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Standard Specification for Polyalkylene Glycol Lubricants Used in Gas Turbines¹

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1. Scope

1.1 This specification¹ covers water insoluble and oil soluble polyalkylene glycol based (PAG) lubricants used in gas turbine lubrication systems.

1.2 This specification is intended to define the properties of water insoluble or oil soluble polyalkylene glycol-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. Auxiliary systems, like hydraulics, gearboxes, and couplings, are also lubricated by the same lubrication systems.

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

1.4 It is possible that other water insoluble and oil soluble polyalkylene glycol-based turbine lubricants that do not meet this specification may perform satisfactorily in some turbines.

1.5 This specification does not include API Group I-IV or non-PAG based API Group V oils. For mineral oil and synthetic (API group I, II, III, or IV) fluids used to lubricate steam or gas turbines, the user is referred to the current version of Specification [D4304](#). The ISO 8068, DIN 51515-1, or DIN 51515-2 may also be of useful reference. For polyol ester fluids used to lubricate land-based gas turbines, the user is referred to the current version of military specification MIL-PRF-23699 for fluid performance requirements. For phosphate ester fluids used as turbine lubricants or steam turbine electro-hydraulic control (EHC) fluids, the user is referred to the current version of Specification [D4293](#) for fluid performance requirements.

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

1.7 *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 appro-*

priate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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 \(and Calculation of Dynamic Viscosity\)](#)
- [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](#)
- [D974 Test Method for Acid and Base Number by Color-Indicator Titration](#)
- [D1500 Test Method for ASTM Color of Petroleum Products \(ASTM Color Scale\)](#)
- [D2270 Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 °C and 100 °C](#)
- [D2272 Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel](#)
- [D2422 Classification of Industrial Fluid Lubricants by Viscosity System](#)
- [D2783 Test Method for Measurement of Extreme-Pressure Properties of Lubricating Fluids \(Four-Ball Method\)](#)
- [D3339 Test Method for Acid Number of Petroleum Products by Semi-Micro Color Indicator Titration](#)

¹ This specification test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.C0 on Turbine Oils.

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

- 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
- D4057** Practice for Manual Sampling of Petroleum and Petroleum Products
- D4172** Test Method for Wear Preventive Characteristics of Lubricating Fluid (Four-Ball Method)
- D4175** Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
- D4293** Specification for Phosphate Ester-Based Fluids for Turbine Lubrication and Steam Turbine Electro-Hydraulic Control (EHC) Applications
- D4304** Specification for Mineral and Synthetic Lubricating Oil Used in Steam or Gas Turbines
- 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)
- D6304** Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
- D6425** Test Method for Measuring Friction and Wear Properties of Extreme Pressure (EP) Lubricating Oils Using SRV Test Machine
- D6439** Guide for Cleaning, Flushing, and Purification of Steam, Gas, and Hydroelectric Turbine Lubrication Systems
- D7042** Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
- D7155** Practice for Evaluating Compatibility of Mixtures of Turbine Lubricating Oils
- D7421** Test Method for Determining Extreme Pressure Properties of Lubricating Oils Using High-Frequency, Linear-Oscillation (SRV) Test Machine
- D7546** Test Method for Determination of Moisture in New and In-Service Lubricating Oils and Additives by Relative Humidity Sensor
- D7547** Specification for Hydrocarbon Unleaded Aviation Gasoline
- D7647** Test Method for Automatic Particle Counting of Lubricating and Hydraulic Fluids Using Dilution Techniques to Eliminate the Contribution of Water and Interfering Soft Particles by Light Extinction
- D7873** Test Method for Determination of Oxidation Stability and Insolubles Formation of Inhibited Turbine Oils at 120 °C Without the Inclusion of Water (Dry TOST Method)

2.2 ISO Standards:³

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

- ISO 4406–99** Particle Count Analysis
- ISO 6072** Rubber—Compatibility Between Hydraulic Fluids and Standard Elastomeric Materials
- ISO 8068** Lubricants, Industrial Oils and Related Products (Class L)—Family T (Turbines)—Specification for Lubricating Turbines

2.3 Military Standards:⁴

- MIL-PRF-23699G** Performance Specification Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Numbers: O-152, O-154, O-156, and O-167

2.4 DIN Standards:⁵

- DIN 51515-1** Lubricants and governor fluids for turbines – Minimum requirements – Part 1: Turbine oils TD for normal service
- DIN 51515-2** Lubricants and governor fluids for turbines – Minimum requirements – Part 2: Turbine oils TG for high temperature service

3. Terminology

3.1 Definitions:

3.1.1 For definition of terms used in this specification, refer to Terminology **D4175**.

3.1.2 *functional properties, n*—those properties of polyalkylene glycol turbine lubricants that are required for satisfactory operation of the machinery.

3.1.2.1 *Discussion*—These properties are listed in Section 5.

3.1.3 *oil soluble polyalkylene glycol, n*—homopolymers of butylene oxide (for example, polybutylene glycol, PBG), co-polymers of propylene oxide and butylene oxide, or propoxylates with a long chain alcohols.

3.1.3.1 *Discussion*—Commercialized base stocks include alkoxylates initiated from *n*-butanol, 1,2-propanediol, or 1,4-butanediol.

