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Lubricants, industrial oils and related products (class L) — Family H (Hydraulic systems) — Specifications for hydraulic fluids in categories HETG, HEPG, HEES and HEPR

Lubrifiants, huiles industrielles et produits connexes (classe L) — Famille H (Systèmes hydrauliques) — Spécifications applicables aux fluides hydrauliques des catégories HETG, HEPG, HEES et HEPR

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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.

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

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This fourth edition cancels and replaces the third edition (ISO 15380:2016), which has been technically revised.

The main changes are as follows:

— addition of Clauses 3 and 6;

— deletion of Annexes B and C;

— updating of the environmental requirements for environmentally acceptable products;

— precision with respect to the stage of the filterability tests, wet and dry.

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

Introduction

The specifications for hydraulic fluids based upon mineral oils (H) are described in ISO 11158 and the specifications for fire-resistant hydraulic fluids (HF) are given in ISO 12922. This document gives specifications for environmentally acceptable hydraulic fluids (HE). These fluids are biodegradable and have a low eco-toxicity. They are designed to minimize the impact upon the environment in the event of a leak or spill.

Table A.1 contains guidelines for changing fluids from mineral-based oils to environmentally acceptable fluids.

Lubricants, industrial oils and related products (class L) — Family H (Hydraulic systems) — Specifications for hydraulic fluids in categories HETG, HEPG, HEES and HEPR

1 Scope

This document specifies the requirements for environmentally acceptable hydraulic fluids and is intended for hydraulic systems, particularly hydraulic fluid power systems. The purpose of this document is to provide guidance and requirements for suppliers and users of environmentally acceptable hydraulic fluids, and for the direction of original equipment manufacturers of hydraulic systems.

This document stipulates the requirements for environmentally acceptable hydraulic fluids at the time of delivery.

Classification of fluids used in hydraulic application is defined in ISO 6743-4. This document encompasses the four categories of environmentally acceptable fluids covered by ISO 6743-4, namely HETG (triglycerides), HEPG (polyglycols), HEES (synthetic esters) and HEPR (polyalphaolefins and other synthetic hydrocarbons).

2 Normative references

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

ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

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

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

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

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

ISO 3016, *Petroleum and related products from natural or synthetic sources — Determination of pour point*

ISO 3104, *Petroleum products — 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 4259-1, *Petroleum and related products — Precision of measurement methods and results — Part 1: Determination of precision data in relation to methods of test*

ISO 4259-2, *Petroleum and related products — Precision of measurement methods and results — Part 2: Interpretation and application of precision data in relation to methods of test*

ISO 4259-3, *Petroleum and related products — Precision of measurement methods and results — Part 3: Monitoring and verification of published precision data in relation to methods of test*

ISO 4259-4, *Petroleum and related products — Precision of measurement methods and results — Part 4: Use of statistical control charts to validate 'in-statistical-control' status for the execution of a standard test method in a single laboratory*

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 using the 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, *Rubber — Compatibility between hydraulic fluids and standard elastomeric materials*

ISO 6245, *Petroleum products — Determination of ash*

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 6743-4, *Lubricants, industrial oils and related products (class L) — Classification — Part 4: Family H (Hydraulic systems)*

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 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 11500, *Hydraulic fluid power — Determination of the particulate contamination level of a liquid sample by automatic particle counting using the light-extinction principle*

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 13226, *Rubber — Standard reference elastomers (SREs) for characterizing the effect of liquids on vulcanized rubbers*

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 (CO2 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 14669, *Water quality — Determination of acute lethal toxicity to marine copepods (Copepoda, Crustacea)*

ISO 16221, *Water quality — Guidance for determination of biodegradability in the marine environment*

ISO 20763, *Petroleum and related products — Determination of anti-wear properties of hydraulic fluids — Vane pump method*

ISO 26422, *Petroleum and related products — Determination of shear stability of lubricating oils containing polymers — Method using a tapered roller bearing*

EN 16807, *Liquid petroleum products — Bio-lubricants — Criteria and requirements of bio-lubricants and bio-based lubricants*

