Designation: D6158 – 16

Standard Specification for Mineral Hydraulic Oils[1]

This standard is issued under the fixed designation D6158; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers mineral and synthetic oils of the types API groups I, II, III, and IV used in hydraulic systems, where the performance requirements demand fluids with one of the following characteristics:

1.1.1 A refined base oil or synthetic base stock (Class HH),

1.1.2 A refined mineral base oil or synthetic base stock with rust and oxidation inhibitors (Class HL),

1.1.3 A refined mineral base oil or synthetic base stock with rust and oxidation inhibitors plus anti-wear characteristics (Class HM),

1.1.4 A refined mineral base oil or synthetic base stock with rust and oxidation inhibitors, anti-wear characteristics, and increased viscosity index higher than 140 (Class HV),

1.1.5 A refined mineral base oil or synthetic base stock with rust and oxidation inhibitors plus anti-wear characteristics meeting a higher performance level than an HM fluid to address higher demanding hydraulic systems (Class HMHP), and

1.1.6 A refined mineral base oil with rust or synthetic base stock and oxidation inhibitors, anti-wear characteristics, and increased viscosity index higher than 140 meeting a higher performance level than an HV fluid to address higher demanding hydraulic systems (Class HVHP).

1.2 This specification defines the requirements of mineral oil-based or synthetic-based hydraulic fluids that are compatible with most existing machinery components when there is adequate maintenance.

1.3 This specification defines only new lubricating oils before they are installed in the hydraulic system.

1.4 This specification defines specific types of hydraulic oils. It does not include all hydraulic oils. Some oils that are not included may be satisfactory for certain hydraulic applications. Certain equipment or conditions of use may permit or require a wider or narrower range of characteristics than those described herein.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5.1 *Exception*—In X1.3.9 on Wear Protection, the values of pump pressure are in MPa, and the psi follows in brackets as a reference point immediately recognized by a large part of the industry.

1.6 The following safety hazard caveat pertains to the test methods referenced in this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitation prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester

D97 Test Method for Pour Point of Petroleum Products

D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D471 Test Method for Rubber Property—Effect of Liquids

D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration

D665 Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water

D892 Test Method for Foaming Characteristics of Lubricating Oils

D943 Test Method for Oxidation Characteristics of Inhibited Mineral Oils

D974 Test Method for Acid and Base Number by Color-Indicator Titration

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.N0 on Hydraulic Fluids.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

D1401 Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
D2070 Test Method for Thermal Stability of Hydraulic Oils
D2270 Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 and 100°C
D2422 Classification of Industrial Fluid Lubricants by Viscosity System
D2619 Test Method for Hydrolytic Stability of Hydraulic Fluids (Beverage Bottle Method)
D2983 Test Method for Low-Temperature Viscosity of Lubricants Measured by Brookfield Viscometer
D3427 Test Method for Air Release Properties of Hydrocarbon Based Oils
D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D4310 Test Method for Determination of Sludging and Corrosion Tendencies of Inhibited Mineral Oils
D5182 Test Method for Evaluating the Scuffing Load Capacity of Oils (FZG Visual Method)
D5950 Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)
D6080 Practice for Defining the Viscosity Characteristics of Hydraulic Fluids
D6973 Test Method for Indicating Wear Characteristics of Petroleum Hydraulic Fluids in a High Pressure Constant Volume Vane Pump
D7043 Test Method for Indicating Wear Characteristics of Non-Petroleum and Petroleum Hydraulic Fluids in a Constant Volume Vane Pump
D7752 Practice for Evaluating Compatibility of Mixtures of Hydraulic Fluids

2.2 *Other Standards:*
ISO 13357-1 Petroleum Products—Determination of the Filterability of Lubricating Oils—Part 1: Procedure for Oils in the Presence of Water[3]
ISO 13357-2 Petroleum Products—Determination of the Filterability of Lubricating oils—Part 2: Procedure for Dry Oils[3]
DIN 51350-6 Testing of Shear Stability of Lubricating Oils Containing Polymers[4]
CEC L-45-A-99 Viscosity Shear Stability of Transmission Lubricants (KRL Taper Roller Bearing Rig)[5]

3. Classification

3.1 *Type HH Hydraulic Oils*—Non-inhibited refined mineral oils or synthetic base stock for hydraulic systems that do not have specific requirements of oxidation stability, rust protection, or anti-wear properties. Type HH oils are usually intended for total loss systems or very light-duty equipment.

3.2 *Type HL Hydraulic Oils*—Refined mineral oils or synthetic base stock with improved rust protection and oxidation stability for hydraulic systems where relatively high temperatures and long periods of operation time are expected, and where there is the possibility of water or humidity that could rust metal parts of the machinery. These oils are intended for use in systems where no metal-to-metal contact is expected between the moving parts. Usually, systems working at low pressures specify HL oils. Some high-pressure piston pumps can operate satisfactorily on these oils.

