RWANDA STANDARD

**DRS 351**

First edition

2017-mm-dd

# Lubricating oils for turbines — Specification



Rwanda Standards Board

Reference number

DRS 351: 2017

In order to match with technological development and to keep continuous progress in industries, Standards are subject to periodic review. Users shall ascertain that they are in possession of the latest edition



Rwanda Standards Board

P.O Box 7099 Kigali-Rwanda

Tel. +250 252 586103/582945

Toll Free: 3250

E-mail: info@rsb.gov.rw

Website: www.rsb.gov.rw

# Contents

Page


Foreword ..... iv

Introduction ..... vi

1 Scope ..... 1

2 Normative references ..... 1

3 Terms and definitions ..... 2

4 Symbols (and abbreviated terms) ..... 4

5 Classification ..... 5
5.1 Grades ..... 5
5.2 Explanation of symbols used ..... 5
5.3 Detailed classification ..... 5

6 Requirements ..... 7
6.1 Description ..... 7
6.2 Homogeneity ..... 8
6.3 Compatibility ..... 8
6.4 Specific requirements ..... 9

7 Packaging and labelling ..... 20
7.1 Packaging ..... 20
7.2 Labelling (see if any ref std) ..... 20

8 Sampling ..... 20

9 Test methods ..... 20

## Foreword

Rwanda Standards are prepared by Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS 351 was prepared by Technical Committee RSB/TC 024, Chemicals and Consumer Products.

In the preparation of this standard, reference was made to the following standard:

IS 1012:2002, Turbine Lubricating Oils — Specification *(Third Revision)*

The assistance derived from the above source is hereby acknowledged with thanks.

### Committee membership

The following organizations were represented on the Technical Committee on Chemicals and Consumer Products (RSB/TC 024) in the preparation of this standard.

ALYVO Rwanda Ltd

AMACO Paints Ltd

Ameki Color Ltd

Better home Ltd

Crown Paints Rwanda Ltd

IKIREZI Natural Products

Integrated Polytechnic Regional Centre-Kigali (IPRC-Kigali)

Inyange Industries Ltd

National Industrial Research and Development Agency (NIRDA)

Rwanda Environment Management Authority (REMA)

Rwanda Plastic Industry Ltd

Sigma Paints

SOPYRWA

SRB Investments (R) Ltd

Star Construction and Consultancy Ltd

The Ihangane Project (TIP)



 

University of Kibungo (UNIK)

University of Rwanda-College of Science and Technology (UR-CST)

Water and Sanitation Corporation Ltd (WASAC Ltd)

Zirumuze Cooperative

Rwanda Standards Board (RSB) – Secretariat

## Introduction

New turbine technologies have emerged in recent years. This leads to changes in lubricant requirements. For example, the development of single shaft combined cycle turbines has resulted in the use of a common lubrication system for both the gas and steam turbines. The lubricant has therefore to meet the requirements for the lubrication of both.

The growing concern regarding the environmental behavior of lubricants is also leading to the use of biodegradable products when there are risks of leakage into soil or surface water. This is particularly the case with hydraulic power plants and lubricants, in this application which should demonstrate a low ecotoxicity.

The following lubricants are considered in this Rwanda Standard:

a) mineral oils;

b) synthetic lubricants, ester and polyalphaolefin types intended for high-temperature gas turbines;

c) synthetic lubricants, ester and polyalphaolefin types, environmentally acceptable for use in hydraulic turbines; and

d) fire-resistant phosphate-ester type lubricants.



 

# Lubricating oils for turbines — Specification

## 1 Scope

This Draft Rwanda Standard specifies the minimum requirements for turbine lubricating oils (mineral oils and synthetic lubricants). It specifies the requirements for a wide variety of turbines for power generation, including steam turbines, gas turbines, combined-cycle turbines with a common lubrication system and hydraulic (water driven) turbines.

This document does not specify the requirements for wind turbines.

This document is applicable to drive rotating equipment, such as pumps and compressors.

It is also applicable to lubrication for complex auxiliary systems including hydraulic systems, gear boxes and couplings.

## 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 8068 *Lubricants, industrial oils and related products (class L) — Family T (Turbines) — Specification for lubricating oils for turbines*

ISO 6743-5 *Lubricants, industrial oils and related products (class L) — Classification — Part 5: Family T (Turbines)*

RS ISO 8681, *Petroleum products and lubricants - Method of classification - Definition of classes*

ISO 6072:2011 *Rubber — Compatibility between hydraulic fluids and standard elastomeric materials*

ISO 6072 *Rubber - Compatibility between hydraulic fluids and standard elastomeric materials*

ISO 3448 *Industrial liquid lubricants — ISO Viscosity Classification*

ISO 3170, *Petroleum liquids. Manual sampling*

RS ISO 2049 *Petroleum products — Determination of colour*

RS ISO 3104 *Petroleum products -- Transparent and opaque liquids -- Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 2909 *Petroleum products -- Calculation of viscosity index from kinematic viscosity*

RS ISO 3016 *Petroleum products -- Determination of pour point*

RS ISO 12185 *Crude petroleum and petroleum products -- Determination of density -- Oscillating U-tube method*

RS ISO 3675 *Crude petroleum and liquid petroleum products -- Laboratory determination of density -- Hydrometer method*

ISO 2592 *Determination of flash and fire points -- Cleveland open cup method*

RS ISO 2719 *Determination of flash point*

ISO 6618 *Petroleum products and lubricants -- Determination of acid or base number -- Colour-indicator titration method*

RS ISO 6619 *Petroleum products and lubricants -- Neutralization number -- Potentiometric titration method*

RS ISO 7537 *Petroleum products -- Determination of acid number -- Semi-micro colour-indicator titration method*

RS ISO 6296 *Petroleum products -- Determination of water -- Potentiometric Karl Fischer titration method*

RS ISO 6247 *Petroleum products -- Determination of foaming characteristics of lubricating oils*

*ISO 9120 Petroleum and related products -- Determination of air-release properties of steam turbine and other oils*

RS ISO 2160 *Petroleum products -- Corrosiveness to copper -- Copper strip test*

ISO 7120 *Petroleum products and lubricants -- Petroleum oils and other fluids -- Determination of rust-preventing characteristics in the presence of water*

RS ISO 6614 *Petroleum products -- Determination of water separability of petroleum oils and synthetic fluids*

ISO 4263-1 *Petroleum and related products -- Determination of the ageing behaviour of inhibited oils and fluids -- TOST test -- Part 1: Procedure for mineral oils*

ASTM D2272 - 14a *Standard Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel*

ISO 7624 *Petroleum products and lubricants -- Inhibited mineral turbine oils -- Determination of oxidation stability*

