TECHNICAL SPECIFICATION

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Petroleum and related products — Guidance for the maintenance and use of triaryl phosphate ester turbine-control fluids

Pétrole et produits connexes — Lignes directrices pour la maintenance et l'utilisation des fluides de régulation de turbines à base d'esters de triaryl phosphate

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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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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/TS 11365 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 4, *Classifications and specifications*.

This first edition of ISO/TS 11365 is a revision of IEC 60978:1989, which was previously maintained by IEC/TC 10, *Fluids for electrotechnical applications*.

Introduction

Many turbine manufacturers and electrical power utilities specify limits on the properties of triaryl phosphate ester hydraulic control fluids in service. Some companies also provide recommendations on the action necessary if these limits are approached or exceeded, but few provide detailed guidance on fluid maintenance and use.

This Technical Specification identifies typical performance limits for used fluids and also contains detailed recommendations on their use and maintenance. While the requirements of the equipment builder and/or operator take precedence, particularly during any warranty period, the content of this Technical Specification can be read in conjunction with manufacturer/operator requirements, or provide guidance in their absence.

Petroleum and related products — Guidance for the maintenance and use of triaryl phosphate ester turbine-control fluids

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

1 Scope

This Technical Specification applies to the use of triaryl phosphate esters as fire-resistant fluids for turbine control and other hydraulic systems in power generation.

This Technical Specification is intended to

— help power equipment operators appreciate the important properties of triaryl phosphate esters;

— provide information on their safe handling, storage and use.

This Technical Specification addresses the causes of fluid deterioration and sets out procedures for examining consignments of new fluid, for monitoring the fluid in use and for maintaining an adequate fluid condition.

2 Normative references

The following referenced documents are indispensable for the application 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 3170:2004, *Petroleum liquids — Manual sampling*

ISO 3722:1976, *Hydraulic fluid power — Fluid sample containers — Qualifying and controlling cleaning methods*

ISO 4021:1992, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system*

3 Description of triaryl phosphate ester fluids

Triaryl phosphates are complex mixtures of products produced from the reaction of phosphorus oxychloride with either xylenols or substituted phenols and they have been used as fire-resistant fluids in power generation applications for over 50 years. While the early fluids were neurotoxic as a result of the presence of tricresyl phosphate, the products in commercial use for about the last 30 years do not contain this component and have very low levels of neurotoxicity. Modern phosphate esters are manufactured to meet the stringent health and safety requirements of the 7th Luxembourg Report[24] and its more recent replacement, CEN/TR 14489. However, as with all chemicals, they should be handled responsibly. The health and safety recommendations given in this Technical Specification are therefore 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 can be sensitive to hydrolysis. These properties will slowly deteriorate during the life of the fluid. While some degradation can be tolerated without adverse effects on the functioning of the system, good monitoring procedures are necessary to determine when the properties have changed sufficiently to warrant action.

ISO 10050 is the technical specification 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 should be consulted.

4 Health and safety precautions

4.1 Fluid handling

Triaryl phosphate ester fluids have extremely low vapour pressures and excellent stability, and at normal operating temperatures 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 know the recommendations set out below.

— Accidental swallowing of the fluid or inhalation of vapours, 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 should be 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 washed thoroughly.

— Exposure to the skin normally constitutes a 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 highly degraded fluid, which is acidic, should be avoided. This can be achieved by using suitable impermeable protective gloves. 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 onto hot pipe work, white fumes may be emitted. If these are inhaled, they can cause irritation of the throat and lungs. When working in a fume-filled environment, breathing apparatus should therefore be worn.

4.2 Waste disposal

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

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

5 Fire hazards

5.1 General points

The 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 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 the customer's operating 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 soaked up by the fluid, because at high temperatures an exothermic reaction can occur leading to a temperature rise and possibly a smouldering fire.

5.2 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 - and 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.

6 Compatibility of materials

6.1 Seals, paints and gaskets

Most seal materials, paints, and gaskets commonly found in hydraulic systems using petroleum-based fluids are not compatible with the 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.

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. Some materials currently used for seals are polytetrafluoroethylene (PTFE), fluorocarbon rubber (FKM) and ethylene propylene diene rubber (EPDM) while butyl rubber (IIR) hoses are recommended. 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.

6.2 Electrical wire insulation

Triaryl phosphate ester fluid will soften and eventually decompose some insulating materials. For example, polyvinyl chloride (PVC) may contain a triaryl phosphate ester as a plasticizer; soaking PVC in this fluid will therefore soften it. 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 cable manufacturers should be contacted in specific cases as many insulating materials and coatings are in use.

The most effective way of preventing problems is by avoiding spills of fluid onto electrical wiring insulation. In areas where spills onto wiring may occur (e.g. during maintenance), the wiring should be shielded.

If wiring insulation of unknown composition has been accidentally wetted with the fluid, it should be wiped clean with rags, preferably wetted in a solvent that will remove the fluid (e.g. isopropanol) 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.

7 Factors affecting service life

7.1 General

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

— system design;

— system operating conditions;

— system maintenance;

— fluid contamination;

— fluid condition monitoring;

— fluid treatment or purification;

— fluid top up rate.

7.2 System design

There are a number of different control system designs in use. Several design factors impact on the severity of operation of the control system and hence on fluid degradation. These include pump type, tank design and operating pressures, as described below.

— **Pump type** Constant volume pumps are the source of two problems, as outlined below.

  1) If the fluid contains air bubbles these may be compressed in the pump with the generation of very high temperatures on the bubble walls.

  2) 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 encourages rapid degradation.

— **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 return line to the pump inlet.

— **Operating pressures** High pressures promote the rapid collapse of air bubbles in the pump and 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.

7.3 System operating conditions

Continuous operation subjects the fluids to less stress than if the unit is subjected to frequent stops and starts.

7.4 System maintenance

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

7.5 Fluid contamination

7.5.1 General

As with most hydraulic fluids, triaryl phosphates are susceptible to contamination. The most common forms of contamination are outlined in 7.5.2 to 7.5.6.

7.5.2 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 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 are installed to minimize water contamination.

7.5.3 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.

In order to reduce particulate levels, the system should be thoroughly flushed before use and new fluid added to the system should be pre-filtered through a 5 µm, (β = 1 000) filter. In service, fine filtration is essential to maintain an acceptable level of the fluid cleanliness.

7.5.4 Mineral oil

Every effort should be made to avoid mineral oil contamination, as this may adversely affect the fire resistance. Deposits may also form as a result of reaction between the triaryl phosphate ester and some mineral-oil additives and these can lead to seizure of sensitive control elements. Mineral oil in small amounts can also adversely affect the fluid foaming and air release characteristics. Unlike other fluid contaminants that can normally be removed or reduced by *in situ* purification, mineral oil dissolved in the phosphate ester is impossible to eliminate by such methods.