INTERNATIONAL STANDARD

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Third edition
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Lubricants, industrial oils and related products (class L) — Family H (hydraulic systems) — Specifications for categories HH, HL, HM, HV and HG

Lubrifiants, huiles industrielles et produits connexes (classe L) — Famille H (systèmes hydrauliques) — Spécifications pour les catégories HH, HL, HM, HV et HG

Reference number
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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 third edition cancels and replaces the second edition (ISO 11158:2009), which has been technically revised.

The main changes are as follows:

— introduction of new anti-wear test VICKERS 35VQ25, hydrolytic stability and high temperature requirements.

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

Fluids for hydraulic systems are used in a wide variety of hydraulic pumps, motors and circuits.

Hydraulic fluids are selected depending upon the anti-wear requirements of the equipment and the operating temperature range (temperature at cold starting and running temperature in stabilized conditions) to ensure the optimum mechanical and volumetric yield of the circuit and to protect pumps and motors against wear.

Mineral hydraulic fluids are formulated with mineral base stocks, from either groups I, II or III and various additives to provide the necessary oxidation stability, wear, rust, corrosion and foaming protection properties. To improve the operating temperature range, viscosity modifier polymers are added.

Lubricants, industrial oils and related products (class L) — Family H (hydraulic systems) — Specifications for categories HH, HL, HM, HV and HG

1 Scope

This document specifies the minimum requirements for new mineral oil hydraulic fluids and is intended for hydraulic systems, particularly for hydrostatic hydraulic fluid power application. The purpose of this document is to guide suppliers and end users of mineral oil hydraulic fluids and to direct equipment manufacturers of hydraulic systems.

This document is written in a general form so that its application can accommodate various climatic conditions. This document also stipulates the requirements for mineral-oil hydraulic fluids at the time of delivery.

This document is intended to be used in conjunction with ISO 6743-4, which classifies fluids used in hydraulic applications. Among the categories covered by ISO 6743-4, only five types of mineral oil-based fluids are covered in this document. These categories are HH, HL, HM, HV and HG.

This document does not cover the extreme cases of use in terms of hydraulic circuits design, temperature and extreme conditions.

NOTE For use in exceptional conditions, suppliers and purchasers of lubricants can mutually agree upon additional testing methods and acceptability criteria of the products.

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 4259-2, *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 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 4406, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 5598, *Fluid power systems and components — Vocabulary*

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

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

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

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

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

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

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

ASTM D2070, *Standard Test Method for Thermal Stability of Hydraulic Oils*

ASTM D2619, *Standard Test Method for Hydrolytic Stability of Hydraulic Fluids (Beverage Bottle Method)*

ASTM D6203, *Standard Test Method for Thermal Stability of Way Lubricants*

ASTM D6973, *Standard Test Method for Indicating Wear Characteristics of Petroleum Hydraulic Fluids in a High Pressure Constant Volume Vane Pump*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598 apply.

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 oils for the purpose of this document, unless otherwise specified, shall be carried out in accordance with the pertinent procedure described in ISO 3170. The sample shall be evaluated on a representative portion. Any drum, barrel, tanker compartment or any type of container delivered to the end user may be sampled and analysed at the discretion of the purchaser.

5 Specifications

5.1 General

Most of the test methods used in the specifications in Tables A.1 to A.5 contain a precision statement. In cases of dispute, the procedure described in ISO 4259-2 shall apply.

5.2 Specifications for hydraulic oils, categories HH, HL, HM, HV and HG

5.2.1 General

For the purpose of this document, oils shall be refined petroleum oils. The classification of these hydraulic oils shall be in accordance with ISO 6743-4.

Oils, when tested under prescribed methods, shall be in accordance with limiting values set out in Tables A.1 to A.5.

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

5.2.2 Specifications of ISO-L-HH hydraulic oils

These oils are based upon mineral base oils of either groups I, II or III, or blends thereof. They do not normally contain any additive. These oils shall be in accordance with the detailed specifications given in Table A.1.

5.2.3 Specifications of ISO-L-HL hydraulic oils

These oils are based upon mineral base oils of either groups I, II or III, or blends thereof. These base oils are supplemented with anti-corrosion, anti-rust, anti-oxidants, pour point depressants and foam inhibitors. These oils shall be in accordance with the detailed specifications given in Table A.2.

5.2.4 Specifications of ISO-L-HM hydraulic oils

These oils are of ISO-L-HL type, with supplementary anti-wear/extreme pressure additives to provide the necessary wear protection properties for the hydraulic equipment. Numerous technologies of anti-wear additives are available, e.g. zinc di-thiophosphate, combinations of phosphorus and sulfur-based additives. Additionally, filterability is required to protect the most sensitive hydraulic circuits. These oils shall be in accordance with the detailed specifications given in Table A.3.

