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Petroleum and related products — Requirements and guidance for the maintenance of triaryl phosphate ester turbine control fluids

Pétrole et produits connexes — Exigences et recommandations pour la maintenance des fluides de régulation de turbines à base d'esters phosphates de triaryle

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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 documents 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*, Sub-committee SC 4, *Classifications and specifications*.

This first edition of ISO 11365 cancels and replaces ISO/TS 11365:2011.

Introduction

Many turbine manufacturers or electrical power utilities have standardized requirements for the maintenance of triaryl phosphate ester hydraulic control fluids in service. A comparison of these requirements has made it possible to develop this document. However, the recommendations given in this document are for guidance and should not be considered as absolute. When interpreting results and deciding action, account has to be taken of various factors such as the conditions of use, the type of equipment, and the general trend in fluid characteristics.

Petroleum and related products — Requirements and guidance for the maintenance of triaryl phosphate ester turbine control fluids

WARNING — The use of this document may involve hazardous materials, operations and equipment. This document does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practice and determine the applicability of regulatory limitations prior to use.

1 Scope

This document is applicable to the use of triaryl phosphate esters as fire-resistant fluids for turbine control and other hydraulic systems in power generation. These fluids fall under category HFDR of ISO 6743-4[1].

This document is intended to:

— assist the power equipment operator to maintain the fluid in a condition that will ensure the safe and reliable operation of the turbine while maximizing fluid life;

— recommend procedures for examining consignments of new fluid and monitoring the fluid in use;

— provide information on the safe handling, storage and disposal of the fluid;

— offer background information on the causes of fluid degradation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3170, *Petroleum liquids — Manual sampling*

ISO 3722, *Hydraulic fluid power — Fluid sample containers — Qualifying and controlling cleaning methods*

ISO 4021, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system*

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

4 Description of triaryl phosphate ester fluids

Triaryl phosphates are complex mixtures of products produced from the reaction of phosphorus oxychloride with substituted phenols, for example xylenol or tertiarybutylphenol, and have been used as fire-resistant fluids in power generation applications for over 55 years. While the early fluids were

neurotoxic as a result of the presence of tri-o-cresyl phosphate, the products in commercial use for about the past 35 years have been free from this component and have very low levels of neurotoxicity. Modern phosphate esters are manufactured to meet the stringent health and safety requirements of CEN/TR 14489[2]. However, such requirements are subject to change and the fluid manufacturers should be contacted for the latest information. As with all chemicals, triaryl phosphates should be handled responsibly. The health and safety recommendations given in this document are intended to minimize exposure and to provide a margin of safety for workers handling these fluids.

Triaryl phosphate ester fluids normally have good resistance to oxidation, moderate to good air release and low foaming properties. However, they are sensitive to hydrolysis. These properties will, of course, slowly deteriorate during the life of the fluid. While some degradation can be tolerated without adverse effects on system performance, good monitoring procedures are necessary to determine when the properties have changed sufficiently to require action.

ISO 10050[3] is the standard for new triaryl phosphate ester hydraulic fluids when used in power generation applications.

For further information on the composition and technical performance of these fluids, the relevant technical literature available from the fluid manufacturers or suppliers should be consulted.

5 Health and safety precautions

5.1 Fluid handling

Triaryl phosphate ester fluids have extremely low vapour pressures and excellent stability, and under normal operating conditions give off no harmful vapours. There have been no reports of toxic effects through continued exposure, where sensible handling precautions have been taken. However, when handling phosphate esters all personnel should be aware of the nature of the material they are handling and consider the recommendations set out below.

— Accidental swallowing of the fluid or inhalation of vapours at elevated temperatures, which are the main potential sources of entry into the body, can be harmful and should be avoided. In event of ingestion, medical attention should be sought immediately.

— Goggles should be worn at all times when the fluid is being handled or when working on hydraulic control or other systems containing the fluid. Eye splashes may cause severe irritation. If any fluid gets into the eyes, they should be irrigated with water as soon as possible and medical attention sought.