RS ISO 13357-1 *Petroleum products -- Determination of the filterability of lubricating oils -- Part 1: Procedure for oils in the presence of water*

ISO 1335-2 *Petroleum products -- Determination of the filterability of lubricating oils -- Part 2: Procedure for dry oils*

ASTM D4636-14 *Standard Test Method for Corrosiveness and Oxidation Stability of Hydraulic Oils, Aircraft Turbine Engine Lubricants, and Other Highly Refined Oils*

ASTM D4304-13 *Standard Specification for Mineral and Synthetic Lubricating Oil Used in Steam or Gas Turbines*



## 3 Terms and definitions

**3.1**

**turbine**

turbomachine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor text of the definition

**3.2**

**turbomachine**

machine in which a transfer of energy takes place between a rotating solid part (a rotor) and a fluid. The turbomachines are generally distinguished according to whether the energy is transferred from the fluid to the rotor or from the rotor to the fluid. In the first case, they are receiving machines such as gas turbines, hydraulic turbines, wind turbines, etc. Whereas in the second case, they are generating machines among which are found pumps, compressors, and ventilators

**3.3**

**lubricant**

substance introduced to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces. Lubricant is a substance used for lubricating an engine or component, such as oil or grease

**3.4**

**lubricating oil**

oily substance that is used to cover or treat machinery so as to lessen friction. Today, lubricating oil, or lube oil, is the most commonly used lubricant because of its wide range of possible applications. The two basic categories of lube oil are ***mineral*** and ***synthetic***. Synthetic oils are manufactured polyalphaolefins, which are hydrocarbon-based polyglycols or ester oils

**3.5**

**turbine lubricating oil**

any oil used to lubricate the bearings and auxiliary machinery in steam and hydraulic turbines, in turbopumps, and in air, gas, and refrigeration turbocompressors. Turbine lubricating oils are also used as lubricants and working fluids in various types of closed-cycle industrial machinery

**3.5**

**mineral oils**

oils refined from naturally occurring petroleum, or crude oil

**3.6**

**synthetic lubricant**

originating from the chemical synthesis of relatively pure organic compounds from one or more of a wide variety of raw materials

**3.7**

**elastomer**

macromolecular material which returns rapidly to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of the stress

**3.8**

**elastomer compatibility index (ECI)**

simple one-line designation incorporating the details of the changes in volume, hardness, tensile strength and elongation at break which standard test specimens of a test elastomer undergo when immersed in a particular fluid under specified test conditions

NOTE An elastomer compatibility index can be established for each combination of fluid and test elastomer specified in Table 2.

## 4 Symbols (and abbreviated terms)

EPDM 1: ethylene propylene diene rubber

FKM 2: fluorocarbon rubber

HNBR 1: hydrogenated acrylonitrile-butadiene rubber

NBR 1: acrylonitrile-butadiene rubbers

NBR 2: acrylonitrile-butadiene rubbers

T: Turbine

TGA: Mineral oils, Gas turbine, direct coupled or geared to the load for normal services

TGB: Mineral oils, Gas turbine, direct coupled or geared to the load for Normal service

TGCE: Synthetic esters, Gas turbine, direct coupled or geared to the load for normal services

TGCH: Synthetic hydrocarbons, Gas turbine, direct coupled or geared to the load for normal services

TGD: Aryl phosphate ester, turbine Gas, direct coupled or geared to the load for normal services

TGE: Mineral oils, Gas turbine, direct coupled or geared to the load for fire resistance,

TGF: Mineral oils, Gas turbine, direct coupled or geared to the load for High temperature service and high load carrying ability

TGSB: Mineral oils, Single shaft combined cycle turbines, with common lubrication system for High temperature service

TGSE: Mineral oils, Single shaft combined cycle turbines, with common lubrication system for High temperature service and high load carrying ability

THA: Mineral oils, Hydraulic turbine for normal service

THCE: Synthetic esters, hydraulic turbine for high load carrying ability

THCH: Synthetic hydrocarbons, hydraulic turbine for special properties

THE: Mineral oils, Hydraulic turbine for high load carrying ability

TSA: Mineral oils, Steam turbine for normal services

TSD: Aryl phosphate ester, turbine steam for fire resistance

TSE: Mineral oils, Steam turbine geared to the load

VG: Viscosity Grade



 

# 5 Classification

## 5.1 Grades

**5.1.1** The lubricating oil shall fall in one of the following five grades as defined in IS 9466:

a) VG32;

b) VG46;

c) VG68;

d) VG100; and

e) VG150.

**5.1.2** Lubricating oils of other intermediate viscosities may also be blended as agreed to between the purchaser and the supplier.

## 5.2 Explanation of symbols used

**4.2.1** The detailed classification of family T has been established by defining the categories of products required for the various applications of this family.

**4.2.2** Each category is designated by a symbol consisting of a group of letters, which together constitute a code.

The first letter of the code (T) identifies the family of the product considered, but any following letters taken separately have no significance of their own.

The designation of each category can be supplemented by a number denoting the viscosity grade (VG) of the lubricant in accordance with ISO 3448.

**4.2.3** In the present classification system, products are designated in a uniform manner. For example, a particular product may be designated in complete form, i.e. ISO-L-TSA 46, or in an abbreviated form, i.e. LTSA 46.

**4.2.4** In this classification system, turbine lubricants are classified separately. It is common that some turbine lubricants may be used in different turbine types. Some examples are given hereafter – the examples below are not restrictive:

a) the same lubricant may cover L-TSA, L-TGA and L-THA categories;

b) the same lubricant may cover L-TSE and L-THE categories;

c) the same lubricant may cover L-TGB and L-TGSB categories;

d) the same lubricant may cover L-TGF and L-TGSE categories;

e) the same lubricant may cover L-TSD, L-TGD and L-TCD categories.

## 5.3 Detailed classification

The detailed classification is shown in Table 1.