3.1.4 *polyalkylene glycol, n*—a family of synthetic polyether polymers derived from petrochemical-based monomers, ethylene oxide, propylene oxide, and butylene oxide.

3.1.4.1 *Discussion*—Also known as PAGs, polyglycols, and polyols, they can be designed to be water soluble, water insoluble, or oil soluble. They are hydrolytically stable and many of lower viscosity are readily biodegradable. PAG based turbine fluids as with all lubricants have advantages and disadvantages. It is recommended the reader contact suppliers of PAG, mineral oil, and PAO based turbine fluids to obtain specific property, performance, and compatibility information to help determine which fluid best fits the reader's requirements.

3.1.5 *Type I polyalkylene glycol lubricants, n*—lubricants comprised of greater than 65 % PAG basestocks for gas turbine lubricating systems where the machinery does not require lubricants with enhanced load carrying capacity.

3.1.5.1 *Discussion*—Type I PAG lubricants usually are available in a non-ISO VG grade having a nominal viscosity at

³ Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandinnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

⁴ Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil>.

⁵ Available from Deutsches Institut für Normung e.V.(DIN), Am DIN-Platz, Burggrafenstrasse 6, 10787 Berlin, Germany <http://www.din.de>.

40 °C of 25 mm²/s and ISO VG 32, 46, and 68 (see Classification [D2422](#)). Such oils normally contain rust and oxidation inhibitors in addition to other additives as required to meet the specified performance characteristic. Type I lubricants are generally satisfactory for turbine sets where bearing temperatures do not exceed 110 °C. Co-base stock blends of PAGs with fully saturated synthetic polyol esters are known.

3.1.6 *Type II polyalkylene glycol lubricants, n*—lubricants comprised of greater than 65 % PAG basestocks for gas turbine lubricating systems where the machinery requires enhanced load carrying capacity.

3.1.6.1 *Discussion*—Type II PAG lubricants usually are available in a non-ISO VG grade having a nominal viscosity at 40 °C of 25 mm²/s and ISO VG 32, 46, 68, 100, and 150. These lubricants are similar to Type I but contain additional anti-wear additives for use in turbines equipped with a gearbox. Type II lubricants are generally satisfactory for turbine sets where bearing temperatures do not exceed 110 °C. Co-base stock blends of PAG with fully saturated synthetic polyol esters are known.

3.1.7 *Type III polyalkylene glycol lubricants, n*—lubricants comprised of greater than 65 % PAG basestocks for heavy duty gas lubricating systems where the lubricant shall withstand higher temperatures and exhibit higher thermal stability than Type I or Type II oils.

3.1.7.1 *Discussion*—Type III lubricants usually are available in a non-ISO VG grade having a nominal viscosity at 40 °C of 25 mm²/s and ISO VG 32 and 46. Type III lubricants are formulated for use in turbine sets where bearing temperatures may exceed 110 °C. The turbine lubrication systems using Type III lubricants may be equipped with a gearbox requiring a lubricant that contains additional anti-wear additives to provide the required load carrying capacity. Co-base stock blends of PAG with fully saturated synthetic polyol esters are known.

3.1.8 *water insoluble polyalkylene glycol, n*—polypropylene glycols or polypropylene glycol *n*-alkyl ethers.

3.1.8.1 *Discussion*—Polypropylene glycols initiated from diols including 1,2-propylene glycol (CAS:25322-69-4; EINECS: 500-039-8) and polypropylene glycol *n*-alkyl ethers initiated from monols (for example, *n*-butanol, fatty alcohols) are typically homo-polymers of propylene oxide, known to be

used in turbine oil compositions. (CAS: 9003-13-8; EINECS: 500-003-1). They can dissolve, depending on oil temperature, up to 2 % by volume of water.

3.1.9 *water soluble polyalkylene glycol, n*—base stocks that are referred usually to co-polymers of ethylene oxide and propylene oxide, which were started upon water, *n*-butanol or a diol; they are not the object of this specification, because they are not currently used in the market for the intended scope of this specification however, they could be in the future.

4. Sampling, Testing, and System Preparation

4.1 *Sampling*—Generally, take all oil samples in accordance with Practice [D4057](#).

4.2 Use the ASTM and other test methods listed in [Tables 1-3](#).

4.3 Test Method [D6439](#) should be referenced for turbine flushing guidance when changing the type of fluid.

4.4 Practice [D7155](#) should be referenced to confirm oil to oil compatibility.

5. Functional Property Requirements

5.1 Polyalkylene glycol lubricants conforming to the specification shall meet the functional property limits specified in [5.2 – 5.4](#) and [Tables 1-3](#). The significance of these properties is discussed in [Appendix X1](#).

5.2 Requirements for Type I polyalkylene glycol turbine lubricants are shown in [Table 1](#).

5.3 Requirements for Type II polyalkylene glycol turbine lubricants with enhanced extreme pressure properties are shown in [Table 2](#).

5.4 Requirements for Type III polyalkylene glycol turbine lubricants with enhanced high temperature capabilities are shown in [Table 3](#).

6. Keywords

6.1 co-polymers of propylene oxide and butylene oxide, alkoxylate, long-chain alcohol; gas turbine lubricants; oil soluble polyalkylene glycol; PAG; polyalkylene glycol, turbine lubricant; polybutylene glycol; polyglycols; polypropylene glycol; turbine lubrication systems; water insoluble polyalkylene glycol