hydraulic systems — Fire hazards

3.1 General

Fluid pressures in hydraulic power systems range up to 40 000 kPa (400 bar) and more. It therefore follows that any lack of integrity in the construction of a system, resulting in a burst or even a small leak, can in many circumstances give rise to a serious fire hazard.

3.2 Fault conditions

Failure of piping (particularly at joints and fittings), valves or gaskets, and rupture of flexible hoses have been principal causes of fluid being released from a system. The period of highest risk of this type of failure is during the commissioning, or after the repair, of a hydraulic system.

The following fire hazards are directly related to the use of hydraulic fluid under fault conditions. In each case, a source of ignition as described in 3.3 is required to initiate combustion:

a) ignition of hydraulic fluids ejected under pressure from hydraulic systems, in the form of a jet, spray or fog;

b) ignition of combustible vapours produced by hydraulic fluid;

c) ignition of hydraulic fluid spilled during transport, or leaking from hydraulic systems, on to absorbent material such as lagging or dust, and the subsequent propagation of fire along the fluid-wet absorbent material;

d) ignition of a fluid stream or pool;

e) ignition of hydraulic fluid where fire resistance has been reduced by chemical or physical changes in the fluid caused by service operation.

EXAMPLE 1 Reduction of the fire resistance of a fluid by evaporation or separation of water from the fluid which relies upon water to confer fire resistance.

EXAMPLE 2 Ignition of fire-resistant fluid contaminated with more combustible substances such as mineral oil.

3.3 Sources of ignition

Sources of ignition include, but are not limited to, the following occurrences:

a) discharge of static electricity;

b) stray electric currents or discharges from malfunctioning electrical equipment leading to high surface temperatures or sparks;

c) friction between moving surfaces, either during normal operation (e.g. brakes) or under fault conditions, leading to high surface temperatures;

d) high surface temperatures due to the presence of hot molten materials or materials undergoing high temperature manufacturing operations;

e) sparks and open flames from manufacturing operations, such as cutting, welding and grinding;

f) acoustic and electromagnetic energy, such as ultrasonic and microwave radiation.

4 Hydraulic systems — General precautions

4.1 Assembly work

Assembly work shall be carried out and supervised by competent staff following good hydraulic practice. The highest risk of leaks is during commissioning of a new system after assembly or during re-commissioning after repair.

4.2 Pipework and hoses

Pipework and hoses shall be mounted and secured in such a way as to minimize the effect of vibration. Consideration shall be given to siting components and routing pipes and hoses to minimize the likelihood of physical damage, particularly chafing of hoses. Wherever possible, pipework should not be routed adjacent to other services, particularly high-voltage electrical supplies.

4.3 Seals and gaskets

Only materials compatible with the fluid shall be used. Failure of incompatible materials can result in the rapid loss of fluid in the form of jets or sprays, which significantly increases the risk of fire.

4.4 High fluid temperatures

The operating temperature of a well-designed hydraulic system should not normally exceed 50 °C at the pump inlet. Higher operating temperatures shall be subject to careful consideration of the increased hazards and preferably with the written agreement of the fluid supplier. Operation at increased temperatures should be accompanied by more frequent monitoring of the fluid condition and properties.

High operating temperatures generally reduce fluid viscosity which can greatly increase the potential leakage rate and may render the system less efficient. Further, when water-based fire-resistant fluids are used in high temperature conditions, evaporation of water can lead to reduced fire resistance and other changes in fluid properties.

It is recommended that thermal shut-down devices be incorporated within the hydraulic reservoir, to operate in the event of high fluid temperatures occurring.

High temperatures also accelerate fluid degradation due to chemical changes. Prolonged exposure to excessive temperatures can promote instability in emulsion-type fluids, resulting in the separation of an oil-rich emulsion (cream) and free oil which is more flammable than the bulk of the fluid. Where installations require reservoir heating for cold start-up, the rating of the heater shall be limited to avoid thermal degradation of the fluid.

5 Requirements for fire-resistant fluids

5.1 General fluid requirements

5.1.1 General

To perform satisfactorily in a hydraulic system, a fire-resistant fluid shall have properties and characteristics which match the system requirements. Conversely if the perceived risk of fire limits the range of fluid types which can be used, the components of the hydraulic system shall be designed to perform adequately with the fire-resistant fluid selected.