**Table 1 classification of lubricating oils for turbines**

| Code letter | General application | Particular application | More specific application | Product type and/or performance requirements | Symbol ISO - L | Typical applications | Remarks |
|---|---|---|---|---|---|---|---|
| T | Turbines | Steam | Normal service | Highly refined petroleum-base stocks rust- and oxidation inhibited | TSA | Power generation and industrial drives and their associated control mechanisms, when fire resistance is not needed or mandatory. Marine drives where improved load-carrying properties are not specified for the gearing | |
| | | | Geared to the load | Highly refined petroleum-base stocks rust- and oxidation inhibited, with enhanced load carrying ability | TSE | Power generation and industrial drives, marine geared drives and their associated control systems, when the gearing requires improved load carrying ability | |
| | | | Fire resistance | Phosphate-ester-based lubricant | TSD | Power generation and industrial drives and their associated control mechanisms, when fire resistance is required | |
| | | Gas, direct coupled or geared to the load | Normal service | Highly refined petroleum-base stocks rust- and oxidation inhibited | TGA | Power generation and industrial drives and their associated control mechanisms, when fire resistance is not needed or mandatory. Marine drives where improved load-carrying properties are not needed for the gearing | |
| | | | High temperature service | Highly refined petroleum-base stocks rust- and oxidation inhibited | TGB | Power generation and industrial drives and their associated control systems where high temperature resistance is required | |
| | | | Special properties | Synthetic fluids, polyalphaolefins and related hydrocarbons | TGCH | Power generation and industrial drives and their associated control systems where special properties of the fluid are of interest for the application (enhanced oxidation stability, low-temperature properties, …) | |
| | | | Special properties | Synthetic fluid, synthetic-ester type | TGCE | Power generation and industrial drives and their associated control systems where special properties of the fluid are of interest for the application (enhanced oxidation stability, low-temperature properties, …) | These fluids may also exhibit some environment acceptability character |
| | | | Fire resistance | Phosphate-ester-based lubricant | TGD | Power generation and industrial drives and their associated control mechanisms, when fire resistance is required | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | High load carrying ability | Highly refined petroleum-base stocks rust- and oxidation inhibited, with enhanced load carrying ability | TGE | Power generation and industrial drives, marine geared drives and their associated control systems, when the gearing requires improved load carrying ability | |
| | | | High temperature service and high load carrying ability | Highly refined petroleum-base stocks rust- and oxidation inhibited, with enhanced load carrying ability | TGF | Power generation and industrial drives and their associated control systems where high temperature resistance and load carrying properties are required | |
| | | Single shaft combined Cycle turbines, with common lubrication system | High temperature service | Highly refined petroleum base stocks or synthetic base stock, rust and oxidation inhibited | TGSB | Power generation and the control systems, where fire resistance is not needed | |
| | | | High temperature service and high load carrying ability | Highly refined petroleum-base stocks or synthetic-base stock, rust- and oxidation inhibited, with enhanced load-carrying ability | TGSE | Power generation and the control systems, where fire resistance is not needed and where the gears require improved load-carrying ability. | |
| | | Control systems | Fire resistant | Phosphate-ester control fluid | TCD | Steam, gas, hydraulic turbine control mechanisms where fluid supply is separate from the turbine lubricant and fire resistance is needed | |
| | | Hydraulic | Normal service | Highly refined petroleum-base stocks rust- and oxidation inhibited. | THA | Hydro-turbines with hydrostatic system | |
| | | | Special properties | Synthetic fluids, polyalphaolefins and related hydrocarbons | THCH | Hydro-turbines, when low water toxicity and environment protection properties are needed | |
| | | | Special properties | Synthetic fluid, synthetic-ester type | THCE | Hydro-turbines, when low water toxicity and environment protection properties are needed | |
| | | | High load carrying ability | Highly refined petroleum-base stocks rust- and oxidation inhibited, with friction and/or load-carrying additives | THE | Hydro-turbines without hydrostatic systems | |



# 6 Requirements

## 6.1 Description

**5.1.1** The oil shall be blended from suitably refined turbine quality base stocks and additives such as rust and oxidation inhibitors and selected additives as required to control wear, foam, demulsibility, etc; to meet the requirements of this standard. The use of viscosity improvers is not permitted.

**5.1.2** The finished oil shall be clear and free from water, suspended matter, dirt, sediment and other extraneous impurities.

## 6.2 Homogeneity

The additives used shall be wholly soluble in the oil and shall be uniformly distributed throughout at all temperatures above the specified pour point up to 120 $^0$C. When cooled to 6 $^0$C below its pour point for 4 h, the oil shall regain homogeneity and shall show no evidence of separation or stratification when brought to the ambient temperature in an undisturbed condition.

## 6.3 Compatibility

**6.3.1** Oils shall be considered to be compatible, if a mixture of equal volumes of unused oils complies fully with the requirements of this standard.

**6.3.2** The elastomer compatibility index shall be determined according to ISO 6072 under the conditions listed in Table 2, according to the product category. Table 4 gives guidelines on acceptable changes of properties.

**6.3.3** Other elastomers and other limits may be used or specified by the end user depending on the purpose and conditions of actual use. In addition, the turbine oil shall be compatible with all material constituents of the lubricating system.

**Table 2 — Test conditions according to ISO 6072 for the determination of the elastomer compatibility index**

| Fluid | Symbol (ISO 6743-5[2]) | Suitable elastomer | Test temperature ± 1 °C | Examples of test duration [a] ± 2 h | |
|---|---|---|---|---|---|
| Mineral oils | TSA, TGA, TSE, TGE, TGB, TGSB, TGF, TGSE, THA, THE | NBR 1,2 | 100 | 168 | 1000 |
| | | HNBR 1 | 130 | | |
| | | FKM 2 | 150 | | |
| Synthetic esters | TGCE, THCE | NBR 1,2 | 60 | 168 | 1000 |
| | | HNBR 1 | 100 | | |
| | | FKM 2 | 100 | | |
| Synthetic hydrocarbons | TGCH, THCH | NBR 1,2 | 100 | 168 | 1000 |
| | | HNBR 1 | 130 | | |
| | | FKM 2 | 150 | | |
| Aryl phosphate ester | TSD TGD | FKM 2 | 150 | 168 | 1000 |
| | | EPDM 1 | 130 | | |

**a** The test duration of 1 000 h is recommended (but a shorter test duration can provide additional compatibility information) for evaluation of elastomer compatibility with fluids which cause longer term changes to the elastomer.

**Table 3 — Guidelines on acceptable changes of properties, according to ISO 6072**

| Immersion time h | Maximum volume swell % | Maximum volume shrinkage % | Hardness change IRHD | Maximum tensile stress change % | Maximum elongation change % |
|---|---|---|---|---|---|
| 168 | 15 | – 4 | ± 8 | – 20 | – 20 |
| 1 000 | 20 | – 5 | ± 10 | – 50 | – 50 |

## 6.4 Specific requirements

**6.4.1** Fluids, when tested under the prescribed methods, shall be in accordance with the limits set out in Tables 4 to 12, depending on the type.

**6.4.2** The appearance of the delivered oils shall be clear and bright and free of any visible particulate matter, under visible light at ambient temperature.

**6.4.3** These oils shall not contain any viscosity-index improver.

**6.4.4** Most of the test methods specified in the tables contains a precision statement. In cases of dispute, the procedure described in ISO 4259 shall apply. Water content is specified using ISO 760, ISO 6296, ISO 12937or ISO 20764. In case of dispute, ISO 20764 shall be used.

