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An American National Standard

Standard Specification for Mineral Hydraulic Oils[1]

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1. Scope

1.1 This specification covers mineral oils used in hydraulic systems, where the performance requirements demand fluids with one of the following characteristics:

1.1.1 A refined base oil (Class HH),

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

1.1.3 A refined mineral base oil with rust and oxidation inhibitors plus antiwear characteristics (Class HM).

1.2 This specification defines the requirements of mineral oil-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 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:*

D 92 Test Method for Flash and Fire Points by Cleveland Open Cup[2]

D 97 Test Method for Pour Point of Petroleum Oils[2]

D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test[2]

D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity)[2]

D 471 Test Method for Rubber Property—Effect of Liquids[3]

D 664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration[2]

D 665 Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water[2]

D 892 Test Method for Foaming Characteristics of Lubricating Oils[2]

D 943 Test Method for Oxidation Characteristics of Inhibited Mineral Oils[2]

D 974 Test Method for Acid and Base Number by Color-Indicator Titration[2]

D 1298 Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method[2]

D 1401 Test Method for Water Separability of Petroleum Oils and Synthetic Fluids[2]

D 2070 Test Method for Thermal Stability of Hydraulic Oils[2]

D 2270 Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 and 100°C[2]

D 2422 Classification of Industrial Fluid Lubricants by Viscosity System[2]

D 2619 Test Method for Hydrolytic Stability of Hydraulic Fluids (Beverage Bottle Method)[4]

D 2882 Test Method for Indicating the Wear Characteristics of Petroleum and Non-Petroleum Hydraulic Fluids on a Constant Volume Vane Pump[4]

D 2983 Test Method for Low-Temperature Viscosity of Automotive Fluid Lubricants Measured by Brookfield Viscometer[4]

D 3427 Test Method for Air Release Properties of Petroleum Oils[4]

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter[4]

D 4310 Test Method for Determination of the Sludging and Corrosion Tendencies of Inhibited Mineral Oils[4]

D 6080 Practice for Defining the Viscosity Characteristics

[1] This specification is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.N on Hydraulic Fluids.

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[2] *Annual Book of ASTM Standards,* Vol 05.01.

[3] *Annual Book of ASTM Standards,* Vol 09.01.

[4] *Annual Book of ASTM Standards,* Vol 05.02.

of Hydraulic Fluids[5]

3. Classification

3.1 *Type HH Hydraulic Oils*—Non-inhibited refined mineral oils 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 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.

[5] *Annual Book of ASTM Standards*, Vol 05.03.

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 D 2422.

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 D 2422.

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 D 2422.

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 D 2422.

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 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.

TABLE 1 Requirements for Type HH Mineral Oil Hydraulic Fluids

Properties	Test Method ASTM (Other)	Parameters	Limits							
Physical										
ISO viscosity grade	D 2422		10	15	22	32	46	68	100	150
Viscosity	D 445	kinematic viscosity at 40°C, cSt	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 cP	D 2983[A]	temperature, °/C	report	report	report	report	report	report	report	report
Viscosity index	D 2270		report	report	report	report	report	report	report	report
Specific gravity	D 1298[B]		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	D 92	temperature, °C, min	125	145	165	175	185	195	205	215
Pour point	D 97	temperature, °C, max	-15	-12	-9	-6	-6	-6	-6	-6
Chemical										
Acid number	D 974/D 664	mg KOH/g, max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Performance										
Elastomer compatibility	D 471	100 ± 1°C/288 ± 2h ± 2h SRE-NBR 1 Elastomer (DIN53 538, Part 1 or AMA 524, Part 1)	report	report	report	report	report	report	report	report
		relative volume change, % C	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 C	report	report	0 to –8	0 to –7	0 to –7	0 to –6	0 to –6	0 to –6

[A] Precision of the test method for hydraulic oils at low temperatures is being improved by Subcommittee D02.07.OC, but the test method is applicable.
[B] Test Method D 4052 can also be used.

TABLE 2 Requirements for Type HL Mineral Oil Hydraulic Fluids (Rust and Oxidation)

