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An American National Standard

Standard Specification for Mineral Lubricating Oil Used in Steam or Gas Turbines[1]

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1. Scope

1.1 This specification covers mineral oils used in steam and gas turbine lubrication systems where the performance requirements demand a highly refined mineral base oil compounded with rust and oxidation inhibitors plus selected additives as needed to control foam, wear, demulsibility, and so forth.

1.2 This specification is intended to define the properties of mineral oil-based turbine lubricating oils that are functionally interchangeable with existing oils of this type, are compatible with most existing machinery components, and with appropriate field maintenance, will maintain their functional characteristics.

1.3 This specification is intended to define only new lubricating oil before it is installed in the machinery.

1.4 This specification is intended to be used as a guide. It is possible that oils that do not meet this specification may perform satisfactorily in some turbines.

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

D 2272 Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Bomb[2]

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

D 3339 Test Method for Acid Number of Petroleum Products by Semi-Micro Color Indicator Titration[3]

D 3427 Test Method for Air Release Properties of Petroleum Oils[3]

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products[3]

D 4310 Test Method for Determination of the Sludging and Corrosion Tendencies of Inhibited Mineral Oils[3]

D 5182 Test Method for Evaluating the Scuffing (Scoring) Load Capacity of Oils (FZG Visual Method)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *Type I mineral oils, n*—oils for steam and gas turbine lubricating systems where the machinery does *not* require lubricants with enhanced load carrying capacity. Such oils normally contain rust and oxidation inhibitors plus other additives as needed to meet the specified performance characteristics. Type I oils usually are available in ISO-VG 32, 46, 68, and 100 (see Classification D 2422).

3.1.2 *Type II mineral oils, n*—oils for steam and gas turbine lubricating systems where the machinery requires enhanced load carrying capacity. These oils are similar to Type I and are typically used in gas turbines with a load carrying gear marine turbines. Such oils contain rust and oxidation inhibitors, plus mild extreme pressure (EP) additives and other additives as needed to meet the specified performance characteristics. Type II oils usually are available in ISO-VG 32, 46, 68, 100, and 150.

3.1.3 *functional properties, n*—those properties of the mineral lubricating oil that are required for satisfactory operation of the machinery. These properties are listed in Section 5.

4. Sampling and Testing

4.1 *Sampling*—Generally, take all oil samples in accordance with Practice D 4057.

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.C on Turbine Oils.

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

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

TABLE 1 Requirements for Type I Turbine Oils

NOTE 1—The nature of some tests are such that they are not necessarily run on each batch. The values are representative.

Property	ASTM Test Method	Limits			
Physical:					
ISO—viscosity grade	D 2422	32	46	68	100
Flash point, °C, min	D 92	180	180	180	180
Pour point, °C, max	D 97[A]	−6	−6	−6	−6
Viscosity, cSt (mm^2/s) 40°C	D 445	28.8–35.2	41.4–50.6	61.2–74.8	90–110
Visual examination at 20°C	...	clear and bright			
Chemical:					
Total Acid Number, mg KOH/g, max	D 974[B]	report	report	report	report
Performance					
Emulsion characteristics:	D 1401				
at 54°C, minutes to 3 mL emulsion, max		30	30	30	...
at 82°C, minutes to 3 mL emulsion, max		...	...	...	60
Foaming characteristics:	D 892				
Sequence I, tendency/stability, mL, max		50/0	50/0	50/0	50/0
Air release, 50°C, minutes max	D 3427	5	7	10	17
Rust preventing characteristics	D 665A	Pass	Pass	Pass	Pass
Copper corrosion, 3 h at 100°C, max	D 130	1	1	1	1
Oxidation stability[C]:					
Hours to neut. No. 2.0, min	D 943	2000	2000	1500	1000
Minutes to 175 kPa drop, min	D 2272	350	350	175	150

[A] Lower pour point may be required for some applications.
[B] Test Method D 664 may be used as an alternative test method.
[C] Test Method D 943 is the accepted test method for oxidation stability of new steam turbine oils in the United States and Canada. It is recognized that Test Method D 943 is a lengthy procedure. Test Method D 2272 is a shorter test for quality control. See X1.3.6 for significance of Test Method D 2272.