### 5.4.1 Specification for TSA and TGA turbine oils

These lubricants are mineral oils with suitable antioxidants and corrosion inhibitors, for the lubrication of steam turbines and gas turbines (normal service). Specifications are given in Table 4.

### 5.4.2 Specification for TSE and TGE turbine oils

These lubricants are TSA and TGA types turbine oils, with additional extreme-pressure performance to lubricate gear systems. Specifications are given in Table 5.

### 5.4.3 Specification for TGB and TGSB turbine oils

These lubricants are mineral oils or synthetic-base stocks with suitable antioxidants and corrosion inhibitors. These oils shall withstand higher temperatures and exhibit higher thermal stability than TSA and TGA oil types. The TGSB type shall fulfill the requirements of both TSA and TGB oils. Specifications are given in Table 6.

### 5.4.4 Specification for TGF and TGSE turbine oils

These lubricants are mineral oils or synthetic-base stocks with suitable antioxidants, corrosion inhibitors and additional extreme-pressure additives to impart the required load carrying performance. These oils shall withstand higher temperatures and exhibit higher thermal stability than TSE and TGE oil types. The TGSE type shall fulfill the requirements of both TGF and TSE oils. Specifications are given in Table 7.

### 5.4.5 Specification for TGCH turbine oils

This type of oil is formulated from synthetic-base oil, polyalphaolefin type, with suitable antioxidants and corrosion inhibitors. It is intended for high-temperature service, with a better oxidation and thermal stability than TGB type oils, and therefore a longer service life. Specifications are given in Table 8.

### 5.4.6 Specification for TGCE turbine oils

This type of oil is formulated from a synthetic ester base with suitable antioxidants and corrosion inhibitors. It is intended for high-temperature service in aero-derivative turbines. These oils should be in accordance with the MIL-PRF-7808L grade or the specifications of MIL-PRF-23699 STD or MIL-PRF-23699 HTS or with the manufacturer's specification.

### 5.4.7 Specification for THA and THE turbine oils

These lubricants are mineral oils with suitable antioxidants, corrosion inhibitors (THA) and additional extreme pressure additives (THE), when the bearings (normal and thrust) operate in boundary/mixed-lubrication regime at start-up of the turbine. THA and THE products are very close to CKB and CKC categories, respectively, as defined in ISO 6743-6 and specified in ISO 12925-1. Specifications are given in Table 9.

### 5.4.8 Specification for THCH turbine oils

This type of oil is formulated from polyalphaolefins and related hydrocarbons, with suitable additives with the exception of viscosity index improvers. This type of oil is essentially “environmentally acceptable”, i.e. biodegradable and with low water toxicity, and close to the product type HEPR defined in ISO 6743-4 and specified in ISO 15380[5]. Specifications are given in Table 10.

### 5.4.9 Specification for THCE turbine oils

This type of oil is formulated from synthetic esters, with suitable additives with the exception of viscosity index improvers. This type of oil is essentially “environmentally acceptable”, i.e. biodegradable and with low water toxicity, and close to the product type HEES defined in ISO 6743-4 and specified in ISO 15380. Specifications are given in Table 11.

### 5.4.10 Specification for TSD and TGD turbine oils

This type of oil is formulated from phosphate esters with suitable additives. It is intended for applications requiring fire resistance. Specifications are given in Table 12.



 

**Table 4 — Specification for turbine oils L-TSA and L-TGA**

| Property | Unit | Viscosity class | | | Test method |
|---|---|---|---|---|---|
| | | 32 | 46 | 68 | |
| Viscosity class | | 32 | 46 | 68 | ISO 3448 |
| Color | rating | report | | | ISO 2049 |
| Appearance | rating | clear and bright | | | Visual |
| Kinematic viscosity at 40 °C<br>— minimum<br>— maximum | $mm^2/s$ | <br>28.8<br>35.2 | <br>41.4<br>50.6 | <br>61.2<br>74.8 | ISO 3104 |
| Viscosity index (minimum) | | 90 | 90 | 90 | ISO 2909 |
| Pour point (maximum) a | $^0C$ | -6 | -6 | -6 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | report | | | ISO 12185 or ISO 3675 |
| Flash point (minimum)<br>— open cup<br>— closed cup | $^0C$ | <br>186<br>170 | <br>186<br>170 | <br>186<br>170 | <br>ISO 2592<br>ISO 2719 |
| Total acid number (maximum) b | mg KOH/g | 0.2 | 0.2 | 0.2 | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (maximum) c<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>450/0<br>50/0<br>450/0 | <br>450/0<br>50/0<br>450/0 | <br>450/0<br>50/0<br>450/0 | ISO 6247 |
| Air release time at 50 °C (maximum) | min | 5 | 5 | 6 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | 1 | ISO 2160 |
| Corrosion-preventive properties (24 h) | rating | pass | | | ISO 7120 (B) |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | 30 | 30 | 30 | ISO 6614 |
| Oxidation stability (rotating pressure vessel) (minimum) e | min | report | | | ASTM D 2272-02 |
| Oxidation stability (“TOST”) f<br>— total acid number at 1000 h (maximum)<br>— time for total acid number 2 mgKOH/g (min)<br>— sludge after 1000 h (maximum) | <br>mg KOH/g<br>h<br>mg | <br>0,3<br>3 500<br>200 | <br>0,3<br>3 000<br>200 | <br>0,3<br>2 500<br>200 | ISO 4263-1 |
| Oxidation stability f<br>— total oxygen-containing products,TOP (max)<br>— sludge (maximum) | <br>% (*m/m*)<br>% (*m/m*) | <br>0,40<br>0,25 | <br>0,50<br>0,30 | <br>0,50<br>0,30 | ISO 7624 |
| Filterability (dry) (minimum) | % | 85 | 85 | 85 | ISO 13357-2 |
| Filterability (wet) | % | pass | | | ISO 13357-1 |
| Cleanliness at the delivery stage g (maximum) | rating | — / 17 / 14 | | | ISO 4406 |

a Lower values may be negotiated between the end user and the supplier.
B In case of dispute, ISO 6618 applies.
c The stability of the foam is recorded at 300 s for the first and third sequences, and at 60 s for the second sequence.
D Applies only to TSA. Lower limits for emulsion volume or time may be specified.
e This value is useful for the follow-up in service. Should not normally be below 250 min.
f Either of the two methods.
G ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles.