5.2.5 Specifications of ISO-L-HV hydraulic oils

These oils are of ISO-L-HM type, with supplementary viscosity modifiers to improve and enlarge their operating temperature range. These oils shall be in accordance with the detailed specifications given in Table A.4.

5.2.6 Specifications of ISO-L-HG hydraulic and slide-ways oils

These oils are of ISO-L-HM type, with friction modifiers to enable smooth motion on the slide-ways and to eliminate the stick-slip phenomenon. These oils shall be in accordance with the detailed specifications given in Table A.5.

Annex A
(normative)

Specification tables

Table A.1 — Specifications for category HH mineral oils hydraulic fluids

Mineral oils of category HH: non-inhibited mineral oils											
Property		**Test method**	**Unit**	**Requirements**							
Viscosity class		ISO 3448		VG 10	VG 15	VG 22	VG 32	VG 46	VG 68	VG 100	VG 150
Kinematic viscosity at −20 °C		ISO 3104	mm^2/s [a]	No requirement							
Kinematic viscosity at 0 °C		ISO 3104	mm^2/s [a]	No requirement							
Kinematic viscosity at 40 °C	min.	ISO 3104	mm^2/s [a]	9	13,5	19,8	28,8	41,4	61,2	90,0	135,0
	max.			11	16,5	24,2	35,2	50,6	74,8	110,0	165,0
Kinematic viscosity at 100 °C		ISO 3104	mm^2/s [a]	No requirement							
Viscosity index		ISO 2909		Report							
Colour [b]		ISO 2049		Report							
Cleanliness [c]		ISO 4406		Report							
Appearance				Bright and clear					Bright		
Density at 15 °C		ISO 12185 or ISO 3675	kg/m^3	Report							
Water content, max.		ISO 12937 or ISO 20764 or ISO 6296	mg/kg	250							
Acid number, max.		ISO 6619	mg KOH/g	0,1							
Pour point, max.		ISO 3016	°C	−15	−12	−9	−6				
Flash point (open cup), min.		ISO 2592	°C	125	140	165	175	185	195	205	215
Corrosiveness to copper 3 h, 100 °C, maximum class		ISO 2160		2							
Water separation		ISO 6614									
Test temperature 54 °C											
Time to reach ≤3 ml emulsion, max.			min	Report						-	
Test temperature 82 °C											
Time to reach ≤3 ml emulsion, max.			min	-						Report	

Key

IRHD international rubber hardness degrees

VG viscosity grade

[a] Square millimetres per second (mm^2/s) is equivalent to centistoke (cSt).

[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

Table A.1 *(continued)*

Mineral oils of category HH: non-inhibited mineral oils			
Property	**Test method**	**Unit**	**Requirements**
Elastomer compatibility [d]	ISO 1817		
SRE NBR28/PX, 100 °C, 168 h			
— Relative volume increase		%	Report
— Change in hardness		IRHD	Report

Key

IRHD international rubber hardness degrees

VG viscosity grade

[a] Square millimetres per second (mm^2/s) is equivalent to centistoke (cSt).

[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

Table A.2 — Specifications for category HL mineral oils hydraulic fluids

Mineral oils of category HL: oils of HH type with improved anti-rust and anti-oxidation properties											
Property		**Test method**	**Unit**	**Requirements**							
Viscosity class		ISO 3448		VG 10	VG 15	VG 22	VG 32	VG 46	VG 68	VG 100	VG 150
Kinematic viscosity at −20 °C, max.		ISO 3104	mm^2/s [a]	600	-	-	-	-	-	-	-
Kinematic viscosity at 0 °C, max.		ISO 3104	mm^2/s [a]	90	150	300	420	780	1 400	2 500	4 500
Kinematic viscosity at 40 °C	min.	ISO 3104	mm^2/s [a]	9	13,5	19,8	28,8	41,4	61,2	90,0	135,0
	max.			11	16,5	24,2	35,2	50,6	74,8	110,0	165,0
Kinematic viscosity at 100 °C, min.		ISO 3104	mm^2/s [a]	2,50	3,20	4,10	5,00	6,10	7,80	9,90	14,0
Viscosity index		ISO 2909		Report							
Colour [b]		ISO 2049		Report							
Cleanliness [c]		ISO 4406		At delivery stage – report							
Appearance				Bright and clear					Bright		
Density		ISO 12185 or ISO 3675	kg/m^3	Report							
Water content, max. [d]		ISO 12937 or ISO 20764 or ISO 6296	mg/kg	250							
Acid number		ISO 6619	mg KOH/g	Report							
Pour point, max.		ISO 3016	°C	−30	−27	−21	−18	−15	−12	−12	−12
Flash point, min.		ISO 2592	°C	125	140	165	175	185	195	205	215
Foaming Tendency/stability, max.		ISO 6247									

Key

IRHD international rubber hardness degrees

VG viscosity grade

[a] Square millimetres per second (mm^2/s) is equivalent to centistoke (cSt).