— While the fluid is being handled, eating, drinking and smoking should be prohibited to prevent contamination of the lips and mouth. After handling the fluid, and before eating, drinking or smoking, the hands shall be thoroughly washed.

— Exposure to the skin normally represents minimal hazard and standard sanitary practices will prevent any adverse health effects. No ill effects have been reported from short-term skin exposure. However, continuous exposure to degraded fluid, which is acidic, should be avoided. This can be achieved using suitable impermeable protective gloves or barrier creams. Particular attention should be paid to the thorough cleaning of the skin and removal of any soiled clothing if extensive and prolonged contact with the fluid occurs.

— If the fluid leaks on to hot pipework, white fumes may be emitted. If these are inhaled, they can cause irritation of the throat and lungs. Therefore, when working in an environment where fumes are being emitted, breathing apparatus should be worn.

If required, further handling and safety information can be obtained from the fluid manufacturers or suppliers.

5.2 Waste disposal

As far as is practicable, spillages shall be prevented from entering surface drainage channels. Fluid that has leaked from containers or from the system should be adsorbed onto sand, sawdust or other suitable adsorbent and disposed of in accordance with local regulations.

The disposal of used fluid in bulk should be carefully controlled to avoid contamination of the environment. All waste fluid shall be considered potentially harmful and be disposed of in accordance with local regulations.

6 Fire hazards

6.1 General points

Triaryl phosphate ester fluids do not readily ignite and do not support combustion but cannot be considered non-inflammable.

If the fluid leaks from the hydraulic system into lagging, it may decompose in the lagging with the emission of smoke and possibly result in a smouldering fire. Good ventilation of areas where fire hazards exist should therefore be provided.

The best method of avoiding a fire hazard is to prevent fluid leaks by following the operating and maintenance instructions, and by keeping the related equipment in a good state of repair at all times. In areas where experience has shown that leaks may develop, the following procedures will give additional protection:

— seal all the lagging material exposed to leaking fluid with finishing cement to provide a non-porous surface;

— cover exposed lagging with aluminium sleeves to prevent entry of fluid;

— provide drip trays to direct spilled fluid away from the lagging to collection points;

— replace any lagging material where the fluid has been absorbed into the insulation.

6.2 Methods of extinguishing fires

If a triaryl phosphate ester fluid is ignited as described above, the fire can be extinguished with foam, dry powder, carbon dioxide or water. However, if water is used, care should be taken to minimize direct contact with hot steel components, since it can cause rapid cooling with severe distortion or cracking. If used near electrical components, it may cause short-circuits and corrosion.

In the event of a lagging fire any damaged lagging should be removed, preferably when the pipe is cool and the fire extinguished. The lagging should then be replaced. If the lagging is cut away, it should be dropped into a container and covered to stop further smouldering, decomposition and the emission of smoke. Gloves, protective clothing and breathing apparatus should be worn when handling smouldering lagging.

7 Compatibility of materials

7.1 Seals, paints and gaskets

Most seal materials, paints, and gaskets commonly found in hydraulic systems using petroleum-based fluids are not compatible with triaryl phosphate ester fluids. The use of unsuitable seals and gaskets can result in swollen or eroded materials, which may lead to fluid leaks or the binding of moving parts. Paints should be resistant to triaryl phosphate ester or the surfaces left unpainted. Some metals, such as copper and zinc, may promote fluid degradation, and their use should be minimized.

Materials currently recommended for use as seals are polytetrafluoroethylene (PTFE), fluorocarbon rubber (FKM) and ethylene propylene diene rubber (EPDM); hoses are normally made of butyl rubber (IIR). Suitable paints include stoved epoxy resins and vinyl ester-based products.

Attention is drawn to the fact that some materials, even those considered physically compatible, can adversely affect fluid performance. For example, silicone-based seals and gaskets should be avoided as they have an adverse effect on fluid foaming and air release properties.

If there is any doubt concerning the compatibility of replacement seals or hoses for the hydraulic system, the supplier of the fluid or the manufacturer of the system shall be consulted.