**Table 5 — Specification for turbine oils L-TSE and L-TGE**

| Property | Unit | Viscosity class | | | Test method |
|---|---|---|---|---|---|
| | | 32 | 46 | 68 | |
| Viscosity class | | 32 | 46 | 68 | ISO 3448 |
| Color | rating | report | | | ISO 2049 |
| Appearance | rating | clear and bright | | | Visual |
| Kinematic viscosity at 40 °C<br>— minimum<br>— maximum | $mm^2/s$ | <br>28.8<br>35.2 | <br>41.4<br>50.6 | <br>61.2<br>74.8 | ISO 3104 |
| Viscosity index (minimum) | | 90 | 90 | 90 | ISO 2909 |
| Pour point (maximum) a | $^0C$ | -6 | -6 | -6 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | report | | | ISO 12185 or ISO 3675 |
| Flash point (minimum)<br>— open cup<br>— closed cup | $^0C$ | <br>186<br>170 | <br>186<br>170 | <br>186<br>170 | <br>ISO 2592<br>ISO 2719 |
| Total acid number (maximum) b | mg KOH/g | 0.2 | 0.2 | 0.2 | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (maximum) c<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>450/0<br>50/0<br>450/0 | <br>450/0<br>50/0<br>450/0 | <br>450/0<br>50/0<br>450/0 | ISO 6247 |
| Air release time at 50 °C (maximum) | min | 5 | 5 | 6 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | 1 | ISO 2160 |
| Corrosion-preventive properties (24 h) | rating | pass | | | ISO 7120 (B) |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | 30 | 30 | 30 | ISO 6614 |
| Oxidation stability (rotating pressure vessel) (minimum) e | min | report | | | ASTM D 2272-02 |
| Oxidation stability (“TOST”) f<br>— total acid number at 1000 h (maximum)<br>— time for total acid number 2 mgKOH/g (min)<br>— sludge after 1000 h (maximum) | <br>mg KOH/g<br>h<br>mg | <br>0,3<br>3 500<br>200 | <br>0,3<br>3 000<br>200 | <br>0,3<br>2 500<br>200 | ISO 4263-1 |
| Filterability (dry) (minimum) | % | 85 | 85 | 85 | ISO 13357-2 |
| Filterability (wet) | % | pass | | | ISO 13357-1 |
| Load-carrying capacity – FZG test (A/8,3/90) Failure-load stage (minimum) f | rating | 8 | 9 | 10 | ISO 14635-1 |
| Cleanliness at the delivery stage g (maximum) | rating | — / 17 / 14 | | | ISO 4406 |

a Lower values may be negotiated between the end user and the supplier.
b In case of dispute, ISO 6618 applies.
c The stability of the foam is recorded at 300 s for the first and third sequences, and at 60 s for the second sequence.
d Applies only to TSA. Lower limits for emulsion volume or time may be specified.
e This value is useful for the follow-up in service. Should not normally be below 250 min.
f Either of the two methods.
g ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles.

**Table 6 — Specification for turbine oils L-TGB and L-TGSB**

| Property | Unit | Viscosity class | | | Test method |
|---|---|---|---|---|---|
| | | 32 | 46 | 68 | |
| Viscosity class | | 32 | 46 | 68 | ISO 3448 |
| Color | rating | report | | | ISO 2049 |
| Appearance | rating | clear and bright | | | Visual |
| Kinematic viscosity at 40 °C<br>— minimum<br>— maximum | $mm^2/s$ | <br>28.8<br>35.2 | <br>41.4<br>50.6 | <br>61.2<br>74.8 | ISO 3104 |
| Viscosity index (minimum) | | 90 | 90 | 90 | ISO 2909 |
| Pour point (maximum) a | $^0C$ | -6 | -6 | -6 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | report | | | ISO 12185 or ISO 3675 |
| Flash point (minimum)<br>— open cup<br>— closed cup | $^0C$ | <br>200<br>190 | <br>200<br>190 | <br>200<br>190 | <br>ISO 2592<br>ISO 2719 |
| Total acid number (maximum) b | mg KOH/g | 0.2 | 0.2 | 0.2 | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (maximum) c<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>450/0<br>50/0<br>450/0 | <br>450/0<br>50/0<br>450/0 | <br>450/0<br>50/0<br>450/0 | ISO 6247 |
| Air release time at 50 °C (maximum) | min | 5 | 5 | 6 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | 1 | ISO 2160 |
| Corrosion-preventive properties (24 h) | rating | pass | | | ISO 7120 (B) |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | 30 | 30 | 30 | ISO 6614 |
| Oxidation stability (rotating pressure vessel) (minimum) | min | 750 | 750 | 750 | ASTM D2272-02 |
| Oxidation stability (rotating pressure vessel) (minimum) e | % | 85 | 85 | 85 | ASTM D 2272-02 |
| Oxidation stability at high temperature (72 h at 175 °C)<br>— viscosity change (maximum)<br>— acid number change (maximum)<br>— metal specimen mass change<br>— steel<br>— aluminium<br>— cadmium<br>— copper<br>— magnesium | <br>%<br>mg KOH/g<br>$mg/cm^2$ | <br>report<br>report<br><br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250 | <br>report<br>report<br><br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250 | <br>report<br>report<br><br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250 | <br><br><br>ASTM D 4636 according to "alternative procedure 2" |
| Oxidation stability ("TOST")<br>— time for total acid number 2 mgKOH/g (min) | h | 3 500 | 3 000 | 2 500 | ISO 4263-1 |
| Filterability (dry) (minimum) | % | 85 | 85 | 85 | ISO 13357-2 |
| Filterability (wet) | % | pass | | | ISO 13357-1 |
| Cleanliness at the delivery stage f (maximum) | rating | — / 17 / 14 | | | ISO 4406 |

a Lower values may be negotiated between the end user and the supplier.
b In case of dispute, ISO 6618 applies.
c The stability of the foam is recorded at 300 s for the first and third sequences, and at 60 s for the second sequence.
d Applies to TGSB only.
e Nitrogen blown RPVOT is performed by treatment of 300 ml of oil at 121 °C, by bubbling clean and dry nitrogen for 48 h at the rate of 3 l/h. The result is expressed as the percent of life versus the sample without treatment.
f ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles.

