INTERNATIONAL STANDARD

ISO 8068

Second edition
2006-09-15

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

Lubrifiants, huiles industrielles et produits connexes (classe L) — Famille T (Turbines) — Spécifications pour les huiles lubrifiantes pour turbines

Reference number
ISO 8068:2006(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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Foreword

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

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

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

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

ISO 8068 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 4, *Classifications and specifications*.

This second edition cancels and replaces the first edition (ISO 8068:1987), which has been technically revised. ISO 8068:1987 is only dealing with the specifications of TSA and TGA categories of turbine oils. This new edition gives specifications for all the turbine oil categories described in ISO 6743-5:2006.

Introduction

New turbine technologies have emerged in recent years leading to the 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 turbine. The lubricant should therefore meet the requirements for the lubrication of both pieces of equipment.

The growing concern regarding the environmental behaviour 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 should demonstrate a low ecotoxicity.

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

WARNING — The handling and use of products as specified in this International Standard can be hazardous, if suitable precautions are not observed. This International Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1 Scope

This International Standard specifies the minimum requirements for turbine lubricants, as delivered. 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 International Standard does not specify the requirements for wind turbines, which are dealt with in ISO 12925-1[4].

Whilst power generation is the primary application for turbines, steam and gas turbines can also be used to drive rotating equipment, such as pumps and compressors. The lubrication systems of these driven loads can be common to that of the turbine.

Turbine installations incorporate complex auxiliary systems requiring lubrication, including hydraulic systems, gearboxes and couplings. Depending upon the design and configuration of the turbine and driven equipment, turbine lubricants can also be used in these auxiliary systems.

This International Standard should be read in conjunction with ISO 6743-5[2], the classification of different turbine lubricant types.

The following lubricants are considered in this International Standard:

— mineral oils;

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

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

— fire-resistant phosphate-ester type lubricants.

NOTE For the purposes of this International Standard, the term "% (m/m)" is used to represent the mass fraction.

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 760, *Determination of water — Karl Fischer method (General method)*

ISO 2049, *Petroleum products — Determination of colour (ASTM scale)*

ISO 2160, *Petroleum products — Corrosiveness to copper — Copper strip test*

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

ISO 2719, *Determination of flash point — Pensky-Martens closed cup method*

ISO 2909, *Petroleum products — Calculation of viscosity index from kinematic viscosity.*

ISO 3016, *Petroleum products — Determination of pour point*

ISO 3104, *Petroleum product — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3170, *Petroleum liquids — Manual sampling*

ISO 3448, *Industrial liquid lubricants — ISO viscosity classification*

ISO 3675, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method*

ISO 4259, *Petroleum products — Determination and application of precision data in relation to methods of test*

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*

ISO 4263-3, *Petroleum and related products — Determination of the ageing behaviour of inhibited oils and fluids — TOST test — Part 3: Anhydrous procedure for synthetic hydraulic fluids*

ISO 4406, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 6072, *Hydraulic fluid power — Compatibility between fluids and standard elastomeric materials*

ISO 6247, *Petroleum products — Determination of foaming characteristics of lubricating oils*

ISO 6296, *Petroleum products — Determination of water — Potentiometric Karl Fischer titration method*

ISO 6341, *Water quality — Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) — Acute toxicity test*

ISO 6614, *Petroleum products — Determination of water separability of petroleum oils and synthetic fluids*

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

ISO 6619, *Petroleum products and lubricants — Neutralization number – Potentiometric titration method*

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

ISO 7346-2, *Water quality — Determination of the acute lethal toxicity of substances to a freshwater fish [Brachydanio rerio Hamilton-Buchanan (Teleostei, Cyprinidae)] — Part 2: Semi-static method*

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

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

ISO 8192, *Water quality — Test for inhibition of oxygen consumption by activated sludge for carbonaceous and ammonium oxidation*

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

ISO 9439, *Water quality — Evaluation of ultimate aerobic biodegradability of organic compounds in aqueous medium — Carbon dioxide evolution test*