EN 17181, *Lubricants — Determination of aerobic biological degradation of fully formulated lubricants in an aqueous solution — Test method based on CO2-production*

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

ASTM D2532, *Standard Test Method for Viscosity and Viscosity Change After Standing at Low Temperature of Aircraft Turbine Lubricants*

ASTM D6081, *Standard Practice for Aquatic Toxicity Testing of Lubricants: Sample Preparation and Results Interpretation*

ASTM D6866, *Standard Test Methods for Determining the Biobased Content of Solid, Liquid and Gaseous Samples Using Radiocarbon Analysis*

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

4 Sampling

Sampling of hydraulic fluids for the purpose of this document shall be carried out in accordance with the pertinent procedure specified in ISO 3170. A representative test specimen should be taken for analysis.

Any drum, barrel, tanker compartment or other type of container delivered to the end user may be sampled and analysed at the purchaser's discretion.

5 Requirements of environmentally acceptable hydraulic fluids

5.1 General

For the purpose of this document, hydraulic fluids shall be triglycerides, polyglycols, synthetic esters, polyalphaolefins and related hydrocarbon products. The classification of these hydraulic oils shall be in accordance with ISO 6743-4 for categories HETG, HEPG, HEES and HEPR. The minimum category-defining base oil type content for each category shall be in accordance with the requirements of Table 1.

Table 1 — Minimum category-defining base fluid content for each category

Category	Mass fraction	Category defining base fluid[a] type content of the total fluid formulation	Total base fluid content of the fluid formulation
HETG	%	>50	≥70
HEPG	%	>50	≥70
HEES	%	>50	≥70
HEPR	%	>50	≥70

[a] Category-defining base fluid is identified as the relevant triglycerides, polyglycols, synthetic esters, polyalphaolefins and related hydrocarbon products.

Environmentally acceptable hydraulic fluids shall comply with the requirements of EN 16807, as follows: HETG, HEPG, HEES and HEPR shall comply with the biodegradability and the toxicity requirements. Additionally, HETG and HEES shall comply with the carbon of biological origin requirements (see Table 2).

The requirements published in EN 16807 are intended as baseline requirements for all bio-based lubricants, and represent minimum requirements compared to, for example, the European Ecolabel for Lubricants[3]. With the exception of content of carbon of biological origin, these requirements can also be minimum requirements for other types of environmental standards existing in the world.

In a product line of either of the categories, for all grades of a line that uses the same additive package and the same range of base stocks, toxicity requirements may be tested only on the lightest, medium and heaviest grade of the line.

The characteristics of the fluids shall comply with the limiting values set out in Table 2 and with the limiting values of the relevant fluid category set out in Tables 3 to 6. The test methods and standards listed in Tables 2 to 6 shall apply.

Table 2 — Environmental requirements for categories HETG, HEPG, HEES and HEPR

Characteristic of test	Unit	Requirement	Test method or applicable standard
Biodegradability resulting in mineralization of the organic material, 28 d, min.	%	60	ISO 14593[c] or ISO 9439[c] or ISO 16221[c] or EN 17181[c]
Toxicity[a]			
Acute fish toxicity, 96 h, LC50	mg/l	> 100	ISO 7346-2[c]
Acute daphnia or copepods toxicity, 48 h, EC50	mg/l	> 100	ISO 6341[c] or ISO 14669[c]
Bacterial inhibition, 3 h, EC50	mg/l	> 100	ISO 8192[c]
Content of carbon of biological origin, min.[b]	%	25	ASTM D6866

[a] Water-soluble fluids shall be tested in accordance with the test method cited. Fluids with low water solubility shall be tested using water-accommodated fractions, and shall be prepared in accordance with ASTM D6081.

[b] Applies only to HETG and HEES type products.

[c] The interpretation of the results of this test method is currently limited due to missing or inapplicable precision data. In case of dispute or doubt, a referee test should be performed in an independent laboratory.

The biodegradability and aquatic toxicity tests should be performed in a laboratory operating in accordance with ISO/IEC 17025 or according to good laboratory practice (GLP).