**Table 7 — Specification for turbine oils L-TGF and L-TGSE**

| Property | Unit | Viscosity class | | | Test method |
|---|---|---|---|---|---|
| | | **32** | **46** | **68** | |
| Viscosity class | | 32 | 46 | 68 | ISO 3448 |
| Color | rating | report | | | ISO 2049 |
| Appearance | rating | clear and bright | | | Visual |
| Kinematic viscosity at 40 °C<br>— minimum<br>— maximum | $mm^2/s$ | <br>28.8<br>35.2 | <br>41.4<br>50.6 | <br>61.2<br>74.8 | ISO 3104 |
| Viscosity index (minimum) | | 90 | 90 | 90 | ISO 2909 |
| Pour point (maximum) a | $^0C$ | -6 | -6 | -6 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | report | | | ISO 12185 or ISO 3675 |
| Flash point (minimum)<br>— open cup<br>— closed cup | $^0C$ | <br>200<br>190 | <br>200<br>190 | <br>200<br>190 | <br>ISO 2592<br>ISO 2719 |
| Total acid number (maximum) b | mg KOH/g | 0.2 | 0.2 | 0.2 | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (maximum) c<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>50/0<br>50/0<br>50/0 | <br>50/0<br>50/0<br>50/0 | <br>50/0<br>50/0<br>50/0 | ISO 6247 |
| Air release time at 50 °C (maximum) | min | 5 | 5 | 6 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | 1 | ISO 2160 |
| Corrosion-preventive properties (24 h) | rating | pass | | | ISO 7120 (B) |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | 30 | 30 | 30 | ISO 6614 |
| Oxidation stability (rotating pressure vessel) (minimum) | min | 750 | 750 | 750 | ASTM D2272-02 |
| Oxidation stability (rotating pressure vessel) (minimum) e | % | 85 | 85 | 85 | ASTM D 2272-02 |
| Oxidation stability at high temperature (72 h at 175 °C)<br>— viscosity change (maximum)<br>— acid number change (maximum)<br>— metal specimen mass change<br>— steel<br>— aluminium<br>— cadmium<br>— copper<br>— magnesium | <br>%<br>mg KOH/g<br>$mg/cm^2$ | <br>report<br>report<br><br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250 | <br>report<br>report<br><br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250 | <br>report<br>report<br><br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250<br>± 0,250 | <br><br><br>ASTM D 4636 according to "alternative procedure 2" |
| Oxidation stability ("TOST")<br>— time for total acid number 2 mgKOH/g (min) | h | 3 500 | 3 000 | 2 500 | ISO 4263-1 |
| Filterability (dry) (minimum) | % | 85 | 85 | 85 | ISO 13357-2 |
| Filterability (wet) | % | pass | | | ISO 13357-1 |
| Load-carrying capacity – FZG test (A/8,3/90)<br>Failure load stage (minimum) e | rating | 8 | 9 | 10 | ISO 14635-1 |
| Cleanliness at the delivery stage f (maximum) | rating | — / 17 / 14 | | | ISO 4406 |

a In case of dispute, ISO 6618 applies.
b The stability of the foam is recorded at 300 s for the first and third sequences, and at 60 s for the second sequence.
c Applies to TGSB only.
d Nitrogen blown RPVOT is performed by treatment of 300 ml of oil at 121 °C, by bubbling clean and dry nitrogen for 48 h at the rate of 3 l/h. The result is expressed as the percent of life versus the sample without treatment.
e Higher failure load stages may be requested by some manufacturers/users.
f ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles.

**Table 8 — Specification for turbine oils L-TGCH**
(Synthetic fluids: polyalphaolefins and related hydrocarbons)

| Property | Unit | Viscosity class | | Test method |
|---|---|---|---|---|
| | | 32 | 46 | |
| Viscosity class | | 32 | 46 | ISO 3448 |
| Color | rating | report | | ISO 2049 |
| Appearance | rating | clear and bright | | Visual |
| Kinematic viscosity at 40 °C<br>— minimum<br>— maximum | $mm^2/s$ | <br>28.8<br>35.2 | <br>41.4<br>50.6 | ISO 3104 |
| Viscosity index | | report | | ISO 2909 |
| Pour point (maximum) a | $^0C$ | -21 | -21 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | report | | ISO 12185 or ISO 3675 |
| Flash point open cup (minimum) | $^0C$ | 200 | 200 | ISO 2592 |
| Total acid number (maximum) b | mg KOH/g | report [a] | | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (maximum) c<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>50/0<br>50/0<br>50/0 | <br>50/0<br>50/0<br>50/0 | ISO 6247 |
| Air release time at 50 °C (maximum) | min | 5 | 5 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | ISO 2160 |
| Corrosion-preventive properties (24 h) | rating | pass | | ISO 7120 (B) |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | report [a] | | ISO 6614 |
| Oxidation stability (rotating pressure vessel) (minimum) | min | 1000 | 1000 | ASTM D2272-02 |
| Oxidation stability (rotating pressure vessel) (minimum) e | % | 85 | 85 | ASTM D 2272-02 |
| Oxidation stability at high temperature (72 h at 175 °C)<br>— viscosity change (maximum)<br>— acid number change (maximum) | <br>%<br>mg KOH/g | <br>-3; +5<br>2 | <br>-3; +5<br>2 | ASTM D 4636 according to “alternative procedure 2” |
| Oxidation stability (“TOST”)<br>— time for total acid number 2 mgKOH/g (min) | h | 4 000 | 3 500 | ISO 4263-1 |
| Filterability (dry) (minimum) | % | 80 | 80 | ISO 13357-2 |
| Filterability (wet) | % | pass | | ISO 13357-1 |
| Cleanliness at the delivery stage f (maximum) | rating | — / 17 / 14 | | ISO 4406 |

a To be negotiated between the end user and the supplier.
b In case of dispute, ISO 6618 applies.
c Oils with results greater than 1 000 min exhibit poor precision according to ASTM D 2272-02, Clause 11. It would be expected that
oils of this type exhibit values significantly higher than 1 000 min and probably greater than 1 500 min.
d Nitrogen blown RPVOT is performed by treatment of 300 ml of oil at 121 °C, by bubbling clean and dry nitrogen for 48 h at the rate of 3 l/h. The result is expressed as the percent of life versus the sample without treatment.
e ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles.