5.1.2 Viscosity

The fluid shall be sufficiently viscous at all working temperatures to prevent unwanted leakage across working clearances wherever a pressure differential exists. Where the chosen fluid has a very low viscosity, system components shall be selected which are designed specifically for use with such fluids.

However, the functional fluid shall be of sufficiently low viscosity at all working temperatures to flow readily through the system and to accommodate rapid changes in velocity and pressure.

5.1.3 Lubrication

The fluid shall have sufficient viscosity and film strength to lubricate working parts effectively, under both hydrodynamic and boundary conditions, over the working temperature range. Where the chosen fluid has a very low viscosity, and adequate lubrication properties are not conferred by additives, system components shall be selected which operate satisfactorily with the fluid.

5.1.4 Compatibility

The fluid shall be compatible with the constructional materials used in the system and be non-corrosive. If necessary, the system or component manufacturer shall be contacted for guidance.

5.1.5 Chemical and thermal stability

The thermal, oxidative and hydrolytic stability of the fluid shall be sufficient to ensure the safe and reliable operation of the system. The service life of the fluid is closely related to the bulk operating temperature as well as the effectiveness of fluid maintenance and the successful control of contamination.

5.1.6 Air release and foaming

The fluid shall release entrained air readily and not produce stable foam.

5.1.7 Shear stability

The fluid shall be shear-stable, i.e. its viscosity shall not display a significant permanent change as a result of applied shear in the system.

5.2 Other fluid properties which may impact on system design

5.2.1 General

The following fluid characteristics shall be considered during the course of system design and fluid selection.

5.2.2 Filterability

The fluid shall be filterable at the rating of the finest filter in the system. The rating (fineness) of the system filters is determined by several factors, including type and condition of the fluid, component design, required component life and reliability.

5.2.3 Density

The density of some fire-resistant fluids is greater than that of mineral oil, which may lead to increased pressure drops in circuit components, and may impose restrictions on the design of the suction line of the pump.

5.2.4 Vapour pressure

The vapour pressure of some fire-resistant fluids, particularly those whose fire resistance is conferred by the presence of water, is much higher than that of mineral oil and varies with fluid temperature. The design of the system, particularly around the suction of the pump, shall minimize the risk of cavitation at the pump inlet. Other than very coarse strainers, filters in suction lines should be avoided, and ideally the pressure at the pump inlet should be greater than 100 kPa (1 bar) absolute.

6 Characteristics of fire-resistant hydraulic fluids and factors affecting their selection

6.1 General

6.1.1 Composition

Fluids used as fire-resistant hydraulic media obtain their fire resistance either from the presence of water, or from their chemical composition.

Water is readily available and completely non-flammable. However, it has a very low viscosity and poor lubrication properties and apart from the obvious temperature limitation, its use also gives rise to problems of erosion, cavitation, and corrosion. Nevertheless, technology is available permitting the use of pure water, or water with corrosion inhibitors added, as a hydraulic fluid. Most hydraulic applications, where fire resistance is a requirement, make use of formulated fluids which have performance advantages over pure water.

6.1.2 Classification of fire-resistant fluids

Table 1 is adapted from ISO 6743-4:1999, Table 1, and the tables of ISO 12922:1999, and gives the classification of fire-resistant fluids used in hydraulic systems together with their operating temperature ranges. There are four basic categories, HFA, HFB, HFC and HFD. There is a sub-division of the HFA and HFD categories according to fluid chemistry.

Table 1

Composition and properties	Symbol ISO-L	Remarks
Oil-in-water emulsions	HFAE	Water content ⩾95 % volume fraction[a] Operating temperature range: +5 °C to +50 °C
Chemical solutions in water	HFAS	Water content ⩾95 % volume fraction[a] Operating temperature range: +5 °C to +50 °C
Water-in-oil emulsions	HFB	Typically contain at least 40 % mass fraction of water Operating temperature range: +5 °C to +50 °C
Water polymer solutions	HFC	Typically contain more than 35 % mass fraction of water in a mixture of glycols and polyglycols Operating temperature range: −20 °C to +50 °C
Synthetic fluids free of water	HFDR	Consisting of phosphate esters Operating temperature range: −20 °C to +70 °C or to +150 °C[b]
Synthetic fluids free of water	HFDU	Consisting of liquids other than phosphate esters Operating temperature range: −20 °C to +70 °C or to +150 °C[b]

[a] A few fluids in this category have viscosities significantly higher than 1 cSt (1 mm^2/s) and may contain ⩾75 % volume fraction of water.