3.3 *Type HM Hydraulic Oils*—Oils of HL type with improved anti-wear properties, for general hydraulic systems, especially for those working at high pressures and where the possibility of metal-to-metal contact between the moving parts exists. Type HM oils are usually specified for hydraulic systems with vane pumps, or when the system is intended to work at maximum pump capacity for long periods of time.

3.4 *Type HV Hydraulic Oils*—Oils of HM type with improved viscosity/temperature properties, for general hydraulic systems where equipment is intended to operate over a wide range of ambient temperatures.

3.5 *Type HMHP Hydraulic Oils*—Oils of HM meeting a higher performance level to meet the changing needs of hydraulic systems, especially for those working at high pressures and temperatures intended to work at maximum pump capacity for long periods of time.

3.6 *Type HVHP Hydraulic Oils*—Oils of HMHP type with improved viscosity/temperature properties, for more demanding hydraulic systems where equipment is intended to operate over a wide range of ambient temperatures.

4. Classification Requirements

4.1 *Type HH*—The requirements for this type of oil are presented in Table 1 and include Viscosity Grades ISO VG from 10 to 150, in accordance with Classification D2422.

4.2 *Type HL*—The requirements for this type of oil are presented in Table 2 and include Viscosity Grades ISO VG from 10 to 150, in accordance with Classification D2422.

4.3 *Type HM*—The requirements for this type of oil are presented in Table 3 and include Viscosity Grades ISO VG from 10 to 150, in accordance with Classification D2422.

4.4 *Type HV*—The requirements for this type of oil are presented in Table 4 and include Viscosity Grades ISO VG from 10 to 150, in accordance with Classification D2422.

4.5 *Type HMHP*—The requirements for this type of oil are presented in Table 5 and include Viscosity Grades ISO VG from 22 to 150 in accordance with Classification D2422.

4.6 *Type HVHP*—The requirements for this type of oil are presented in Table 6 and include Viscosity Grades ISO VG from 22 to 150 in accordance with Classification D2422.

5. Inspection

5.1 Inspection of the material shall be agreed upon between the purchaser and the supplier.

6. Packaging and Package Marking

6.1 The material shall be suitably packaged to permit acceptance by the carrier and to afford adequate protection

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[4] Available from Deutsches Institut für Normung e.V.(DIN), Am DIN-Platz, Burggrafenstrasse 6, 10787 Berlin, Germany, http://www.din.de.
[5] Available from Coordinating European Council (CEC), Services provided by Kellen Europe, Avenue Jules Bordet 142 - 1140, Brussels, Belgium, http://www.cectests.org.

TABLE 1 Requirements for Type HH Mineral Oil or Synthetic Base Stock Hydraulic Fluids

Properties	Test Method ASTM (Other)	Parameters	Limits							
Physical:										
ISO-viscosity grade	D2422		10	15	22	32	46	68	100	150
Viscosity	D445	kinematic viscosity at 40 °C, mm^2/s	9.0–11.0	13.5–16.5	19.8–24.2	28.8–35.2	41.4–50.6	61.2–74.8	90.0–110	135–165
Viscosity, ≤750 mPa·s	D2983	temperature, °C	report	report	report	report	report	report	report	report
Viscosity index	D2270		report	report	report	report	report	report	report	report
Specific gravity	D1298[A]		report	report	report	report	report	report	report	report
Appearance	Visual		clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright
Flash point	D92	temperature, °C, min	125	145	165	175	185	195	205	215
Pour point	D97[B]	temperature, °C, max	–15	–12	–9	–6	–6	–6	–6	–6
Chemical:										
Acid number	D974/D664	KOH, mg/g, max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Performance:										
Elastomer compatibility	D471	100 °C ± 1 °C/288 h ± 2 h NBR-1 Elastomer								
		relative volume change, percent	report	report	0 to 15	0 to 12	0 to 12	0 to 10	0 to 10	0 to 10
		change in Shore A hardness, rating	report	report	0 to –8	0 to –7	0 to –7	0 to –6	0 to –6	0 to –6

[A] Test Method D4052 can also be used.
[B] Test Method D5950 can also be used.