**Table 9 — Specification for turbine oils L-THA and L-THE**

| Property | Unit | Viscosity class | | | Test method |
|---|---|---|---|---|---|
| | | 68 | 100 | 150 | |
| Viscosity class | | 68 | 100 | 150 | ISO 3448 |
| Color | rating | report | | | ISO 2049 |
| Appearance | rating | clear and bright | | | Visual |
| Kinematic viscosity at 40 °C<br>— minimum<br>— maximum | $mm^2/s$ | <br>61.2<br>74.8 | <br>90.0<br>110.0 | <br>135<br>165 | ISO 3104 |
| Viscosity index (minimum) | | 90 | 90 | 90 | ISO 2909 |
| Pour point (maximum) | $^0C$ | -12 | -12 | -9 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | report | | | ISO 12185 or ISO 3675 |
| Flash point open cup (minimum) | $^0C$ | 180 | 200 | 200 | ISO 2592 |
| Total acid number (maximum) a | mg KOH/g | report | | | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (maximum) c<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>100/0<br>100/0<br>100/0 | <br>100/0<br>100/0<br>100/0 | <br>100/0<br>100/0<br>100/0 | ISO 6247 |
| Air release time at 50 °C (maximum)<br>Air release time at 75 °C (maximum) | min | 12<br>— | —<br>18 | —<br>30 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | 1 | ISO 2160 |
| Corrosion-preventive properties (24 h) | rating | pass | | | ISO 7120 (B) |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | 30 | — | — | ISO 6614 |
| Demulsibility for THA<br>— free water (minimum)<br>— emulsion (maximum)<br>— water in oil (maximum) | <br>ml<br>ml<br>ml | <br>—<br>—<br>— | <br>30<br>2<br>0,5 | <br>30<br>2<br>0,5 | ASTM D 2711 |
| Demulsibility for THE<br>— free water (minimum)<br>— emulsion (maximum)<br>— water in oil (maximum) | <br>ml<br>ml<br>ml | <br>—<br>—<br>— | <br>80<br>1<br>2 | <br>80<br>1<br>2 | ASTM D 2711-01a (Appendix X 2) |
| Oxidation stability (“TOST”)<br>— time for total acid number 2 mgKOH/g (min) | h | 1 000 | 1 000 | 1 000 | ISO 4263-1 |
| Oxidation stability at 95 °C for THE<br>— viscosity at 100 °C increase (maximum)<br>— precipitation number (maximum) | % | 6<br>0.1 | 6<br>0.1 | 6<br>0.1 | ASTM D 2893-04 |
| Filterability (dry) (minimum) | % | 80 | 80 | not required | ISO 13357-2 |
| Filterability (wet) | % | pass | | not required | ISO 13357-1 |
| Load carrying ability – FZG (A/8,3/90) b<br>Failure load stage (minimum) | rating | 10 | 10 | 10 | ISO 14635-1 |
| Cleanliness at the delivery stage c (maximum) | rating | — / 17 / 14 | | | ISO 4406 |
| NOTE 1 In most cases, CKB type products (see ISO 6743-6[3] and ISO 12925-1[4]) may be applied for THA type products.<br>NOTE 2 In some cases, where high extreme-pressure performance is requested, CKC type products (see ISO 6743-6[3] and ISO 12925-1[4]) may be applied for THE type products. | | | | | |
| a In case of dispute, ISO 6618 applies.<br>b Applies to THE only.<br>c ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles. | | | | | |

**Table 10 — Specification for turbine oils L-THCH — Environmentally acceptable turbine oils**
(Synthetic fluids: polyalphaolefins and related hydrocarbons)

| Property | Unit | Viscosity class | | | Test method |
|---|---|---|---|---|---|
| | | **46** | **68** | **100** | |
| Viscosity class | | 46 | 68 | 100 | ISO 3448 |
| Color | rating | report | | | ISO 2049 |
| Appearance | rating | clear and bright | | | Visual |
| Kinematic viscosity at 40 °C<br>— at –20 °C maximum<br>— at 0 °C maximum<br>— at 40 °C minimum<br>— at 40 °C maximum<br>— at 100 °C minimum | $mm^2/s$ | <br>a<br>780<br>41,4<br>50,6<br>6,1 | <br>a<br>1 400<br>61,2<br>74,8<br>7,8 | <br>a<br>1 500<br>90,0<br>110,0<br>10 | ISO 3104 |
| Viscosity index | | report | | | ISO 2909 |
| Pour point (maximum) | $^0C$ | -15 | -12 | -9 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | report | | | ISO 12185 or ISO 3675 |
| Flash point open cup (minimum) | $^0C$ | 186 | 196 | 206 | ISO 2592 |
| Total acid number (maximum) b | mg KOH/g | report [a] | | | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (maximum) c<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>150/0<br>70/0<br>150/0 | <br>150/0<br>70/0<br>150/0 | <br>150/0<br>70/0<br>150/0 | ISO 6247 |
| Air release time at 50 °C (maximum) | min | 10 | 10 | 14 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | 1 | ISO 2160 |
| Corrosion-preventive properties (24 h) [c] | rating | pass | | | ISO 7120 (B) |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | report [a] | | | ISO 6614 |
| Oxidation stability (“TOST”)<br>— time for total acid number 2 mgKOH/g (min) | h | report [a] | | | ISO 4263-1 |
| Filterability (dry) (minimum) | % | 80 | 80 | 80 | ISO 13357-2 |
| Filterability (wet) | % | pass | | | ISO 13357-1 |
| Load carrying ability – FZG (A/8,3/90)<br>Failure load stage (minimum) | rating | 10 | 10 | 10 | ISO 14635-1 |
| Toxicity d<br>— acute Fish toxicity LL50 (minimum)<br>— acute Daphnia toxicity EC 50 (minimum)<br>— bacteria Inhibition 3 h EC 50 (minimum) | <br>mg/l<br>mg/l<br>mg/l | <br>100<br>100<br>100 | <br>100<br>100<br>100 | <br>100<br>100<br>100 | <br>ISO 7346-2<br>ISO 6341<br>ISO 8192 |
| Biodegradability (minimum) e | % | 60 | 60 | 60 | ISO 14593 or ISO 9439 |
| Cleanliness at the delivery stage [f] (maximum) | rating | — / 17 / 14 | | | ISO 4406 |
| NOTE See also category HEPR, as per ISO 6743-4[1] and ISO 15380[5]. | | | | | |
| a To be negotiated between the end user and the supplier.<br>b In case of dispute, ISO 6618 applies.<br>c Test duration changed from 24 h (ISO 7120) to 4 h and a longer or shorter duration may be negotiated.<br>d Water soluble fluids shall be tested according to the test methods cited. Fluids with low water solubility shall be tested using water accommodated fractions prepared according to ASTM D 6081 or ISO 10634.<br>e Without 10 days window requirement. Some national requirements may be more severe.<br>f ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles. | | | | | |