[b] The higher temperature indicates the approximate upper limit for short-term operation. This depends upon whether the application is hydrostatic or hydrodynamic and, for HFDU fluids, the composition of the fluid. Where doubt exists, clarification should be sought from the equipment manufacturer or fluid supplier.

6.1.3 Fluid mixing

The mixing of fire-resistant fluids from different categories shall be avoided. It is also not recommended that fluids of the same category but of different origins be mixed unless the compatibility of the fluids with each other has been clearly established.

Changing the hydraulic fluid in a system from mineral oil to a fire-resistant fluid or from one category of fire-resistant fluid to another, calls for special precautions and reference should be made in these circumstances to Clause 8.

6.2 Characteristics of fluids in different categories

6.2.1 HFAE — Oil-in-water emulsions (thickened and unthickened)

6.2.1.1 General

HFAE fluids are extremely fire resistant due to their very high water content and are available as thickened and unthickened fluids (see 6.2.1.2). The unthickened type is usually supplied as a concentrate which is mixed with water by the user, commonly in the ratio of 2 % to 5 % volume fraction of concentrate with a volume fraction of 98 % to 95 % of water. The optimum concentration shall be decided after tests with the fluid and the diluting water, and discussion with the fluid supplier. When prepared manually, it is usual to add the concentrate gradually, with continued stirring, to the required volume of water. For large volumes, automatic mixers are available. The concentrate typically consists of a mineral oil together with suitable emulsifiers, corrosion inhibitors, pH buffers and coupling agents. Anti-wear additives, anti-foam agents, bactericides and fungicides may be included. For the thickened fluids in this category, the additive package and thickener are up to 25 % of the total volume; these fluids are normally supplied ready mixed, rather than as concentrates.

Emulsions with a particularly small oil droplet size and usually lower mineral oil content are commonly known as micro-emulsions and, depending upon the hardness of the diluting water, may be translucent in appearance.

The finished fluid is usually alkaline, with a pH typically in the region of 9,0 to 9,5.

6.2.1.2 Viscosity

Due to the very high content of water in unthickened fluids, their viscosities are close to that of pure water (approximately 0,8 mm^2/s at 40 °C). Accordingly, hydraulic components designed specifically for use with low viscosity fluids are normally used in hydraulic systems filled with unthickened HFAE fluids. Thickened HFAE fluids have viscosities comparable to mineral oil (e.g. ISO VG 32 and ISO VG 46), allowing more conventional hydraulic components to be used; however, the components are still required to operate reliably with the reduced lubricating properties of these fluids.

6.2.1.3 Lubrication properties

The lubrication properties of HFAE fluids are generally poor. The oil present in the fluid provides basic protection for lubricated contacts, but specially designed hydraulic components are usually required for use with these fluids. The lives of rolling element bearings within components tend to be short.

6.2.1.4 Corrosion protection

In order to ensure adequate corrosion protection, it is important that at all times the recommended proportion of the concentrate in the finished fluid be maintained.

6.2.1.5 Compatibility

a) With seals, gaskets, hoses etc.

Acrylonitrile-butadiene rubber with high nitrile content (NBR) and fluorinated (FKM) rubbers are the preferred elastomeric sealing materials for HFAE fluids. Other elastomers can be compatible, but their compatibility shall be confirmed by the fluid and seal suppliers. Some polyurethane seals (AU and EU) can be damaged by hydrolysis. Absorbent materials such as leather, paper, and cork should be avoided.

NOTE See ISO 1629 for rubber nomenclature.

b) With paints and coatings

HFAE fluids are generally not compatible with conventional paints. Reservoir interiors should either be left unpainted or covered with two-component epoxy coatings. Where corrosion in the non-wetted areas of a reservoir is likely to be a problem, stainless steel can be considered for the reservoir and its cover.

c) With metals

The majority of metals used in the construction of hydraulic systems designed for use with mineral hydraulic oils are also compatible with HFAE fluids. However cadmium, lead, and magnesium alloys should not be used. Aluminium may be suitable if anodized and zinc-plated components are compatible with some fluids, provided the surfaces are passivated. Where uncertainty exists, the fluid supplier shall be consulted.