TABLE 2 Requirements for Type HL Mineral Oil or Synthetic Base Stock Hydraulic Fluids (Rust and Oxidation)

Properties	Test Method ASTM (Other)	Parameters	Limits							
Physical:										
ISO-viscosity grade	D2422		10	15	22	32	46	68	100	150
Viscosity	D445	kinematic viscosity at 40 °C, mm^2/s	9.0–11.0	13.5–16.5	19.8–24.2	28.8–35.2	41.4–50.6	61.2–74.8	90.0–110	135–165
Viscosity, ≤750 mPa·s	D2983	temperature, °C, max	–33	–23	–15	–8	–2	4	10	16
Viscosity index	D2270	min	90	90	90	90	90	90	90	90
Specific gravity	D1298[A]		report	report	report	report	report	report	report	report
Appearance	visual, at 20 °C		clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright
Flash point	D92	temperature, °C, min	125	145	165	175	185	195	205	215
Pour point	D97[B]	temperature, °C, max	–33	–24	–21	–18	–15	–12	–12	–12
Chemical:										
Acid Number	D974/D664	KOH, mg/g	report	report	report	report	report	report	report	report
Performance:										
Rust prevention	D665A[C]	visual evaluation pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
	D665B[C]	visual evaluation pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
Corrosion	D130	copper corrosion, 3 h at 100 °C, visual, max	2	2	2	2	2	2	2	2
Water separation	D1401	time (mins) to 3 mL emulsion at 54 °C, max	30	30	30	30	30	30	...	...
		time (mins) to 3 mL emulsion at 82 °C, max	...	...	...	...	...	...	60	60
Elastomer compatibility	D471	100 °C ± 1 °C/288 h ± 2 h NBR-1 Elastomer								
		relative volume change, percent	report	report	0 to 15	0 to 12	0 to 12	0 to 10	0 to 10	0 to 10
		change in Shore A hardness, rating	report	report	0 to –8	0 to –7	0 to –7	0 to –6	0 to –6	0 to –6
Foam	D892	Sequence I, tendency/stability, mL, max	150/0	150/0	150/0	150/0	150/0	150/0	150/0	150/0
		Sequence II, tendency/stability, mL, max	75/0	75/0	75/0	75/0	75/0	75/0	75/0	75/0
		Sequence III, tendency/stability, mL, max	150/0	150/0	150/0	150/0	150/0	150/0	150/0	150/0
Air release	D3427	time, mins. at 50 °C, max	5	5	5	5	10	10	...	...
		time, mins. at 75 °C	...	...	...	...	...	...	report	report
Oxidation stability	D943	time for KOH acid number of 2 mg/kg, h, min	1000	1000	1000	1000	1000	1000	1000	1000
Sludge tendency	D4310	total insoluble sludge, mg, max	200	200	200	200	200	200	200	200
		copper in oil/water/sludge, mg	report	report	report	report	report	report	report	report
Thermal stability	D2070	copper appearance, visual max	report	report	report	5	5	5	report	report
		steel appearance, visual max	report	report	report	2	2	2	report	report
		sludge, mg/100 mL, max	report	report	report	25	25	25	report	report

[A] Test Method D4052 can also be used.
[B] Test Method D5950 can also be used.
[C] Test Method D665—soak time is 24 h.

TABLE 3 Requirements for Type HM Mineral Oil or Synthetic Base Stock Hydraulic Fluids (Anti-wear)

Properties	Test Method ASTM (Other)	Parameters	Limits							
Physical:										
ISO-viscosity grade	D2422		10	15	22	32	46	68	100	150
Viscosity	D445	kinematic viscosity at 40 °C, mm^2/s	9.0–11.0	13.5–16.5	19.8–24.2	28.8–35.2	41.4–50.6	61.2–74.8	90.0–110	135–165
Viscosity ≤750 mPa·s	D2983	temperature, °C, max	–33	–23	–15	(–8)	–2	4	10	16
Viscosity index	D2270	min	90	90	90	90	90	90	90	90
Specific gravity	D1298[A]		report	report	report	report	report	report	report	report
Appearance	Visual, at 20 °C		clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright
Flash point	D92	temperature, °C, min	125	145	165	175	185	195	205	215
Pour point	D97[B]	temperature, °C, max	–33	–24	–21	–18	–15	–12	–12	–12
Chemical:										
Acid number	D974/D664	KOH, mg/g	report	report	report	report	report	report	report	report
Performance:										
Rust prevention	D665A[C]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
	D665B[C]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
Corrosion	D130	copper corrosion, 3 h at 100 °C, visual, max	2	2	2	2	2	2	2	2
Water separability	D1401	time (mins) to 3 mL emulsion max at 54 °C	30	30	30	30	30	30	...	...
		time (mins) to 3 mL emulsion max at 82 °C	...	...	...	...	...	...	60	60
Elastomer compatibility	D471	100 °C ± 1 °C/288 h ± 2 h NBR-1 Elastomer								
		relative volume change, percent	report	report	0 to 15	0 to 12	0 to 12	0 to 10	0 to 10	0 to 10
		change in Shore A hardness, rating	report	report	0 to –8	0 to –7	0 to –7	0 to –6	0 to –6	0 to –6
Foam	D892	Sequence I tendency/stability mL max	150/0	150/0	150/0	150/0	150/0	150/0	150/0	150/0
		Sequence II tendency/stability mL max	75/0	75/0	75/0	75/0	75/0	75/0	75/0	75/0
		Sequence III tendency/stability mL max	150/0	150/0	150/0	150/0	150/0	150/0	150/0	150/0
Air release	D3427	time (mins) at 50 °C, max	5	5	5	5	10	13	...	...
		time (mins) at 75 °C	...	...	...	...	...	...	report	report
Oxidation stability	D943	time for KOH acid number of 2 mg/kg, h, min	1000	1000	1000	1000	1000	1000	1000	1000
Sludge tendency	D4310	total insoluble sludge, mg, max	200	200	200	200	200	200	200	200
		copper oil/water/sludge, mg	report	report	report	report	report	report	report	report
Thermal stability	D2070	copper appearance, visual	report	report	report	5	5	5	report	report
		steel appearance, visual	report	report	report	2	2	2	report	report
		sludge, mg/100 mL	report	report	report	25	25	25	report	report
Wear protection	D7043	mass loss vanes + ring, mg, max at 65.6 °C/100 h	...	...	report	report	report	...	...	...
		mass loss vanes + ring, mg, max at 79.4 °C/100 h	...	...	...	...	...	report	report	report