5.2 Biodegradability

In case of dispute, the referee method for compliance with the biodegradability requirement shall be the method specified in EN 17181. In order to check the procedure during the referee process, a reference compound of known biodegradability shall be tested in parallel. Aniline shall be used when testing water-soluble test compounds. For poorly water-soluble test substances, high oleic reference oil (HORO) shall be used.

5.3 Acute daphnia or copepods toxicity

In case of dispute, the referee method for compliance with the invertebrate requirement shall be the method specified in ISO 6341.

In order to check the procedure during the referee process, a reference compound of known toxicity shall be tested in parallel. Tetrapropylenebenzenesulfonic acid shall be used when testing water-soluble test compounds. For poorly water-soluble test substances potassium 2,4,5-trichlorophenoxyacetate shall be used.

All other detailed specifications of each category mentioned in this document are provided in Tables 3 to 6, respectively, and as indicated below:

— Table 3: category HETG;

— Table 4: category HEPG;

— Table 5: category HEES;

— Table 6: category HEPR.

All of the categories listed above pertain to lubricants, industrial oils and related products of Group HE, i.e. environmentally acceptable hydraulic fluids, a typical application of which is in general hydraulic systems. The composition of each category is specified in the title of Tables 3 to 6. These elements are taken from ISO 6743-4.

Table 3 — Specifications for type HETG hydraulic fluids, triglycerides

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Density at 15 °C	kg/m³	report	report	report	report	ISO 12185 ISO 3675
Colour[a]	-	report	report	report	report	ISO 2049
Appearance at 25 °C	-	clear and bright	clear and bright	clear and bright	clear and bright	-
Ash content by mass	%	[b]	[b]	[b]	[b]	ISO 6245
Flash point Cleveland open cup, min.	°C	165	175	185	195	ISO 2592
Kinematic viscosity — at –20 °C — at 0 °C, max. — at 40 °C — at 100 °C, min.	 mm²/s mm²/s mm²/s mm²/s	 [b] 300 19,8 to 24,2 4,1	 [b] 420 28,8 to 35,2 5,0	 [b] 780 41,4 to 50,6 6,1	 [b] 1 400 61,2 to 74,8 7,8	ISO 3104
Viscosity Index	-	report	report	report	report	ISO 2909
Pour point	°C	[b]	[b]	[b]	[b]	ISO 3016
Low temperature fluidity after 7 days	°C	[b]	[b]	[b]	[b]	ASTM D2532
Acid number	mg KOH/g	[b]	[b]	[b]	[b]	ISO 6619 ISO 6618
Water content, max.	mg/kg	1 000	1 000	1 000	1 000	ISO 12937 ISO 6296
Cleanliness level	[b]	[b]	[b]	[b]	[b]	ISO 4406 ISO 11500
Copper corrosion, 100 °C 3 h, max.	rating	2	2	2	2	ISO 2160
Rust prevention, 24 h: Procedure A Procedure B	 - -	 Pass Pass	 Pass Pass	 Pass Pass	 Pass Pass	ISO 7120

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or values of characteristics shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HETG performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HETG in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HETG in this document.

[f] TAN = total acid number

[g] RPVOT = rotating pressure vessel oxidation test

Table 3 *(continued)*

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Foam — at 24 °C, max. (Sequence I)	ml	150/0	150/0	150/0	150/0	ISO 6247
— at 93 °C, max. (Sequence II)	ml	80/0	80/0	80/0	80/0	
— at 24 °C, max. (Sequence III)	ml	150/0	150/0	150/0	150/0	
Air release, 50 °C, max.	min	5	5	10	13	ISO 9120
Water separation Time to 3 ml emulsion at 54 °C	min	[b]	[b]	[b]	[b]	ISO 6614
Elastomer compatibility[c] 1 000 h at given temperature						
NBR 1 according to ISO 6072	°C	60	80	80	80	
HNBR/1 according to ISO 13226	°C	60	80	80	80	
FKM/2 according to ISO 13226	°C	60	80	80	80	ISO 1817
Change in shore A hardness	grade	±10	±10	±10	±10	
Change in volume	%	−3 to +10	−3 to +10	−3 to +10	−3 to +10	
Change in elongation, max.	%	30	30	30	30	
Change in tensile strength, max.	%	30	30	30	30	
Oxidation stability:						
Dry TOST test, time to reach ΔTAN[f] = 2 mg KOH/g	h	report [b]	report [b]	report [b]	report [b]	ISO 4263-3
RPVOT[g]	min	report	report	report	report	ASTM D2272

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or values of characteristics shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HETG performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HETG in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HETG in this document.