[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability), can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HL filterability level specified in ISO 11158 should be claimed.

Table A.2 *(continued)*

Mineral oils of category HL: oils of HH type with improved anti-rust and anti-oxidation properties						
Property	**Test method**	**Unit**	**Requirements**			
Sequence I at 24 °C		ml/ml	150/10			
Sequence II at 93 °C		ml/ml	80/10			
Sequence III at 24 °C after 93 °C		ml/ml	150/10			
Air release	ISO 9120					
— At 50 °C, max.		min	5	10	13	-
— At 75 °C		min	-	-	-	Report
Corrosiveness to copper 3 h, 100 °C, maximum class	ISO 2160	Rating	2			
Water separation [e]	ISO 6614					
Test temperature 54 °C						
Time to reach ≤3 ml emulsion, max.		min	30			-
Test temperature 82 °C						
Time to reach ≤3 ml emulsion, max.		min	-			30
Rust test (24 hours)	ISO 7120					
— Procedure A			Pass	Pass		
— Procedure B			Report	Pass		
Oxidation stability	ISO 4263-1					
— Acid number increase after 1 000 h, max.		mg KOH/g	2,0			
— Insoluble sludge		mg	Report			
— Total copper content		mg/kg	Report			

Key

IRHD international rubber hardness degrees

VG viscosity grade

[a] Square millimetres per second (mm^2/s) is equivalent to centistoke (cSt).

[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability), can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HL filterability level specified in ISO 11158 should be claimed.

Table A.2 *(continued)*

Mineral oils of category HL: oils of HH type with improved anti-rust and anti-oxidation properties										
Property	**Test method**	**Unit**	**Requirements**							
— Total iron content		mg/kg	Report							
Thermal stability (168 h at 135 °C)	ASTM D2070									
— Sludge		mg/100 ml	Report							
Hydrolytic stability	ASTM D2619									
— Copper mass loss		mg/cm^2	Report							
— Acidity of water layer		mg KOH	Report							
Elastomer compatibility [f]	ISO 1817									
SRE NBR28/PX, 100 °C, 168 h										
— Relative volume increase		%	0 to 18	0 to 15	0 to 15	0 to 12	0 to 12	0 to 10	0 to 10	0 to 10
— Change in hardness		IRHD	0 to −10	0 to −8	0 to −8	0 to −7	0 to −7	0 to −6	0 to −6	0 to −6
Filterability – dry [g]	ISO 13357-2									
— Stage I, min.		%	80							-
— Stage II, min.		%	60							-
Filterability – wet [g]	ISO 13357-1									
— Stage I, min.		%	70							-
— Stage II, min.		%	50							-

Key

IRHD international rubber hardness degrees

VG viscosity grade

[a] Square millimetres per second (mm^2/s) is equivalent to centistoke (cSt).

[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability), can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HL filterability level specified in ISO 11158 should be claimed.

Table A.3 — Specifications for category HM mineral oils hydraulic fluids

Mineral oils of category HM: oils of HL type with improved anti-wear and filterability properties											
Property		**Test method**	**Unit**	**Requirements**							
Viscosity class		ISO 3448		VG 10	VG 15	VG 22	VG 32	VG 46	VG 68	VG 100	VG 150
Kinematic viscosity at –20 °C, max.		ISO 3104	mm^2/s [a]	600	-	-	-	-	-	-	-
Kinematic viscosity at 0 °C, max.		ISO 3104	mm^2/s [a]	90	150	300	420	780	1 400	2 500	4 500
Kinematic viscosity at 40 °C	min.	ISO 3104	mm^2/s [a]	9	13,5	19,8	28,8	41,4	61,2	90,0	135,0
	max.			11	16,5	24,2	35,2	50,6	74,8	110,0	165,0
Kinematic viscosity at 100 °C, min.		ISO 3104	mm^2/s [a]	2,50	3,20	4,10	5,00	6,10	7,80	9,90	14,0
Viscosity index		ISO 2909		Report							
Colour [b]		ISO 2049		Report							
Cleanliness [c]		ISO 4406		At delivery stage – report							
Appearance				Bright and clear					Bright		
Density		ISO 12185 or ISO 3675	kg/m^3	Report							
Water content, max. [d]		ISO 12937 or ISO 20764 or ISO 6296	mg/kg	250							
Acid number		ISO 6619	mg KOH/g	Report							
Pour point, max.		ISO 3016	°C	–30	–27	–21	–18	–15	–12	–12	–12
Flash point, min.		ISO 2592	°C	125	140	165	175	185	195	205	215
Foaming Tendency/stability, max.		ISO 6247									