Properties	Test Method ASTM (Other)	Parameters	Limits							
Physical:										
ISO-viscosity grade	D 2422		10	15	22	32	45	68	100	150
Viscosity	D 445	kinematic viscosity at 40°C, cSt	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 cP	D 2983[A]	temperature, °C, max	-33	-23	-15	-8	-2	4	10	16
Viscosity index	D 2270	min	90	90	90	90	90	90	90	90
Specific gravity	D 1298[B]		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	D 92	temperature, °C, min	125	145	165	175	185	195	205	215
Pour point	D 97	temperature, °C, max	-33	-24	-21	-18	-15	-12	-12	-12
Chemical:										
Acid Number	D 974/D 664	mg KOHg	report	report	report	report	report	report	report	report
Performance:										
Rust prevention	D 665A[C]	visual evaluation pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
	D 665B[C]		pass	pass	pass	pass	pass	pass	pass	pass
Corrosion	D 130	copper corrosion, 3 h at 100°C, visual, max	2	2	2	2	2	2	2	2
Water separation	D 1401	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	D 471	100± °C/288, ± 2 h SRE-NBR 1 Elastomer (DIN 53 538, Part 1 or AAMA 524 Part 1)								
		relative volume change, %[D]	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[D]	report	report	0 to -8	0 to -7	0 to -7	0 to -6	0 to -6	0 to -6
Foam	D 892	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	D 3427	time, (mins. at 50°C, max)	5	5	5	5	10	10	-	-
		time, (mins. at 75°C, max)	-	-	-	-	-	-	report	report
Oxidation stability	D 943	time for acid number of 2 mg KOH/g, h, min	1000	1000	1000	1000	1000	1000	1000	1000
Sludge tendency	D 4310	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	D 2070	copper appearance, visual max	report	report	report	5	5	5	report	report
		steel appearance, visual max	report	report	report	1	1	1	report	report
		sludge, mg/100 mL, max	report	report	report	25	25	25	report	report

[A]Precision of the test method for hydraulic fuels at low temperatures is being improved by Subcommittee D02.07.OC, but the test method is applicable.
[B]Test Method D 4052 can also be used.
[C]Test Method D 665 — soak time is 24 h.
[D]These numbers are provisional; ASTM is trying to establish a technical consensus for possible revision.

TABLE 3 Requirements for Type HM Mineral Oil Hydraulic Fluids (Anti-wear)

Properties	Test Method ASTM (Other)	Parameters	Limits							
Physical:										
ISO-viscosity grade	D 2422		10	15	22	32	46	68	100	150
Viscosity	D 445	kinematic viscosity at 40°C, cSt	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 cP	D 2983[A]	temperature, °C, max	-33	-23	-15	(-8)	-2	4	10	16
Viscosity index	D 2270	*min	90	90	90	90	90	90	90	90
Specific gravity	D 1298[B]		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	D 92	temperature, °C, min	125	145	165	175	185	195	205	215
Pour point	D 97	temperature, °C, max	-33	-24	-21	-18	-15	-12	-12	-12
Chemical:										
Acid number	D 974/D 664	mg KOH/g, max	report	report	report	report	report	report	report	report
Performance										
Rust prevention	D 665A[C]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
	D 665B[C]	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
Corrosion	D 130	copper corrosion, 3 h at 100°C, visual, max	2	2	2	2	2	2	2	2
Water separability	D 1401	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	D 471	100 ± 1°C/288 ± 2 h SRE-NBR 1 Elastomer (DIN53 538, Part 2 or AAMA 524, Part 2)								
		relative volume change, %[D]	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[D]	report	report	0 to -8	0 to -7	0 to -7	0 to -6	0 to -6	0 to -6
Foam	D 892	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	D 3427	time (mins) at 50°C, max	5	5	5	5	10	13	-	-
		time (mins) at 75°C max	-	-	-	-	-	-	report	report
Oxidation stability	D 943	time for acid number of 2 mg KOH/g, h, min	1000	1000	1000	1000	1000	1000	1000	1000
Sludge tendency	D 4310	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	D 2070	copper appearance, visual	report	report	report	5	5	5	report	report
		steel appearance, visual	report	report	report	1	1	1	report	report
		sludge, mg/100 mL	report	report	report	25	25	25	report	report
Wear protection	D 2882	weight loss vanes + ring, mg, max at 65 6°C/100H	-	-	50	50	50	-	-	-
		weight loss vanes + ring, mg, max at 79 4°C/100H	-	-	-	-	-	50	50	50

[A]Precision of the test method for hydraulic oils at low temperatures is being improved by Subcommittee D02.07.OC, but the test method is applicable.
[B]Test Method D 4052 can also be used.
[C]Test Method D 665 — soak time is 24 h.
[D]These numbers are provisional; ASTM is trying to establish a technical consensus for possible revision.