[f] TAN = total acid number

[g] RPVOT = rotating pressure vessel oxidation test

Table 3 *(continued)*

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Shear stability, tapered roller bearing, 20 h at 60 °C						
— Loss in kinematic viscosity at 40 °C	%	report	report	report	report	ISO 26422
— Loss in kinematic viscosity at 100 °C	%	report	report	report	report	
Load-carrying properties, FZG A/8,3/90, min.	Fail load stage	-	10	10	10	ISO 14635-1
Vane pump, Procedure A						
Ring, max.	mg	-	120	120	120	ISO 20763
Vane, max.	mg	-	30	30	30	
Filterability, dry[d]						
— Stage I filterability, min.	%	80	80	80	80	ISO 13357-2
— Stage II filterability, min.	%	60	60	60	60	
Filterability, wet[e]						
— Stage I filterability	%	report	report	report	report	ISO 13357-1
— Stage II filterability	%	report	report	report	report	

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or values of characteristics shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HETG performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HETG in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HETG in this document.

[f] TAN = total acid number

[g] RPVOT = rotating pressure vessel oxidation test

Table 4 — Specifications for type HEPG hydraulic fluids, polyglycols

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Density at 15 °C	kg/m³	report	report	report	report	ISO 12185 ISO 3675
Colour[a]	-	report	report	report	report	ISO 2049
Appearance at 25 °C	-	clear and bright	clear and bright	clear and bright	clear and bright	-
Ash content by mass	%	[b]	[b]	[b]	[b]	ISO 6245
Flash point Cleveland open cup, min.	°C	165	175	185	195	ISO 2592
Kinematic viscosity — at –20 °C — at 0 °C, max. — at 40 °C, min. to max. — at 100 °C, min.	 mm²/s mm²/s mm²/s mm²/s	 [d] 300 19,8 to 24,2 4,1	 [d] 420 28,8 to 35,2 5,0	 [d] 780 41,4 to 50,6 6,1	 [d] 1 400 61,2 to 74,8 7,8	ISO 3104
Viscosity Index	-	report	report	report	report	ISO 2909
Pour point, max.	°C	–21	–18	–15	–12	ISO 3016
Low temperature fluidity after 7 days	°C	[b]	[b]	[b]	[b]	ASTM D2532
Acid number	mg KOH/g	[b]	[b]	[b]	[b]	ISO 6619 ISO 6618
Water content, max	mg/kg	5 000	5 000	5 000	5 000	ISO 12937 ISO 6296
Cleanliness level	[b]	[b]	[b]	[b]	[b]	ISO 4406 ISO 11500
Copper corrosion, 100 °C 3 h, max.	rating	2	2	2	2	ISO 2160
Rust prevention, 24 h: Procedure A Procedure B	 - -	 Pass Pass	 Pass Pass	 Pass Pass	 Pass Pass	ISO 7120

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEPG performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEPG in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEPG in this document.

[f] TAN = total acid number.