[A] Test Method D4052 can also be used.
[B] Test Method D5950 can also be used.
[C] Test Method D665—soak time is 24 h.

TABLE 4 Requirements for Type HV Mineral Oil or Synthetic Base Stock Hydraulic Fluids (Multigrade Anti-wear)

Properties	Test Method ASTM (Other)	Parameters	Limits							
Physical:										
ISO-viscosity grade	D2422		10	15	22	32	46	68	100	150
Viscosity of fresh oil	D445	kinematic viscosity at 40 °C, mm^2/s	9.0–11.0	13.5–16.5	19.8–24.2	28.8–35.2	41.4–50.6	61.2–74.8	90.0–110	135–165
Viscosity ≤750 mPa·s	D2983	temperature, °C, max	–33	–23	–15	–8	–2	4	10	16
Low temperature viscosity grade	D6080		report	report	report	report	report	report	report	report
Viscosity index of fresh oil	D2270	min	140	140	140	140	140	140	140	140
Viscosity after shear	D6080	kinematic viscosity at 40 °C, mm^2/s	report	report	report	report	report	report	report	report
Viscosity index after shear	D6080		report	report	report	report	report	report	report	report
Specific gravity	D1298[A]		report	report	report	report	report	report	report	report
Appearance	Visual, at 20 °C		clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright
Flash point	D92	temperature, °C, min	125	145	165	175	185	195	205	215
Pour point	D97[B]	temperature, °C, max	–33	–24	–21	–18	–15	–12	–12	–12
Chemical:										
Acid number	D974/D664	KOH, mg/g	report	report	report	report	report	report	report	report
Performance:										
Rust prevention	D665A[C]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
	D665B[C]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
Corrosion	D130	copper corrosion, 3 h at 100 °C, visual, max	2	2	2	2	2	2	2	2
Water separability	D1401	time (mins) to 3 mL emulsion max at 54 °C	30	30	30	30	30	30	...	...
		time (mins) to 3 mL emulsion max at 82 °C	...	...	...	...	...	...	60	60
Elastomer compatibility	D471	100 °C ± 1 °C/288 h ± 2 h NBR-1 Elastomer								
		relative volume change, percent	report	report	0 to 15	0 to 12	0 to 12	0 to 10	0 to 10	0 to 10
		change in Shore A hardness, rating	report	report	0 to –8	0 to –7	0 to –7	0 to –6	0 to –6	0 to –6
Foam	D892	Sequence I tendency/stability mL max	150/0	150/0	150/0	150/0	150/0	150/0	150/0	150/0
		Sequence II tendency/stability mL max	75/0	75/0	75/0	75/0	75/0	75/0	75/0	75/0
		Sequence III tendency/stability mL max	150/0	150/0	150/0	150/0	150/0	150/0	150/0	150/0
Air release	D3427	time (mins) at 50 °C, max	5	5	5	5	10	13	...	...
		time (mins) at 75 °C	...	...	...	...	...	...	report	report
Oxidation stability	D943	time for KOH acid number of 2 mg/kg, h, min	1000	1000	1000	1000	1000	1000	1000	1000
Sludge tendency	D4310	total insoluble sludge, mg, max	200	200	200	200	200	200	200	200
		copper oil/water/sludge, mg	report	report	report	report	report	report	report	report
Thermal stability	D2070	copper appearance, visual	report	report	report	5	5	5	report	report
		steel appearance, visual	report	report	report	2	2	2	report	report
		sludge, mg/100 mL	report	report	report	25	25	25	report	report

TABLE 4 *Continued*

Properties	Test Method ASTM (Other)	Parameters	Limits							
Wear protection	D7043	mass loss vanes + ring, mg, max at 65.6 °C ⁄ 100 h	...	...	report	report	report	...	...	...
		mass loss vanes + ring, mg, max at 79.4 °C ⁄ 100 h	...	...	...	...	...	report	report	report

[A] Test Method D4052 can also be used.
[B] Test Method D5950 can also be used.
[C] Test Method D665—soak time is 24 h.