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

Properties	Test Method ASTM (Other)	Parameters	Limits							
Physical:										
ISO-viscosity grade	D 2422		10	15	22	32	46	68	100	150
Viscosity of fresh oil	D 445	kinematic viscosity at 40°C, cSt	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 cP	D 2983[A]	temperature, °C, max	–33	–23	–15	(–8)	–2	4	10	16
Low temperature Viscosity grade	D 6080		Report	Report	Report	Report	Report	Report	Report	Report
Viscosity index of fresh oil	D 2270	min	140	140	140	140	140	140	140	140
Viscosity after shear	D 6080	kinematic viscosity at 40°C, cSt	Report	Report	Report	Report	Report	Report	Report	Report
Viscosity index after shear	D 6080		Report	Report	Report	Report	Report	Report	Report	Report
Specific gravity	D 1298[B]		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	D 92	temperature,° C, min	125	145	165	175	185	195	205	215
Pour point	D 97	temperature,° C, max	–33	–24	–21	–18	–15	–12	–12	–12
Chemical:										
Acid number	D 974/D 664	mg KOH/g, max	report	report	report	report	report	report	report	report
Performance										
Rust prevention	D 665A	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
	D 665B	visual evaluation, pass or fail	pass	pass	pass	pass	pass	pass	pass	pass
Corrosion	D 130	copper corrosion, 3 h at 100°C, visual, max	2	2	2	2	2	2	2	2
Water separability	D 1401	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	D 471	100 ± 1°C/288 ± 2h SRE-NBR 1 Elastomer (DIN53 538, Part 2 or AAMA 524, Part 2)								
		relative volume change, %[C]	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[C]	report	report	0 to –8	0 to –7	0 to –7	0 to –6	0 to –6	0 to –6
Foam	D 892	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	D 3427	time (mins) at 50°C, max	5	5	5	5	10	13	—	—
		time (mins) at 75°C max	—	—	—	—	—	—	report	report
Oxidation stability	D 943	time for acid number of 2 mg KOH/g, h, min	1000	1000	1000	1000	1000	1000	1000	1000
Sludge tendency	D 4310	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	D 2070	copper appearance, visual	report	report	report	5	5	5	report	report
		steel appearance, visual	report	report	report	1	1	1	report	report
		sludge, mg/100 mL	report	report	report	25	25	25	report	report
Wear protection	D 2882	weight loss vanes + ring, mg, max at 65 6°C/100 H	—	—	50	50	50	—	—	—
		weight loss vanes + ring, mg, max at 79 4°C/100 H	—	—	—	—	—	50	50	50

[A] Precision of the test method for hydraulic oils at low temperatures is being improved by Subcommittee D02.07.OC, but the test method is applicable.
[B] Test Method D 4052 can also be used.
[C] These numbers are provisional; ASTM is trying to establish a technical consensus for possible revision.

7. Keywords

7.1 antiwear protection; guideline; hydraulic oils; mineral oils; rust and oxidation protection; specifications; viscosity index

APPENDIX

(Nonmandatory Information)

X1. SIGNIFICANCE OF TEST METHODS USED IN THE SPECIFICATION FOR MINERAL HYDRAULIC OILS

X1.1 Physical Properties

X1.1.1 *ISO Viscosity Grade (Classification D 2422)*—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 D 445 and D 2983)*—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 D 2270)*—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 D 6080)*—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 D 6080 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, (Practice D 1298)*—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 D 4052 can also be used.

X1.1.5 *Flash Point (Test Method D 92)*—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 D 97, Low Temperature Viscosity (Test Method D 2983)*—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 D 2983 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 D 664)*—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 D 664 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 D 974)*—In this test method acid number is determined by a color-indicator titration method and is used as an alternative to Test Method D 664. 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 D 664, but it is generally of the same order of magnitude.

X1.3 Performance Properties

X1.3.1 *Rust Preventing Characteristics (Test Method D 665)*—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 D 130)*—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 D 1401)*—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 D 1401 determines the water separation characteristics of oils.

X1.3.4 *Foaming Characteristics (Test Method D 892)*—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 D 892 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 D 3427)*—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 D 943)*—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 D 943 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 D 4310 and X1.3.7).

X1.3.7 *Sludging Tendency (Test Method D 4310)*—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 D 4310 also measures the total copper present in the oil, water, and sludge. It is a complement to Test Method D 943.

X1.3.8 *Thermal Stability (Test Method D 2070)*—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 D 2882)*—Hydraulic systems running at high 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. Test Method D 2882 is a constant-volume high-pressure 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. ASTM Subcommittee D02.N is considering a replacement test method.

X1.3.10 *Filterability*—Although it is recognized that filterability of hydraulic oils is very important, no consensus exists that a satisfactory test method is available.

X1.3.11 *Elastomer Compatibility (Test Method D 471)*—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.

X1.3.12.1 Test Method D 2619 is frequently used in hydraulic oil standards or specifications. This particular test method is not used in this specification because of its poor precision and its inadmissibility in some European countries. There is an activity in Subcommittee D02.N to improve the precision of the test method.