Key

IRHD international rubber hardness degrees

VG viscosity grade

[a] Square millimetres per second (mm^2/s) is equivalent to centistoke (cSt).

[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Vane pump performance shall be proven by using either the V104 test specified in ISO 20763 or the 35VQ25 test specified in ASTM D6973.

[h] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability) can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HM filterability level specified in ISO 11158 should be claimed.

Table A.3 *(continued)*

Mineral oils of category HM: oils of HL type with improved anti-wear and filterability properties						
Property	**Test method**	**Unit**	**Requirements**			
Sequence I at 24 °C		ml/ml	150/10			
Sequence II at 93 °C		ml/ml	80/10			
Sequence III at 24 °C after 93 °C		ml/ml	150/10			
Air release	ISO 9120					
— At 50 °C, max.		min	5	10	13	-
— At 75 °C		min	-	-	-	Report
Corrosiveness to copper 3 h, 100 °C, maximum class	ISO 2160		2			
Water separation [e]	ISO 6614					
Test temperature 54 °C						
Time to reach ≤3 ml emulsion, max.		min	30			-
Test temperature 82 °C						
Time to reach ≤3 ml emulsion, max.		min	-			30
Rust test (24 hours)	ISO 7120					
— Procedure A			Pass	Pass		
— Procedure B			Report	Pass		
Oxidation stability	ISO 4263-1					
— Acid number increase after 1 000 h, max.		mg KOH/g	2,0			
— Insoluble sludge		mg	Report			

Key

IRHD international rubber hardness degrees

VG viscosity grade

[a] Square millimetres per second (mm^2/s) is equivalent to centistoke (cSt).

[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Vane pump performance shall be proven by using either the V104 test specified in ISO 20763 or the 35VQ25 test specified in ASTM D6973.

[h] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability) can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HM filterability level specified in ISO 11158 should be claimed.

Table A.3 *(continued)*

Mineral oils of category HM: oils of HL type with improved anti-wear and filterability properties										
Property	**Test method**	**Unit**	**Requirements**							
— Total copper content		mg/kg	Report							
— Total iron content		mg/kg	Report							
Thermal stability (168 h at 135 °C)	ASTM D2070									
— Sludge		mg/100 ml	Report							
Hydrolytic stability	ASTM D2619									
— Copper mass loss		mg/cm^2	Report							
— Acidity of water layer		mg KOH	Report							
Elastomer compatibility [f]	ISO 1817									
SRE NBR28/PX, 100 °C, 168 h										
— Relative volume increase		%	0 to 18	0 to 15	0 to 15	0 to 12	0 to 12	0 to 10	0 to 10	0 to 10
— Change in hardness		IRHD	0 to −10	0 to −8	0 to −8	0 to −7	0 to −7	0 to −6	0 to −6	0 to −6
Wear protection – gears	ISO 14635-1									
FZG test A/8,3/90			-	-	-	Failure load stage ≥10				
Protection against wear [g]	ISO 20763									
— Vanes mass loss, max.		mg	-	-	-	30			-	-
— Cam ring mass loss, max.		mg	-	-	-	120			-	-
Protection against wear [g]	ASTM D6973									
— Vanes mass loss, max.		mg	-	-	-	15	-			
— Cam ring mass loss, max.		mg	-	-	-	75	-			
Filterability – dry [h]	ISO 13357-2									

Key

IRHD international rubber hardness degrees

VG viscosity grade

[a] Square millimetres per second (mm^2/s) is equivalent to centistoke (cSt).

[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Vane pump performance shall be proven by using either the V104 test specified in ISO 20763 or the 35VQ25 test specified in ASTM D6973.

[h] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability) can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HM filterability level specified in ISO 11158 should be claimed.