TABLE 2 Requirements for Type II Turbine Oils

NOTE 1—The nature of some tests are such that they are not necessarily run on each batch.

Property	ASTM Test Method	Limits				
Physical:						
ISO—viscosity grade	D 2422	32	46	68	100	150
Flash point, °C, min	D 92	180	180	180	180	210
Pour point, °C, max	D 97[A]	–5	–5	–5	–5	–5
Viscosity, cSt, 40°C (mm^2/s)	D 445	28.8–35.2	41.4–50.6	61.2–74.8	90–110	135–165
Visual examination at 20°C	...	clear and bright				
Chemical:						
Total Acid Number, mg KOH/g, max	D 974[B]	report	report	report	report	report
Performance						
Emulsion characteristics:	D 1401					
at 54°C, minutes to 3 mL emulsion, max		30	30	30	...	...
at 82°C, minutes to 3 mL emulsion, max		...	...	...	60	60
Foaming characteristics:	D 892					
Sequence I, tendency/stability, mL, max		50/0	50/0	50/0	50/0	50/0
Air release, 50°C minutes max	D 3427	5	10	10	17	25
Rust preventing characteristics	D 665B	pass	pass	pass	pass	pass
Copper corrosion, 3 h at 100°C, max	D 130	1	1	1	1	1
Oxidation stability:[C]						
Hours to neut. No. 2.0, min	D 943	2000	2000	1500	1000	1000
Minutes to 175 kPa drop, min	D 2272	350	350	175	150	150
Load carrying capacity:						
fail stage, min	D 5182[D]	8	8	8	8	8

[A] Lower pour point may be required for some applications.
[B] Test Method D 664 may be used as alternative method.
[C] Test Method D 943 is the accepted test method for oxidation stability of new steam turbine oils in the United States and Canada. It is recognized that Test Method D 943 is a lengthy procedure. Thus, Test Method D 2272 is a suggested shorter test for quality control. See X1.3.6 for significance of Test Method D 2272.
[D] Higher values may be required for some applications.

4.2 Use the ASTM and other test methods described in Tables 1 and 2.

5. Functional Property Requirements

5.1 Mineral lubricating oils conforming to the specification shall meet the functional property limits specified in 5.2 and 5.3 and Table 1 and Table 2. The significance of these properties is discussed in Appendix X1.

5.2 Requirements for Type I oils are shown in Table 1.

5.3 Requirements for Type II oils are shown in Table 2.

6. Keywords

6.1 gas turbine oil; mineral oil; R and O oils; steam turbine oil; turbine lubricating oils; turbine lubrication systems

APPENDIX

(Nonmandatory Information)

X1. SIGNIFICANCE OF FUNCTIONAL PROPERTIES OF TURBINE 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 turbine should comply with the turbine manufacturer's recommendations.

X1.1.2 *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 the flammability of these volatiles contained therein. This is mainly of value as a quality control test and for regulatory reasons.

X1.1.3 *Pour Point Test Method D 97*—The pour point is an indication of the lowest temperature at which the 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.

X1.1.4 *Viscosity Test Method D 445*—The viscosity of a turbine oil determines its ability to flow in a lubrication system and to support bearing loads, transfer heat, and operate hydraulic controls.

X1.1.5 *Visual Examination*—In the manufacture, distribution, and use of turbine oils, fresh oils should be examined for appearance and clarity as a check against contamination. Oils may be compared to a standard reference sample.

X1.1.6 *Cleanliness Test Methods*—Insoluble contaminants, including metallic and nonmetallic materials, can cause abrasive wear of bearings, pumps, and seals; faulty control functioning; plugged oil lines; and reduced filter life. There are several recommended standards for lubrication system cleanliness published by technical societies and equipment manufacturers.

X1.1.6.1 Insolubles may be evaluated by different techniques, such as microscopic particle analysis and counting or electronic particle counting. (No standard test method is identified.)

X1.2 Chemical Properties

X1.2.1 *Acid Number by Color–Indicator Titration Test Method D 974*—The total 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. Oils in service oxidize to form acids. Thus changes in acid number can be used to monitor the progress of oxidation of the oil.