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

ISO 12937, *Petroleum products — Determination of water — Coulometric Karl Fischer titration method*

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

ISO 13357-2, *Petroleum products — Determination of the filterability of lubricating oils — Part 2: Procedure for dry oils*

ISO 14593, *Water quality — Evaluation of ultimate aerobic biodegradability of organic compounds in aqueous medium — Method by analysis of inorganic carbon in sealed vessels (CO_2 headspace test)*

ISO 14635-1, *Gears — FZG test procedures — Part 1: FZG test method A/8,3/90 for relative scuffing load-carrying capacity of oils*

ISO 14935, *Petroleum and related products — Determination of wick flame persistence of fire-resistant fluids*

ISO 20764, *Petroleum and related products — Preparation of a test portion of high-boiling liquids for the determination of water content — Nitrogen purge method*

ISO 20823, *Petroleum and related products — Determination of the flammability characteristics of fluids in contact with hot surfaces — Manifold ignition test*

ASTM D2272-02, *Standard Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel*

ASTM D 2711-01a, *Standard Test Method for Demulsibility Characteristics of Lubricating Oils*

ASTM D 2893, *Standard Test Method for Oxidation Characteristics of Extreme-Pressure Lubrication Oils*

ASTM D 4636, *Standard Test Method for Corrosiveness and Oxidation Stability of Hydraulic Oils, Aircraft Turbine Engine Lubricants, and Other Highly Refined Oils*

ASTM D 6081, *Standard Practice for Aquatic Toxicity Testing of Lubricants: Sample Preparation and Results Interpretation*

EN 14832, *Petroleum and related products — Determination of the oxidation stability and corrosivity of fire-resistant phosphate ester fluids*

EN 14833, *Petroleum and related products — Determination of hydrolytic stability of fire-resistant phosphate ester fluids*

DIN 51554-3, *Testing of mineral oils — Test of susceptibility to ageing according to Baader — Testing at 95 °C*

3 Sampling

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

4 Requirements for turbine oils

Fluids, when tested under the prescribed methods, shall be in accordance with the limits set out in Tables 3 to 11, depending on the type.

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

These oils shall not contain any viscosity-index improver.

Most of the test methods specified in the tables contain 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 12937 or ISO 20764. In case of dispute, ISO 20764 shall be used.

The elastomer compatibility index shall be determined according to ISO 6072 under the conditions listed in Table 1, according to the product category. Table 2 gives guidelines on acceptable changes of properties. 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 1 — 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	1 000
		HNBR 1	130		
		FKM 2	150		
Synthetic esters	TGCE THCE	NBR 1,2	60	168	1 000
		HNBR 1	100		
		FKM 2	100		
Synthetic hydrocarbons	TGCH THCH	NBR 1,2	100	168	1 000
		HNBR 1	130		
		FKM 2	150		
Aryl phosphate ester	TSD TGD	FKM 2	150	168	1 000
		EPDM 1	130		

[a] The test duration of 1 000 h is recommended for evaluation of elastomer compatibility with fluids which cause longer term changes to the elastomer.

Table 2 — 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

5 Specification tables

5.1 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 3.

5.2 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 4.

5.3 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 fulfil the requirements of both TSA and TGB oils. Specifications are given in Table 5.

5.4 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 fulfil the requirements of both TGF and TSE oils. Specifications are given in Table 6.

5.5 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 7.

5.6 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[6] or the specifications of MIL-PRF-23699 STD[7] or MIL-PRF-23699 HTS[7] or with the manufacturer's specification.

5.7 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[3] and specified in ISO 12925-1[4]. Specifications are given in Table 8.

5.8 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[1] and specified in ISO 15380[5]. Specifications are given in Table 9.

5.9 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[1] and specified in ISO 15380[5]. Specifications are given in Table 10.

5.10 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 11.