TABLE 5 Requirements for Type HMHP Mineral Oil or Synthetic Base Stock Hydraulic Fluids (Anti-wear/High Performance)

Properties	Test Method ASTM (Other)	Parameters	Limits					
Physical:								
ISO-viscosity grade	D2422		22	32	46	68	100	150
Viscosity	D445	kinematic viscosity at 40 °C, mm^2/s	19.8–24.2	28.8–35.2	41.4–50.6	61.2–74.8	90.0–110	135–165
Viscosity ≤750 mPa·s	D2983[A]	temperature, °C, max	–15	–8	–2	4	10	16
Viscosity index	D2270	min	90	90	90	90	90	90
Specific gravity	D1298[B]		report	report	report	report	report	report
Appearance	Visual, at 20 °C		clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright
Flash point	D92	temperature, °C, min	165	175	185	195	205	215
Pour point	D97[C]	temperature, °C, max	–21	–18	–15	–12	–12	–12
Chemical:								
Acid number	D974/D664	KOH, mg/g	report	report	report	report	report	report
Performance:								
Rust prevention	D665A[D]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass
	D665B[D]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass
Corrosion	D130	copper corrosion, 3 h at 100 °C, visual, max	2	2	2	2	2	2
Hydrolytic Stability	D2619	copper corrosion D130 rating	2	2	2	2	2	2
		copper mass loss mg/cm^2 max	0.4	0.4	0.4	0.4	0.4	0.4
		acidity of water layer, KOH mg/g	4.0	4.0	4.0	4.0	4.0	4.0
Water separability	D1401	time (mins) to 3 mL emulsion max at 54 °C	30	30	30	30	...	...
		time (mins) to 3 mL emulsion max at 82 °C	...	...	...	...	30	30
Elastomer compatibility	D471	100 °C ± 1 °C/288 h ± 2 h						
		NBR-1 Elastomer						
		relative volume change, percent	0 to 15	0 to 12	0 to 12	0 to 10	0 to 10	0 to 10
		change in Shore A hardness, rating	0 to –8	0 to –7	0 to –7	0 to –6	0 to –6	0 to –6
Foam	D892	Sequence I tendency/stability mL max	75/0	75/0	75/0	75/0	75/0	75/0
		Sequence II tendency/stability mL max	50/0	50/0	50/0	50/0	50/0	50/0
		Sequence III tendency/stability mL max	75/0	75/0	75/0	75/0	75/0	75/0
Air release	D3427	time (mins) at 50 °C, max	5	5	7	10	...	...
		time (mins) at 75 °C	...	...	...	...	report	report
Oxidation stability	D943	time for KOH acid number of 2 mg/kg, h, min	2500	2500	2500	2500	2500	2500
Sludge tendency	D4310	Acid number KOH mg/g, 1000 h, max	2.0	2.0	2.0	2.0	2.0	2.0
		total insoluble sludge, mg, max	150	150	150	150	150	150
		copper oil/water/sludge, mg	200	200	200	200	200	200
Thermal stability	D2070	copper appearance, visual	report	5	5	5	report	report

TABLE 5 *Continued*

Properties	Test Method ASTM (Other)	Parameters	Limits					
		steel appearance, visual	report	2	2	2	report	report
		sludge, mg/100 mL	report	25	25	25	report	report
Wear protection	D6973	mass loss vanes + ring, mg, max at 93 °C/50 h	See note[E]	90	See note[E]	See note[E]	See note[E]	See note[E]
Wear protection	D5182	Fail load stage	10	10	11	11	11	11
Filterability	ISO 13557–1(wet)							
	Phase I		70	70	70	70	report	report
	Phase II		50	50	50	50	report	report
	ISO 13557–2 (dry)							
	Phase I		80	80	80	80	report	report
	Phase II		60	60	60	60	report	report

[A] Precision of Test Method D2983 is being improved by Subcommittee D02.07.C0, but the test method is applicable.
[B] Test Method D4052 can also be used.
[C] Test Method D5950 can also be used.
[D] Test Method D665—soak time is 24 h.
[E] These values can be read across from the ISO 32 testing report. ISO VG 22 best practices would be to run the pump test to verify results. Best practice is to run multiple cartridges to establish results.