**Table 11 — Specification for turbine oils L-THCE — Environmentally acceptable turbine oils**
(Synthetic fluids: synthetic ester types)

| Property | Unit | Viscosity class | | | Test method |
|---|---|---|---|---|---|
| | | **46** | **68** | **100** | |
| Viscosity class | | 46 | 68 | 100 | ISO 3448 |
| Color | rating | report | | | ISO 2049 |
| Appearance | rating | clear and bright | | | Visual |
| Kinematic viscosity at 40 °C<br>— at –20 °C maximum<br>— at 0 °C maximum<br>— at 40 °C minimum<br>— at 40 °C maximum<br>— at 100 °C minimum | $mm^2/s$ | <br>a<br>780<br>41,4<br>50,6<br>6,1 | <br>a<br>1 400<br>61,2<br>74,8<br>7,8 | <br>a<br>1 500<br>90,0<br>110,0<br>10 | ISO 3104 |
| Viscosity index | | report | | | ISO 2909 |
| Pour point (maximum) | $^0C$ | -15 | -12 | -9 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | report | | | ISO 12185 or ISO 3675 |
| Flash point open cup (minimum) | $^0C$ | 186 | 196 | 206 | ISO 2592 |
| Total acid number (maximum) b | mg KOH/g | report [a] | | | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (maximum) c<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>150/0<br>70/0<br>150/0 | <br>150/0<br>70/0<br>150/0 | <br>150/0<br>70/0<br>150/0 | ISO 6247 |
| Air release time at 50 °C (maximum) | min | 10 | 10 | 14 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | 1 | ISO 2160 |
| Corrosion-preventive properties (24 h) [c] | rating | pass | | | ISO 7120 (B) |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | report [a] | | | ISO 6614 |
| Oxidation stability (“TOST”)<br>— time for total acid number 2 mgKOH/g (min) | h | report [a] | | | ISO 4263-3 [c] |
| Oxidation stability Baader test 72 h at 110 °C<br>Viscosity at 40 °C increase (maximum) | % | 20 | 20 | 20 | DIN 51554-3 |
| Filterability (dry) (minimum) [d] | % | 80 | 80 | 80 | ISO 13357-2 |
| Load carrying ability – FZG (A/8,3/90)<br>Failure load stage (minimum) | rating | 10 | 10 | 10 | ISO 14635-1 |
| Toxicity [e]<br>— acute Fish toxicity LL50 (minimum)<br>— acute Daphnia toxicity EC 50 (minimum)<br>— bacteria Inhibition 3 h EC 50 (minimum) | <br>mg/l<br>mg/l<br>mg/l | <br>100<br>100<br>100 | <br>100<br>100<br>100 | <br>100<br>100<br>100 | <br>ISO 7346-2<br>ISO 6341<br>ISO 8192 |
| Biodegradability (minimum) [f] | % | 60 | 60 | 60 | ISO 14593 or ISO 9439 |
| Cleanliness at the delivery stage [f] (maximum) | rating | — / 17 / 14 | | | ISO 4406 |
| NOTE See also category HEES, as per ISO 6743-4[1] and ISO 15380[5]. | | | | | |

a To be negotiated between the end user and the supplier.
b In case of dispute, ISO 6618 applies.
c The oxidation stability test is performed without water.
d ISO 13357-2 applies normally to mineral oils; compatibility between the fluid and the membrane has to be checked before testing.
e Water soluble fluids shall be tested according to the test methods cited. Fluids with low water solubility shall be tested using water accommodated fractions prepared according to ASTM D 6081 or ISO 10634.
f Without 10 days window requirement. Some national requirements may be more severe.
f ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles.

**Table 12 — Specification for turbine oils L-TSD and L-TGD**
(Phosphate esters)

| Property | Unit | Viscosity class | | Test method |
|---|---|---|---|---|
| | | 32 | 46 | |
| Viscosity class | | 32 | 46 | ISO 3448 |
| Color | rating | report | | ISO 2049 |
| Appearance | rating | clear and bright | | Visual |
| Kinematic viscosity at 40 °C<br>— at 0 °C maximum<br>— at 40 °C minimum<br>— at 40 °C maximum | $mm^2/s$ | <br>2 000<br>28,8<br>35,2 | <br>2 500<br>41,4<br>50,6 | ISO 3104 |
| Viscosity index | | report | | ISO 2909 |
| Pour point (maximum) | $^0C$ | -15 | -15 | ISO 3016 |
| Density at 15 °C | $kg/m^3$ | 1 200 | 1 200 | ISO 12185 or ISO 3675 |
| Fire point (minimum) | $^0C$ | 300 | 300 | ISO 2592 |
| Manifold-ignition test (minimum) | $^0C$ | 700 | 700 | ISO 20823 |
| Wick-flame persistence (maximum) | s | 10 | 10 | ISO 14935 |
| Total acid number (maximum) a | mg KOH/g | 0.1 | 0.1 | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (maximum) | % (*m/m*) | 0,10 | 0,10 | ISO 760 or ISO 20764 |
| Foaming (tendency/stability) (maximum)<br>— sequence 1 °C at 24 °C<br>— sequence 2 °C at 93 °C<br>— sequence 3 °C at 24 °C after 93 °C | <br>ml/ml<br>ml/ml<br>ml/ml | <br>150/0<br>30/0<br>150/0 | <br>150/0<br>30/0<br>150/0 | ISO 6247 |
| Air release time at 50 °C (maximum) | min | 5 | 6 | ISO 9120 |
| Copper corrosion (3 h at 100 °C) (maximum) | rating | 1 | 1 | ISO 2160 |
| Demulsibility d (maximum time to reach 3 ml emulsion at 54 °C) | min | 15 | 15 | ISO 6614 |
| Oxidation stability<br>— acid number (maximum)<br>— mass change Fe (maximum)<br>— mass change Cu (maximum) | <br>mg KOH/g<br>mg<br>mg | <br>1,5<br>1,0<br>2,0 | <br>1,5<br>1,0<br>2,0 | EN 14832 |
| Hydrolytic stability<br>— Acid number (maximum) | <br>mg KOH/g | <br>0.5 | <br>0.5 | EN 14833 |
| Cleanliness at the delivery stage [b](maximum) | rating | — / 17 / 14 | | ISO 4406 |

a In case of dispute, ISO 6618 applies.
b ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles.

# 7 Packaging and labelling

## 7.1 Packaging

The condition of the drums or smaller containers and the bulk tankers into which the oil is filled shall be such as to have detrimental effect on the quality of the oil during normal transportation and storage. Only containers of the same size filled with oil of the same batch identification shall be packaged together in a carton.

## 7.2 Labelling (see if any ref std)

**7.2.1** Each container shall be securely closed and labelled with the following information:

a) the manufacturer's identification and/or distributor's name;;

b) ISO classification;

c) Viscosity Grade

d) Net mass in the container

e) Batch number or code number;

f) Date of manufacture;

g) shelf life (best before)

h) country of origin

i) safety symbol

k) Recognized trade-mark, if any with identification in code of otherwise to enable the lot of consignment or manufacturer to be traced back.

**7.2.2** Small containers packed in cartons, the batch identification may be marked on each carton only.

**7.2.3** Lubricants packed in bulk tankers, the batch identification shall be marked on the consignment documents.

# 8 Sampling

Unless otherwise specified in commodity specifications, samples shall be taken in accordance with ISO 3170

# 9 Test methods

The requirements enumerated in tables (from 5 to 13) specification shall be determined in accordance with the ISO methods indicated in above tables.



 

ICS 75.100