Table 3 — 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
Colour	rating	report			ISO 2049
Appearance	rating	clear and bright			visual
Kinematic viscosity at 40 °C — minimum — maximum	mm^2/s	28,8 35,2	41,4 50,6	61,2 74,8	ISO 3104
Viscosity index (minimum)		90	90	90	ISO 2909
Pour point (maximum) [a]	°C	– 6	– 6	– 6	ISO 3016
Density at 15 °C	kg/m^3	report			ISO 12185 or ISO 3675
Flash point (minimum) — open cup — closed cup	°C	186 170	186 170	186 170	ISO 2592 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] — sequence 1 °C at 24 °C — sequence 2 °C at 93 °C — sequence 3 °C at 24 °C after 93 °C	ml/ml ml/ml ml/ml	450/0 50/0 450/0	450/0 50/0 450/0	450/0 50/0 450/0	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

Table 3 (*continued*)

Property	Unit	Viscosity class			Test method
		32	46	68	
Oxidation stability (rotating pressure vessel) (minimum) [e]	min	report			ASTM D 2272-02
Oxidation stability ("TOST") [f] — total acid number at 1 000 h (maximum) — time for total acid number 2 mg KOH/g (minimum) — sludge after 1 000 h (maximum)	mg KOH/g h mg	0,3 3 500 200	0,3 3 000 200	0,3 2 500 200	ISO 4263-1
Oxidation stability [f] — total oxygen-containing products, TOP (maximum) — sludge (maximum)	% (*m*/*m*) % (*m*/*m*)	0,40 0,25	0,50 0,30	0,50 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 4 — 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
Colour	rating	report			ISO 2049
Appearance	rating	clear and bright			visual
Kinematic viscosity at 40 °C — minimum — maximum	mm^2/s	 28,8 35,2	 41,4 50,6	 61,2 74,8	ISO 3104
Viscosity index (minimum)		90	90	90	ISO 2909
Pour point (maximum) [a]	°C	– 6	– 6	– 6	ISO 3016
Density at 15 °C	kg/m^3	report			ISO 12185 or ISO 3675
Flash point (minimum) — open cup — closed cup	°C	 186 170	 186 170	 186 170	 ISO 2592 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] — sequence 1 °C at 24 °C — sequence 2 °C at 93 °C — sequence 3 °C at 24 °C after 93 °C	 ml/ml ml/ml ml/ml	 450/0 50/0 450/0	 450/0 50/0 450/0	 450/0 50/0 450/0	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”) — total acid number at 1 000 h (maximum) — time for total acid number 2 mg KOH/g (minimum) — sludge after 1 000 h (maximum)	 mg KOH/g h mg	 0,3 3 500 200	 0,3 3 000 200	 0,3 2 500 200	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 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 to TSE only.

[e] This value is useful for the follow-up in service. Should not normally be below 250 min.

[f] Higher failure load stages may be requested by some manufacturers/users.