TABLE 6 Requirements for Type HVHP Mineral Oil or Synthetic Base Stock Hydraulic Fluids (Multigrade Anti-wear/High Performance)

Properties	Test Method ASTM (Other)	Parameters	Limits					
Physical:								
ISO-viscosity grade	D2422		22	32	46	68	100	150
Viscosity of fresh oil	D445	kinematic viscosity at 40 °C, mm^2/s	19.8–24.2	28.8–35.2	41.4–50.6	61.2–74.8	90.0–110	135–165
Viscosity ≤750 mPa·s	D2983[A]	temperature, °C, max	–15	–8	–2	4	10	16
Viscosity index of fresh oil	D2270	min	140	140	140	140	140	140
Viscosity after shear	CEC L-45-A-99	kinematic viscosity at 40 °C, mm^2/s	report[B]	report[B]	report[B]	report[B]	report[B]	report[B]
Viscosity after shear	CEC L-45-A-99	kinematic viscosity at 100 °C, mm^2/s	≥4.2[B]	≥5.2[B]	≥6.5[B]	≥8.3[B]	≥10.7[B]	≥14.1[B]
Viscosity index after shear	D2270		report	report	report	report	report	report
Specific gravity	D1298[C]		report	report	report	report	report	report
Appearance	Visual, at 20 °C		clear and bright	clear and bright	clear and bright	clear and bright	clear and bright	clear and bright
Flash point	D92	temperature, °C, min	165	175	185	195	205	215
Pour point	D97[D]	temperature, °C, max	–21	–18	–15	–12	–12	–12
Chemical:								
Acid number	D974/D664	KOH, mg/g	report	report	report	report	report	report
Performance:								
Rust prevention	D665A[E]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass
	D665B[E]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass
Corrosion	D130	copper corrosion, 3 h at 100 °C, visual, max	2	2	2	2	2	2
Hydrolytic Stability	D2619	copper corrosion D130 rating, max	2	2	2	2	2	2
		copper mass loss mg/cm^2, max	0.4	0.4	0.4	0.4	0.4	0.4
		acidity of water layer, KOH mg/g	4.0	4.0	4.0	4.0	4.0	4.0
Water separability	D1401	time (mins) to 3 mL emulsion max at 54 °C	30	30	30	30	...	...
		time (mins) to 3 mL emulsion max at 82 °C	...	...	...	...	30	30
Elastomer compatibility	D471	100 °C ± 1 °C/288 h ± 2 h NBR-1 Elastomer						
		relative volume change, percent	0 to 15	0 to 12	0 to 12	0 to 10	0 to 10	0 to 10
		change in Shore A hardness, rating	0 to –8	0 to –7	0 to –7	0 to –6	0 to –6	0 to –6
Foam	D892	Sequence I tendency/stability mL max	75/0	75/0	75/0	75/0	75/0	75/0
		Sequence II tendency/stability mL max	50/0	50/0	50/0	50/0	50/0	50/0
		Sequence III tendency/stability mL max	75/0	75/0	75/0	75/0	75/0	75/0

TABLE 6 *Continued*

Properties	Test Method ASTM (Other)	Parameters	Limits					
Air release	D3427	time (mins) at 50 °C, max	5	5	7	10	...	...
		time (mins) at 75 °C	...	...	...	...	report	report
Oxidation stability	D943	time for KOH acid number of 2 mg/kg, h, min	2500	2500	2500	2500	2500	2500
Sludge tendency	D4310	Acid number KOH mg/g, 1000 h, max	2.0	2.0	2.0	2.0	2.0	2.0
		total insoluble sludge, mg, max	150	150	150	150	150	150
		copper oil/water/sludge, mg, max	200	200	200	200	200	200
Thermal stability	D2070	copper appearance, visual, max	report	5	5	5	report	report
		steel appearance, visual, max	report	2	2	2	report	report
		sludge, mg/100 mL, max	report	25	25	25	report	report
Wear protection	D6973	mass loss vanes + ring, mg, max at 93 °C/50 h	See note[F]	90	See note[F]	See note[F]	See note[F]	See note[F]
Wear protection	D5182	Fail load stage	10	10	11	11	11	11
Filterability	ISO 13557–1 (wet)							
	Phase I		70	70	70	70	report	report
	Phase II		50	50	50	50	report	report
	ISO 13557–2 (dry)							
	Phase I		80	80	80	80	report	report
	Phase II		60	60	60	60	report	report

[A] Precision of Test Method D2983 is being improved by Subcommittee D02.07.C0, but the test method is applicable.
[B] Results should target stay in grade performance but can be discussed with customer and new values agreed upon.
[C] Test Method D4052 can also be used.
[D] Test Method D5950 can also be used.
[E] Test Method D665—soak time is 24 h.
[F] These values can be read across from the ISO 32 testing report. ISO VG 22 best practices would be to run the pump test to verify results. Best practice is to run multiple cartridges to establish results.

from normal hazards of handling and shipping. Packaging shall conform to applicable carrier rules and regulations.