X1.2.2 *Acid Number by Semi-micro Color-Indicator Titration Test Method D 3339*—This test method, which can be used in cases in which the amount of sample available to be analyzed is too small to allow accurate analysis by Test Method D 974, is an alternative to Test Method D 974. Test Methods D 974 and D 3339 correlate within the precision for the two test methods.

X1.3 Performance Properties

X1.3.1 *Emulsion Characteristics Test Method D 1401*—This test method is used to measure the ability of an oil to separate gross amounts of water. Water in turbine systems can promote oil oxidation, reduce oil stability, promote sludge formation, promote foaming, form emulsions, promote rusting and corrosion, reduce additive concentration, impede lubrication, alter fluid viscosity, reduce filter life, and foster bacterial growth.

X1.3.2 *Foaming Characteristics Test Method D 892*—In oil systems having high circulation rates, it is important that air introduced through seals or at the reservoir tank is rapidly released from the fluid without collecting as foam. Foam can produce cavitation and impede proper oil 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.

X1.3.3 *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 loss of oil pressure, incomplete oil films in contact zones, and if the oil is used in a hydraulic system, poor system performance. This test method measures the time for 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 oil's capacity to separate entrained air over a period of time.

X1.3.4 *Rust Preventive Characteristics Test Method D 665*—This test method measures the ability of an oil to prevent rusting of steel surfaces when water is present. Distilled water is used with Procedure A and synthetic sea water with Procedure B.

X1.3.5 *Copper Corrosion Test Method D 130*—This test method indicates the relative tendency of oils to corrode copper and copper alloys that may be present in the lubrication system.

X1.3.6 *Oxidation Stability*—Several laboratory tests are used to indicate oxidation stability of mineral oils, and there is a continuing search to correlate these test results with field experience. The test methods referenced in this document are Test Methods D 943 and D 2272.

X1.3.6.1 Test Method D 943 reports the time in hours for the acidity to reach 2.0 mg of KOH per gram of sample in a

sample of oil containing water, in the presence of a steel and copper wire coiled together and maintained at a temperature of 95°C (203°F) with oxygen passing through. This test method includes the following statements:

"This method is widely used for specification purposes and is considered of value in estimating the oxidation stability of lubricants, especially those that are prone to water contamination."

"It should be recognized, however, that correlation between results of this test method and the oxidation stability of a lubricant in field service may vary markedly with field service conditions and with various lubricants."

"Furthermore, in the course of testing a lubricant by this test method, other signs of deterioration, such as sludge formation or catalyst coil corrosion, may appear which are not reflected in the calculated oxidation lifetime. For cases when it is desired to measure sludge formation or catalyst coil corrosion, Test Method D 4310 should be used."

X1.3.6.2 In Test Method D 2272, the test oil, water, and copper catalyst coil, contained in a covered glass container, are placed in a pressure vessel equipped with a pressure gage. The pressure vessel is charged with oxygen to a pressure of 90 psi (620 kPa), placed in a constant-temperature oil bath set at 150°C, and rotated axially at 100 rpm at an angle of 30° from the horizontal. The time for the test oil to react with a given volume of oxygen is measured, completion of the time being indicated by a specific drop in pressure. This test method includes the following statements:

"This test method utilizes an oxygen-pressured vessel to evaluate the oxidation stability of new and in-service turbine oils having the same composition (base stock and additives). This estimation of oxidation stability is useful in controlling the continuity of this property. For batch acceptance of production lots having the same composition. It is not intended that this test method be a substitute for Test Method D 943 or be used to compare the service lives of new oils of different compositions. This test method is also used to assess the remaining oxidation life of in-service oils."

X1.3.6.3 The correlation of oxidation laboratory test results with field service is a difficult one. The tests used and the values given in this specification are a representation of the present state of the art.

X1.3.7 *Load Carrying Capacity Test Method D 5182*—This test method measures the scuffing load capacity of a turbine oil in a four square-type gear rig. An FZG Gear Test Machine (A/83/90°C) is operated at constant speed for a fixed period at successively increasing loads until a predetermined level of gear scuffing and scoring is reached.