[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-TGB and L-TGSB

Property	Unit	Viscosity class			Test method
		32	46	68	
Viscosity class	—	32	46	68	ISO 3448
Colour	rating	report			ISO 2049
Appearance	rating	clear and bright			visual
Kinematic viscosity at 40 °C — minimum — maximum	mm^2/s	 28,8 35,2	 41,4 50,6	 61,2 74,8	ISO 3104
Viscosity index (minimum)		90	90	90	ISO 2909
Pour point (maximum) [a]	°C	− 6	− 6	− 6	ISO 3016
Density at 15 °C	kg/m^3	report			ISO 12185 or ISO 3675
Flash point (minimum) — open cup — closed cup	°C	 200 190	 200 190	 200 190	 ISO 2592 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] — sequence 1 °C at 24 °C — sequence 2 °C at 93 °C — sequence 3 °C at 24 °C after 93 °C	 ml/ml ml/ml ml/ml	 450/0 50/0 450/0	 450/0 50/0 450/0	 450/0 50/0 450/0	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 D 2272-02
Oxidation stability (rotating pressure vessel) (minimum) [e]	%	85	85	85	ASTM D 2272-02
Oxidation stability at high temperature (72 h at 175 °C) — viscosity change (maximum) — acid number change (maximum) — metal specimen mass change — steel — aluminium — cadmium — copper — magnesium	 % mg KOH/g mg/cm^2	 report report ± 0,250 ± 0,250 ± 0,250 ± 0,250 ± 0,250	 report report ± 0,250 ± 0,250 ± 0,250 ± 0,250 ± 0,250	 report report ± 0,250 ± 0,250 ± 0,250 ± 0,250 ± 0,250	 ASTM D 4636 according to “alternative procedure 2”
Oxidation stability (“TOST”) — time for total acid number 2 mg KOH/g (minimum)	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 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 6 — 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
Colour	rating	report			ISO 2049
Appearance	rating	clear and bright			visual
Kinematic viscosity at 40 °C — minimum — maximum	mm^2/s	28,8 35,2	41,4 50,6	61,2 74,8	ISO 3104
Viscosity index (minimum)		90	90	90	ISO 2909
Pour point (maximum)	°C	– 6	– 6	– 6	ISO 3016
Density at 15 °C	kg/m^3	report			ISO 12185 or ISO 3675
Flash point (minimum) — open cup — closed cup	°C	200 190	200 190	200 190	ISO 2592 ISO 2719
Total acid number (maximum) [a]	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) [b] — sequence 1 at 24 °C — sequence 2 at 93 °C — sequence 3 at 24 °C after 93 °C	 ml/ml ml/ml ml/ml	 50/0 50/0 50/0	 50/0 50/0 50/0	 50/0 50/0 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 [c] (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 D 2272-02
Oxidation stability (rotating pressure vessel) (minimum) [d]	%	85	85	85	ASTM D 2272-02
Oxidation stability at high temperature (72 h at 175 °C) — Viscosity change (maximum) — Acid number change (maximum) — Metal specimen mass change — steel — aluminium — cadmium — copper — magnesium	 % mg KOH/g mg/cm^2	 report report ± 0,250 ± 0,250 ± 0,250 ± 0,250 ± 0,250	 report report ± 0,250 ± 0,250 ± 0,250 ± 0,250 ± 0,250	 report report ± 0,250 ± 0,250 ± 0,250 ± 0,250 ± 0,250	ASTM D 4636 (according to alternative procedure 2)
Oxidation stability ("TOST") - time for total acid number 2 mg KOH/g (minimum)	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) Failure load stage (minimum) [e]	rating	8	9	10	ISO 14635-1
Cleanliness at 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 TGSE 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 7 — 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
Colour	rating	report		ISO 2049
Appearance	rating	clear and bright		visual
Kinematic viscosity at 40 °C — minimum — maximum	mm^2/s	 28,8 35,2	 41,4 50,6	ISO 3104
Viscosity index		report		ISO 2909
Pour point	°C	− 21	− 21	ISO 3016
Density at 15 °C	kg/m^3	report		ISO 12185 or ISO 3675
Flash point open cup (minimum)	°C	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) — sequence 1 °C at 24 °C — sequence 2 °C at 93 °C — sequence 3 °C at 24 °C after 93 °C	 ml/ml ml/ml ml/ml	 50/0 50/0 50/0	 50/0 50/0 50/0	ISO 6247
Air-release time at 50 °C (minimum)	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 (maximum time to reach 3 ml emulsion at 54 °C)	min	report [a]		ISO 6614
Oxidation stability (rotating pressure vessel) (minimum) [c]	min	1 000	1 000	ASTM D 2272-02
Oxidation stability (rotating pressure vessel) (minimum) [d]	%	85	85	ASTM D 2272-02
Oxidation stability at high temperature (72 h at 175 °C) — viscosity change (maximum) — acid number change (maximum)	 % mg KOH/g	 − 3; + 5 2	 − 3; + 5 2	ASTM D4636 (according to alternative procedure 2)
Oxidation stability ("TOST") — time for total acid number 2 mg KOH/g (minimum)	h	4 000	3 500	ISO 4263-1
Filterability (dry) (minimum)	%	80	80	ISO 13357-2
Filterability (wet)	%	pass		ISO 13357-1
Cleanliness at delivery stage [e] (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 8 — 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
Colour	rating	report			ISO 2049
Appearance	rating	clear and bright			visual
Kinematic viscosity at 40 °C — minimum — maximum	mm^2/s	61,2 74,8	90,0 110,0	135 165	ISO 3104
Viscosity index (minimum)		90	90	90	ISO 2909
Pour point (maximum)	°C	– 12	– 12	– 9	ISO 3016
Density at 15 °C	kg/m^3	report			ISO 12185 or ISO 3675
Flash point open cup (minimum)	°C	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) — sequence 1 °C at 24 °C — sequence 2 °C at 93 °C — sequence 3 °C at 24 °C after 93 °C	 ml/ml ml/ml ml/ml	 100/0 100/0 100/0	 100/0 100/0 100/0	 100/0 100/0 100/0	ISO 6247
Air release time at 50 °C (maximum) Air release time at 75 °C (maximum)	min	12 —	— 18	— 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 (maximum time to reach 3 ml emulsion at 54 °C)	min	30	—	—	ISO 6614
Demulsibility for THA — free water (minimum) — emulsion (maximum) — water in oil (maximum)	 ml ml ml	 — — —	 30 2 0,5	 30 2 0,5	ASTM D 2711
Demulsibility for THE — free water (minimum) — emulsion (maximum) — water in oil (maximum)	 ml ml ml	 — — —	 80 1 2	 80 1 2	ASTM D 2711-01a (Appendix X 2)
Oxidation stability for THA ("TOST") - time for total acid number 2 mg KOH/g (minimum)	h	1 000	1 000	1 000	ISO 4263-1
Oxidation stability at 95 °C for THE — viscosity at 100 °C increase (maximum) — precipitation number (maximum)	%	6 0,1	6 0,1	6 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] Failure load stage (minimum)	rating	10	10	10	ISO 14635-1
Cleanliness at 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.