7.2 Electrical cable insulation

Triaryl phosphate ester fluid will soften and degrade some insulating materials, for example, polyvinyl chloride (PVC). Insulation containing PVC should therefore not be used in the vicinity of the control system. The fluid manufacturers recommend polytetrafluoroethylene, polyamide, polyethylene or polypropylene, but suppliers of the cable should be contacted in specific cases as many insulating materials and coatings are in use.

Care should be taken to avoid fluid spills onto cable insulation and in areas where spills may occur, the cabling should be shielded.

If cable insulation of unknown composition has accidentally come into contact with the fluid, it should be wiped clean with rags, preferably wetted in a solvent that will remove the fluid and not harm the insulation. Chlorinated solvents should not be used. Cables should then be inspected periodically to determine if they are suffering any deterioration.

8 Factors affecting service life

8.1 General

Factors that affect the service life of triaryl phosphate ester fluids include:

— system design;

— system operating conditions;

— system maintenance;

— fluid contamination;

— fluid condition monitoring;

— fluid treatment or purification;

— fluid top up rate.

A more detailed explanation of these factors is provided below.

8.2 System design

There are a number of different control system designs in use. Several design factors impact upon the severity of operation of the control system, hence on fluid degradation. These include the following.

Pump type – constant volume pumps are the source of two problems:

a) Large volumes of fluid are continuously circulated at high flow rates over pressure relief valves. The fluid is heated in the valve and turbulence is often created as the fluid returns to the tank. This aerates the fluid and, at the elevated temperature, encourages degradation.

b) If the fluid contains air bubbles these may be compressed in the pump with the generation of very high temperatures on the bubble walls. This process is known as dieseling.

Tank design – the discharges from warming and fluid return lines should be located below the lowest level of fluid in the tank and the return line should be located as far away from the pump inlet as possible. The design should ensure that any entrained air has adequate time to be released. This can be assisted by the appropriate use of sieves and baffles that direct fluid flow around the tank, and avoid a rapid move from the return line entry to the pump inlet.

Operating pressures – high pressures promote the rapid collapse of air bubbles in the pump and the development of very high temperatures at the bubble wall (dieseling). They will also result in higher temperatures as the fluid passes through the relief valve.

8.3 System operating conditions

Continuous turbine operation subjects the fluid to less stress than frequent stops and starts, while the use of tank heating (where fitted) or the operation of both circulating pumps concurrently can result in significant fluid degradation.

8.4 System maintenance

The quality of the fluid is adversely affected by, for example, any water leaks, the use of exhausted filters or incorrectly set relief valves.

8.5 Fluid contamination

8.5.1 General

As with most hydraulic fluids, triaryl phosphates are susceptible to contamination. The most common forms of contamination are indicated below in 8.5.2 to 8.5.6.

8.5.2 Air

Air, in either dissolved or dispersed form, is a common contaminant that causes the oxidative degradation of the fluid. Dissolved air can lead to the formation of varnish precursors and eventually to varnish itself if the precursors precipitate. Dispersed air (as bubbles) can cause dieseling when the bubbles are compressed in the pump with the generation of very high temperatures. Both mechanisms (but particularly dieseling) can result in the formation of significant amounts of small, even sub-micron, particulate together with acidic degradation products.

8.5.3 Water

Triaryl phosphate esters are susceptible to hydrolysis and the acidic degradation products formed further catalyse this reaction. In addition, the acidity developed may cause system corrosion, initiate servo-valve erosion and react with some adsorbent solid filters to produce gelatinous deposits in the system. Control of the water content is, therefore, particularly important. Desiccant breathers and, in some cases vacuum dehydrators or membrane dryers, are installed to minimize water contamination.

8.5.4 Particulates

Hydraulic control systems are sensitive to particulate contamination since very fine tolerances are found in some of the components. Where the fluid moves at high velocity, particulates can be abrasive and deposition in critical areas can impede system operation. They can be present in the system following assembly, in the original fluid or produced in service by wear, fluid degradation and/or system corrosion.