Table 4 *(continued)*

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Foam						
— at 24 °C, max. (Sequence I)	ml	150/0	150/0	150/0	150/0	
— at 93 °C, max. (Sequence II)	ml	80/0	80/0	80/0	80/0	ISO 6247
— at 24 °C, max. (Sequence III)	ml	150/0	150/0	150/0	150/0	
Air release, 50 °C, max.	min	7	7	10	13	ISO 9120
Elastomer compatibility[c] after 1 000 h at given temperature						
NBR 1 according to ISO 6072	°C	60	80	—	—	
HNBR/1 according to ISO 13226	°C	60	80	100	100	
FKM/2 according to ISO 13226	°C	60	80	100	100	ISO 1817
Change in shore A hardness, max.	grade	±10	±10	±10	±10	
Change in volume	%	−3 to +10	−3 to +10	−3 to +10	−3 to +10	
Change in elongation, max.	%	30	30	30	30	
Change in tensile strength, max.	%	30	30	30	30	
Oxidation stability:						
Dry TOST test, time to reach ΔTAN^{f} = 2 mg KOH/g, min.	h	1 000	1 000	1 000	1 000	ISO 4263-3
Shear stability, tapered roller bearing, 20 h at 60 °C						
— Loss in kinematic viscosity at 40 °C	%	report	report	report	report	ISO 26422
— Loss in kinematic viscosity at 100 °C	%	report	report	report	report	

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEPG performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEPG in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEPG in this document.

[f] TAN = total acid number.

Table 4 *(continued)*

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Load-carrying properties, FZG A/8,3/90, min.	Fail load stage	-	10	10	10	ISO 14635-1
Vane pump, Procedure A						
Ring, max.	mg	-	120	120	120	ISO 20763
Vane, max.	mg	-	30	30	30	
Filterability, dry[d]						
— Stage I filterability, min.	%	80	80	80	80	ISO 13357-2
— Stage II filterability, min.	%	60	60	60	60	
Filterability, wet[e]						
— Stage I filterability	%	report	report	report	report	ISO 13357-1
— Stage II filterability	%	report	report	report	report	

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEPG performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEPG in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEPG in this document.

[f] TAN = total acid number.

Table 5 — Specifications for type HEES hydraulic fluids, synthetic esters

Characteristic of test	Unit	Requirement					Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**100**	**ISO 3448**
Density at 15 °C	kg/m³	report	report	report	report	report	ISO 12185 ISO 3675
Colour[a]	-	report	report	report	report	report	ISO 2049
Appearance at 25 °C	-	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	-
Ash content by mass	%	b	b	b	b	b	ISO 6245
Flash point Cleveland open cup, min.	°C	165	175	185	195	205	ISO 2592
Kinematic viscosity							ISO 3104
— at −20 °C	mm²/s	d	d	d	d	d	
— at 0 °C, max.	mm²/s	300	420	780	1 400	1 500	
— at 40 °C, min. to max.	mm²/s	19,8 to 24,2	28,8 to 35,2	41,4 to 50,6	61,2 to 74,8	90,0 to 110	
— at 100 °C, min.	mm²/s	4,1	5,0	6,1	7,8	10,0	
Viscosity Index	-	report	report	report	report	report	ISO 2909
Pour point, max	°C	−21	−18	−15	−12	−9	ISO 3016
Low temperature fluidity after 7 days	°C	b	b	b	b	b	ASTM D2532
Acid number	mg KOH/g	b	b	b	b	b	ISO 6619 ISO 6618
Water content, max.	mg/kg	1 000	1 000	1 000	1 000	1 000	ISO 12937 ISO 6296
Cleanliness level	b	b	b	b	b	b	ISO 4406 ISO 11500
Copper corrosion, 100 °C, 3 h, max.	rating	2	2	2	2	2	ISO 2160

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEES performance levels specified in this doucment should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEES in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEES in this document.

[f] TAN = total acid number.

[g] RPVOT = rotating pressure vessel oxidation test.