Table A.3 *(continued)*

Mineral oils of category HM: oils of HL type with improved anti-wear and filterability properties				
Property	**Test method**	**Unit**	**Requirements**	
— Stage I, min.		%	80	-
— Stage II, min.		%	60	-
Filterability – wet [h]	ISO 13357-1			
— Stage I, min.		%	70	-
— Stage II, min.		%	50	-

Key

IRHD international rubber hardness degrees

VG viscosity grade

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[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Vane pump performance shall be proven by using either the V104 test specified in ISO 20763 or the 35VQ25 test specified in ASTM D6973.

[h] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability) can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HM filterability level specified in ISO 11158 should be claimed.

Table A.4 — Specifications for category HV mineral oils hydraulic fluids

Mineral oils of category HV: oils of HM type with improved viscosity/temperature properties											
Property		**Test method**	**Unit**	**Requirements**							
Viscosity class		ISO 3448		VG 10	VG 15	VG 22	VG 32	VG 46	VG 68	VG 100	VG 150
Kinematic viscosity at –20 °C		ISO 3104	mm^2/s [a]	Report							
Kinematic viscosity at 0 °C		ISO 3104	mm^2/s [a]	Report							
Kinematic viscosity at 40 °C	min.	ISO 3104	mm^2/s [a]	9	13,5	19,8	28,8	41,4	61,2	90,0	135,0
	max.			11	16,5	24,2	35,2	50,6	74,8	110,0	165,0
Kinematic viscosity at 100 °C		ISO 3104	mm^2/s [a]	Report							
Viscosity index, min.		ISO 2909		140	140	140	140	140	140	140	120
Colour [b]		ISO 2049		Report							
Cleanliness [c]		ISO 4406		At delivery stage – report							
Appearance				Bright and clear					Bright		
Density		ISO 12185 or ISO 3675	kg/m^3	Report							
Water content, max. [d]		ISO 12937 or ISO 20764 or ISO 6296	mg/kg	250							
Acid number		ISO 6619	mg KOH/g	Report							
Pour point, max.		ISO 3016	°C	–39	–39	–39	–30	–27	–24	–21	–18
Flash point, min.		ISO 2592	°C	125	140	165	175	185	195	205	215
Foaming Tendency/stability, max.		ISO 6247									

Key

IRHD international rubber hardness degrees

VG viscosity grade

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[b] For the purpose of identification, dye may be used by agreement between the supplier and the end user.

[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Vane pump performance shall be proven by using either the V104 test specified in ISO 20763 or the 35VQ25 test specified in ASTM D6973.

[h] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability) can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HV filterability level specified in ISO 11158 should be claimed.

Table A.4 *(continued)*

Mineral oils of category HV: oils of HM type with improved viscosity/temperature properties							
Property	**Test method**	**Unit**	**Requirements**				
Sequence I at 24 °C		ml/ml	150/10				
Sequence II at 93 °C		ml/ml	80/10				
Sequence III at 24 °C after 93 °C		ml/ml	150/10				
Air release	ISO 9120						
— At 50 °C, max.		min	5	10	13	-	
— At 75 °C		min	-	-	-	Report	
Corrosiveness to copper 3 h, 100 °C, maximum class	ISO 2160		2				
Water separation [e]	ISO 6614						
Test temperature 54 °C							
Time to reach ≤3 ml emulsion, max.		min	30			-	-
Test temperature 82 °C							
Time to reach ≤3 ml emulsion, max.		min	-			30	30
Rust test (24 hours)	ISO 7120						
— Procedure A			Pass	Pass			
— Procedure B			Report	Pass			
Oxidation stability	ISO 4263-1						
— Acid number increase after 1 000 h, max.		mg KOH/g	2,0				
— Insoluble sludge		mg	Report				

Key

IRHD international rubber hardness degrees

VG viscosity grade

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[c] The requirements of the cleanliness of the hydraulic fluid is system dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end user. It should be noted that the fluid is exposed to various influences during transport and storage – the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

[d] For detergent hydraulic oils, the limit is increased up to 500 mg/kg.

[e] This property does not apply to fluid containing high detergent additive content (detergent hydraulic oil).

[f] The standard reference elastomer shall be in accordance with ISO 13226. Elastomers in addition to SRE-NBR 28/PX (e.g. FPM, EPDM, AU) may be agreed between the end user and the suppliers.

[g] Vane pump performance shall be proven by using either the V104 test specified in ISO 20763 or the 35VQ25 test specified in ASTM D6973.

[h] Oils that do not meet the requirements specified in ISO 13357-2 (for dry filterability) and/or ISO 13357-1 (for wet filterability) can perform satisfactorily in less critical hydraulic systems. However, no reference to meeting the relevant HV filterability level specified in ISO 11158 should be claimed.