INTERNATIONAL STANDARD

ISO 7745

Third edition

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

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

PROOF/ÉPREUVE

Reference number
ISO 7745:2023(E)

Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, Subcommittee SC 4, *Classifications and specifications.*

This third edition cancels and replaces the second edition (ISO 7745:2010), which has been technically revised.

The main changes are as follows:

— addition of Clause 2 “Normative references” and renumbering of subsequent clauses accordingly;

— update of Table 2;

— update of the dated references.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 the 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 the released fluid must not propagate a fire, such 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 therefore important to select a fire-resistant fluid which matches its proposed application and the perceived hazards in use.

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

1 Scope

This document specifies the operational characteristics for the various categories of fire-resistant fluids defined by ISO 6743-4. It includes requirements and guidelines for use of these fluids and specifies the factors to consider when selecting a fluid from these categories for a proposed application.

This document identifies difficulties which can arise from the use of such fluids and indicates how they can be minimized. 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 document does not apply to fire-resistant fluids used in the hydraulic systems of commercial or military aircraft.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
fire-resistant hydraulic fluid
hydraulic fluid which is difficult to ignite and shows little tendency to propagate flame

[SOURCE: ISO 5598:2020, 3.2.282]

4 Hydraulic systems — Fire hazards

4.1 General

Fluid pressures in hydraulic power systems range up to 50 000 kPa (500 bar) and more. Therefore, any lack of integrity in the construction of a system which results in a burst or even a small leak, can in many circumstances give rise to a serious fire hazard.

4.2 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.

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, onto 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.

NOTE In each case, a source of ignition as described in 4.3 is crucial to initiate combustion.

4.3 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 electro-magnetic energy, such as ultrasonic and microwave radiation.

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.

The functional fluid, however, 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 that operate satisfactorily with the fluid shall be selected.

5.1.4 Compatibility

The fluid shall be compatible with the constructional materials used in the system and 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 upon 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 can lead to increased pressure drops in circuit components and 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. It has, however, 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, there is technology available that permits 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-resistance fluids

Table 1 is adapted from ISO 6743-4:2015, Table 1, and ISO 12922:2020, Tables 1 to 3. Table 1 gives the classification and brief description of fire-resistant fluids used in hydraulic systems together with their operating temperature ranges. There are four basic categories: HFA, HFB, HFC and HFD (see ISO 6743-4:2015, Table 1 for a definition). There is a sub-division of the HFA and HFD categories according to fluid chemistry.

Table 1 — Classification of fire-resistant fluids

Composition and properties	Symbol ISO-L	Remarks
Oil in water emulsions	HFAE	Water content typically ≥ 95 % volume fraction [a]. Operating temperature range: +5 °C to +50 °C.
Chemical solutions in water	HFAS	Water content typically ≥ 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 fluid free of water	HFDR	Consisting of phosphate esters [b]. Operating temperature range: −20 °C to +70 °C or to +150 °C [c].
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 [c].

[a] A few fluids in this category have viscosities significantly higher than 0,8 mm^2/s (0,8 cSt) at 40 °C and can contain as little as 75 % volume fraction of water.

[b] Many fluids in category HFDR also meet the requirements of fluids category TCD (phosphate-ester control fluids) as specified in ISO 6743-5.

[c] The higher temperature indicates the approximate upper limit for short-term operation. This depends upon whether the application is hydrostatic or hydrodynamic. For HFDU fluids, this depends upon the composition of the fluids. Where uncertainty 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 between the fluids 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. In such circumstances, reference should be made to Clause 9.

6.2 Characteristics of fluids in different categories

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

6.2.1.1 General

HFAE fluids are extremely fire-resistant due to their very high water content and are available as thickened and un-thickened fluids (see 6.2.1.2). The un-thickened 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, can 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 un-thickened 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 un-thickened 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. The components, however, 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 to maintain at all times the recommended proportion of the concentrate in the finished fluid.

6.2.1.5 Compatibility

a) Compatibility 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, i.e. polyester urethane (AU) and polyether urethane (EU), can be damaged by hydrolysis. Absorbent materials such as leather, paper, and cork should be avoided.