6.2 Packaging and labeling shall comply with state or federal regulations.

6.3 Each container shall be plainly marked with the manufacturer's name and brand, production code or lot number, type of material, volume content, and any other information required by state or federal law.

7. Keywords

7.1 antiwear protection; guideline; hydraulic oils; mineral oils; rust and oxidation protection; synthetic base stocks; viscosity index

APPENDIX

(Nonmandatory Information)

X1. SIGNIFICANCE OF TEST METHODS USED IN THE SPECIFICATION FOR MINERAL AND SYNTHETIC (GROUP I-IV) HYDRAULIC OILS

X1.1 Physical Properties

X1.1.1 *ISO Viscosity Grade (Classification D2422)*—The International Standards Organization has established a viscosity classification system for industrial fluid lubricants. Such lubricants are classified by grades designated as ISO-VG based on their viscosities in centistokes at 40 °C. The choice of viscosity grade for use in a particular hydraulic system should comply with the system requirements and the hydraulic pump manufacturer's recommendations.

X1.1.2 *Viscosity (Test Methods D445 and D2983)*—Viscosity is the measurement of a fluid's resistance to flow. It is considered to be the most important characteristic of a hydraulic fluid. The optimum value is always a compromise. It has to be high enough at the working temperature to ensure that the fluid will not leak through the seals or junctions and to maintain proper lubrication. Also, the viscosity has to be low enough to ensure fluid flow and to maintain system efficiency and lubrication.

X1.1.3 *Viscosity Index (VI) (Practice D2270)*—The VI number expresses the sensitivity of the fluid's viscosity toward changes of temperature. In general, the VI is not very critical when the system works at a stable operating temperature. When the variation of temperature among different points in the system is high (over 30 °C), or the operational temperatures vary considerably, then a high VI (over 90) is usually recommended.

X1.1.3.1 *Viscosity-Modified Oils, (Practice D6080)*—High VI hydraulic fluids (Category HV) usually contain high molecular weight thickeners, called viscosity index improvers (VII), which impart non-Newtonian characteristics to the fluid. These polymers may shear in operation, effectively reducing the viscosity of the fluid at a given system operating temperature. Practice D6080 can be used to classify oils for (*1*) low temperature viscosity and (*2*) high temperature viscosity after shearing. This information helps users ensure that fluid will have suitable viscosity throughout the operating temperature range of the system.

X1.1.4 *Specific Gravity, Density, (Test Method D1298)*—This property is of value to hydraulic system designers and operators for calculating system weight, internal pressure, wall thickness, and pump requirements.

NOTE X1.1—Test Method D4052 can also be used.

X1.1.5 *Flash Point (Test Method D92)*—Flash point is the temperature at which the fluid contained in a test cup and heated at a constant rate will flash but not continue to burn when a flame is passed over the cup. It is indirectly a measure of both the volatility of the oil and flammability of the volatiles contained therein. This is mainly of interest as a quality control test and for regulatory reasons. However, some manufacturers use it as a safety criterion for work at high temperatures.

X1.1.6 *Pour Points (Test Method D97, Low Temperature Viscosity (Test Method D2983))*—The pour point is an indication of the lowest temperature at which an oil will flow by gravity. The fluid viscosity must allow the system to start up and operate at low temperatures. As a practical rule, the fluid should have a pour point 10 °C below the minimum expected ambient temperature. Test Method D2983 can be used to determine the temperature at which a fluid's viscosity is less than 750 cP, which is suggested as the highest viscosity that the equipment can tolerate without risk of damage during operation.

X1.2 Chemical Properties

X1.2.1 *Acid Number (Test Method D664)*—The acid number is the milligrams of potassium hydroxide (KOH) required to neutralize the acidic constituents in a gram of sample. The initial acid number is influenced by base oil and additives. Test Method D664 is a potentiometric titration test method used for acid number calculations. This is mainly of value as a quality control test.

X1.2.2 *Acid Number (Test Method D974)*—In this test method, acid number is determined by a color-indicator titration method and is used as an alternative to Test Method D664. It should be noted that the acid number obtained by this test method may or may not be numerically the same as that obtained by Test Method D664, but it is generally of the same order of magnitude.