Table 5 *(continued)*

Characteristic of test	Unit	Requirement					Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**100**	**ISO 3448**
Rust prevention, 24 h:							
Procedure A	-	Pass	Pass	Pass	Pass	Pass	ISO 7120
Procedure B	-	Pass	Pass	Pass	Pass	Pass	
Foam							
— at 24 °C, max. (Sequence I)	ml	150/0	150/0	150/0	150/0	150/0	
— at 93 °C, max. (Sequence II)	ml	80/0	80/0	80/0	80/0	80/0	ISO 6247
— at 24 °C, max. (Sequence III)	ml	150/0	150/0	150/0	150/0	150/0	
Air release, 50 °C, (75 °C for ISO VG 100), max.	min	5	7	10	13	[a]	ISO 9120
Water separation							
Time to 3 ml emulsion at 54 °C	min	[b]	[b]	[b]	[b]	[b]	ISO 6614
Elastomer compatibility[c] after 1 000 h at given temperature							
NBR 1 according to ISO 6072	°C	60	80	80	—	—	
HNBR/1 according to ISO 13226	°C	60	80	80	100	100	
FKM/2 according to ISO 13226	°C	60	80	80	100	100	ISO 1817
Change in shore A hardness, max.	grade	±10	±10	±10	±10	±10	
Change in volume	%	−3 to +10	−3 to +10	−3 to +10	−3 to +10	−3 to +10	
Change in elongation, max.	%	30	30	30	30	30	
Change in tensile strength, max.	%	30	30	30	30	30	

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEES performance levels specified in this doucment should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEES in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEES in this document.

[f] TAN = total acid number.

[g] RPVOT = rotating pressure vessel oxidation test.

Table 5 *(continued)*

Characteristic of test	Unit	Requirement					Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**100**	**ISO 3448**
Oxidation stability:							
Dry TOST test, time to reach ΔTAN[f] = 2 mg KOH/g	h	report [b]	report [b]	report [b]	report [b]	report [b]	ISO 4263-3
RPVOT[g]	min	report	report	report	report	report	ASTM D2272
Shear stability, tapered roller bearing, 20 h at 60 °C							
— Loss in kinematic viscosity at 40 °C	%	report	report	report	report	report	ISO 26422
— Loss in kinematic viscosity at 100 °C	%	report	report	report	report	report	
Load-carrying properties, FZG A/8,3/90, min.	Fail load stage	—	10	10	10	10	ISO 14635-1
Vane pump. Procedure A							
Ring, max.	mg	—	120	120	120	—	ISO 20763
Vane, max.	mg	—	30	30	30	—	
Filterability, dry[d]							
— Stage I filterability, min.	%	80	80	80	80	80	ISO 13357-2
— Stage II filterability, min.	%	60	60	60	60	60	
Filterability, wet[e]							
— Stage I filterability	%	report	report	report	report	report	ISO 13357-1
— Stage II filterability	%	report	report	report	report	report	

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEES performance levels specified in this doucment should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEES in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEES in this document.

[f] TAN = total acid number.

[g] RPVOT = rotating pressure vessel oxidation test.

Table 6 — Specifications for type HEPR hydraulic fluids, polyalphaolefins and other synthetic hydrocarbons

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Density at 15 °C	kg/m^3	report	report	report	report	ISO 12185 ISO 3675
Colour[a]	-	report	report	report	report	ISO 2049
Appearance at 25 °C	-	clear and bright	clear and bright	clear and bright	clear and bright	-
Ash content by mass	%	[b]	[b]	[b]	[b]	ISO 6245
Flash point Cleveland open cup, min.	°C	165	175	185	195	ISO 2592
Kinematic viscosity						ISO 3104
— at −20 °C, max.	mm^2/s	[b]	[b]	[b]	[b]	
— at 0 °C, max.	mm^2/s	300	420	780	1 400	
— at 40 °C, min. to max.	mm^2/s	19,8 to 24,2	28,8 to 35,2	41,4 to 50,6	61,2 to 74,8	
— at 100 °C, min.	mm^2/s	4,1	5,0	6,1	7,8	
Viscosity index	-	report	report	report	report	ISO 2909
Pour point, max.	°C	−21	−18	−15	−12	ISO 3016
Low temperature fluidity after 7 days	°C	[b]	[b]	[b]	[b]	ASTM D2532
Acid number[b], max.	mg KOH/g	[b]	[b]	[b]	[b]	ISO 6619 ISO 6618
Water content, max.	mg/kg	1 000	1 000	1 000	1 000	ISO 12937 ISO 6296
Cleanliness level	[b]	[b]	[b]	[b]	[b]	ISO 4406 ISO 11500
Copper corrosion, 100 °C, 3 h, max.	rating	2	2	2	2	ISO 2160
Rust prevention, 24 h:						ISO 7120
Procedure A	-	Pass	Pass	Pass	Pass	
Procedure B	-	Pass	Pass	Pass	Pass	

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEPR performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEPR in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEPR in this document.