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.

[b] Applies to THE only.

[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 9 — 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
Colour	rating	report			ISO 2049
Appearance	rating	clear and bright			visual
Kinematic viscosity — at –20 °C maximum — at 0 °C maximum — at 40 °C minimum — at 40 °C maximum — at 100 °C minimum	mm^2/s	 a 780 41,4 50,6 6,1	 a 1 400 61,2 74,8 7,8	 a 1 500 90,0 110,0 10	ISO 3104
Pour point (maximum)	°C	– 15	– 12	– 9	ISO 3016
Density at 15 °C	kg/m^3	report			ISO 12185 or ISO 3675
Flash point open cup (minimum)	°C	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) — sequence 1 °C at 24 °C — sequence 2 °C at 93 °C — sequence 3 °C at 24 °C after 93 °C	 ml/ml ml/ml ml/ml	 150/0 70/0 150/0	 150/0 70/0 150/0	 150/0 70/0 150/0	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 (4 h) [c]	rating	pass			ISO 7120 (B)
Demulsibility (maximum time to reach 3 ml emulsion at 54 °C)	min	report [a]			ISO 6614
Oxidation stability (“TOST”) — time for total acid number 2 mg KOH/g (minimum)	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 test (A/8,3/90) Failure load stage (minimum)		10	10	10	ISO 14635-1
Toxicity [d] — acute Fish toxicity LL50 (minimum) — acute Daphnia toxicity EC 50 (minimum) — bacteria Inhibition 3 h EC 50 (minimum)	 mg/l mg/l mg/l	 100 100 100	 100 100 100	 100 100 100	 ISO 7346-2 ISO 6341 ISO 8192
Biodegradability (minimum) [e]	%	60	60	60	ISO 14593 or ISO 9439
Cleanliness at 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.

[b] In case of dispute, ISO 6618 applies.

[c] Test duration changed from 24 h (ISO 7120) to 4 h and a longer or shorter duration may be negotiated.

[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.

[e] 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.