X1.3 Performance Properties

X1.3.1 *Rust Preventing Characteristics (Test Method D665)*—This test method measures the ability of the oil to prevent rusting of steel surfaces when water is present. Procedure A involves the use of distilled water, and Procedure B involves the use of synthetic sea water.

X1.3.2 *Copper Corrosion Characteristics (Test Method D130)*—Some components of hydraulic systems contain copper alloys (for example, vane pump bushings and piston pump shoes). This test method indicates the relative tendency of oils to corrode copper.

X1.3.3 *Water Separability Characteristics (Test Method D1401)*—Water in large hydraulic systems may be removed by mechanical procedures that take advantage of the demulsibility properties of the oil. An emulsion can reduce the viscosity of the circulating fluid, creating lubrication problems, which may lead to deposits. Test Method D1401 determines the water separation characteristics of oils.

X1.3.4 *Foaming Characteristics (Test Method D892)*—In oil systems having high circulation rates, it is important that air introduced through the seals or at the reservoir tank be readily released from the body of the fluid and not collect as foam on the surface of the fluid, since this can produce cavitation or impede proper circulation. Test Method D892 measures the tendency of the oil to form foam and the stability of such foam. There are three sequences: Sequence I at 24 °C; Sequence II at 93.5 °C; and Sequence III at 24 °C, using the same sample tested in Sequence II.

X1.3.5 *Air Release (Test Method D3427)*—Agitation of lubricating oil with air in equipment may produce a dispersion of finely divided air bubbles in the oil. If the residence time in the reservoir is too short to allow air bubbles to rise to the surface, a mixture of air and oil will circulate through the lubrication system. This may result in the incapability to maintain oil pressure, incomplete oil films in contact zones, and poor hydraulic system performance or failure. This test method measures the time for the entrained air content to fall to the relatively low value of 0.2 % volume under standardized test conditions, and hence permits the comparison of the oils' capacity to separate entrained air over a period of time.

X1.3.6 *Oxidation Stability (Test Method D943)*—Oxidation of the oil may increase oil viscosity, produce sludge that can make valves stick and plug filters, and generate materials that are corrosive to metals. Test Method D943 measures the time that the oil resists oxidation in the presence of oxygen, water, and metal catalysts. It should be recognized, however, that correlation between results of this test method and the oxidation stability of a lubricant in field service can vary markedly with field service conditions. This test method does not measure sludge formation or catalyst coil corrosion (see Test Method D4310 and X1.3.7).

X1.3.7 *Sludging Tendency (Test Method D4310)*—As stated in X1.3.6, insoluble or corrosive materials may form in oils when they are subjected to oxidation conditions. This 1000 h-test determines the tendency of oil to form sludge in the presence of oxygen, water, and metal catalysts. Test Method D4310 also measures the total copper present in the oil, water, and sludge. It is a complement to Test Method D943.

X1.3.8 *Thermal Stability (Test Method D2070)*—The thermal degradation of a lubricant can yield insoluble materials that plug filters, block narrow clearances, and corrode metals. This test method determines the tendency of oils to form sludge at high temperatures in the absence of water and in the presence of iron and copper.

X1.3.9 *Wear Protection (Test Method D7043 and D6973)*—Hydraulic systems running at medium pressures, designed with small clearances, and subject to metal-to-metal contact (for example, vane, piston, and gear pumps) should use fluids that have anti-wear properties.

X1.3.9.1 Test Method D7043 is a constant-volume medium-pressure 13.8 MPa (2000 psi) vane pump test. The evaluation parameter is the weight loss of the ring and the vanes. The rig simulates fluid performance in small hydraulic systems.

X1.3.9.2 Test Method D6973 is a constant-volume high-pressure 20.7 MPa (3000 psi) vane pump test. The evaluation parameter is the weight loss of the cam ring and the vanes. The rig simulates fluid performance in medium to large hydraulic systems.

X1.3.10 *Filterability*— Filterability of hydraulic oils is very important and Test Method ISO 13357–1 and ISO 13357–2 is one method for evaluating this performance attribute and is also used in Practice D7752.

X1.3.11 *Elastomer Compatibility (Test Method D471)*—The compatibility of a fluid with elastomers is recognized to be very important.

X1.3.12 *Hydrolytic Stability*—The resistance of hydraulic fluids to hydrolysis is important. Reaction of a finished product with water can lead to the formation of corrosive substances, acids, insoluble by-products, and very stable emulsions that can, in turn, cause corrosion, sticky valves, plugged filters, and change in oil viscosity.

SUMMARY OF CHANGES

Subcommittee D02.N0 has identified the location of selected changes to this standard since the last issue (D6158 – 14) that may impact the use of this standard. (Approved Jan. 15, 2016.)

(1) Revised Sections 1, 3, 4, and subsection X1.3.

(2) Revised Tables 1-4, and added new Tables 5 and 6.