[f] TAN = total acid number.

Table 6 *(continued)*

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Foam						
— at 24 °C, max. (Sequence I)	ml	150/0	150/0	150/0	150/0	
— at 93 °C, max. (Sequence II)	ml	80/0	80/0	80/0	80/0	ISO 6247
— at 24 °C, max. (Sequence III)	ml	150/0	150/0	150/0	150/0	
Air release, 50 °C, max.	min	5	5	10	13	ISO 9120
Water separation Time to 3 ml emulsion at 54 °C	min	b	b	b	b	ISO 6614
Elastomer compatibility[c] after 1 000 h at given temperature						
NBR 1 according to ISO 6072	°C	60	80	—	—	
HNBR/1 according to ISO 13226	°C	60	80	100	100	
FKM/2 according to ISO 13226	°C	60	80	100	100	ISO 1817
Change in shore A hardness, max.	grade	±10	±10	±10	±10	
Change in volume	%	−3 to +10	−3 to +10	−3 to +10	−3 to +10	
Change in elongation, max.	%	30	30	30	30	
Change in tensile strength, max.	%	30	30	30	30	
Oxidation stability: TOST test, time to reach ΔTAN^{f} = 2 mg KOH/g, min.	h	1 000	1 000	1 000	1 000	ISO 4263-1
Shear stability, tapered roller bearing, 20 h at 60 °C						
— Loss in kinematic viscosity at 40 °C	%	report	report	report	report	ISO 26422
— Loss in kinematic viscosity at 100 °C	%	report	report	report	report	
Load carrying properties, FZG A/8,3/90, min.	Fail load stage	—	10	10	10	ISO 14635-1

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEPR performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEPR in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit >50 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEPR in this document.

[f] TAN = total acid number.

Table 6 *(continued)*

Characteristic of test	Unit	Requirement				Test method or applicable standard
Viscosity grade		**22**	**32**	**46**	**68**	**ISO 3448**
Vane pump, Procedure A						
Ring, max.	mg	120	120	120	120	ISO 20763
Vane, max.	mg	30	30	30	30	
Filterability, dry[d]						
— Stage I filterability, min.	%	80	80	80	80	ISO 13357-2
— Stage II filterability, min.	%	60	60	60	60	
Filterability, wet[e]						
— Stage I filterability	%	report	report	report	report	ISO 13357-1
— Stage II filterability	%	report	report	report	report	

[a] For purposes of identification, dye may be used by agreement between supplier and end user.

[b] Criteria of performance or characteristics values shall be negotiated between supplier and end user.

[c] The requirements for two of the listed elastomer types shall be met. The values are minimum requirements for standard reference elastomers. The elastomers are suitable for guidance and selection of the correct sealing material. Other materials and/or test conditions may be agreed between supplier and customer. The applicability to the behaviour of the elastomer used in practice should be considered.

[d] Oils that do not meet the dry filterability requirements specified in ISO 13357-2 can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HEPR performance levels specified in this document should be claimed.

[e] Report the results of the wet filterability test in accordance with ISO 13357-1:2017, 11.2. HEPR in this document requires only the result from ISO 13357-1 to be reported and does not specify pass or fail criteria for ISO 13357-1 filtration. A lubricating oil, therefore, is not required to exhibit ≥90 % wet filterability performance levels as specified in ISO 13357-1, to meet the requirements for HEPR in this document.

[f] TAN = total acid number.

6 Precision

Most of the test methods specified in Table 3 to Table 6 contain a precision statement. In cases of dispute, the procedure described in ISO 4259-2 shall apply, only if the conditions specified in ISO 4259-1, ISO 4259-3 and ISO 4259-4 are met.

Annex A
(informative)

Guidelines for changing fluids from mineral-based oils to environmentally acceptable fluids