



Designation: D2880 – 23

Standard Specification for Gas Turbine Fuel Oils¹

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This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers the grades of fuels for gas turbines, excepting gas turbines used in aircraft, for the guidance of interested parties such as turbine manufacturers and the suppliers and purchasers of fuel oils. These grades are described as follows:

1.1.1 Grades No. 0-GT S5000, No. 0-GT S500, and No. 0-GT S15 includes naphtha, Jet B, and other light hydrocarbon liquids that characteristically have low flash point and low viscosity as compared with kerosine and fuel oils.

1.1.2 Grades No. 1-GT S5000, No. 1-GT S500, and No. 1-GT S15 are a light distillate fuel oil suitable for use in nearly all gas turbines.

1.1.3 Grades No. 2-GT S5000, No. 2-GT S500, and No. 2-GT S15, which is a heavier distillate than Grade No. 1-GT, can be used by gas turbines not requiring the clean burning characteristics of Grade No. 1-GT. Fuel heating equipment may be required by the gas turbine depending on the fuel system design or ambient temperature conditions, or both.

1.1.4 Grade No. 3-GT may be a heavier distillate than Grade No. 2-GT, a residual fuel oil that meets the low ash requirements, or a blend of distillate with a residual fuel oil. Fuel heating will be required by the gas turbine in almost every installation.

1.1.5 Grade No. 4-GT includes most residuals and some topped crudes. Because of the wide variation and lack of control of properties, the gas turbine manufacturer should be consulted with regard to acceptable limits on properties.

1.2 Three appendixes are provided for informational purposes only and do not constitute a requirement of this specification unless mutually agreed upon between the interested parties.

1.2.1 **Appendix X1** describes the five grades of gas turbine fuels covered by this specification. Further, it states the significance of various test methods used in inspecting the fuels.

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.E0 on Burner, Diesel and Non-Aviation Gas Turbine Fuels.

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1.2.2 **Appendix X2** discusses the sources of fuel contaminants and notes the significance of such contaminants in the operation of gas turbines and gas turbine fuel systems. The particular significance of trace metals in gas turbine fuels is noted. Upper limits of trace metals are recommended for the various grades of gas turbine fuels, but these recommended limits do not constitute a requirement of the specification unless mutually agreed upon by the interested parties. Limitations due to the use of used or recycled oil are also noted.

NOTE 1—The gas turbine operator should consult Practice D4418 for methods of ensuring fuels of adequate cleanliness and for guidance on long-term storage of distillate fuels and on liquids from non-petroleum sources as gas turbine.

NOTE 2—The generation and dissipation of static electricity can create problems in the handling of distillate gas turbine fuel oils. For more information on the subject, see Guide D4865.

1.3 This specification, unless otherwise provided by agreement between the purchaser and the supplier, prescribes the required properties of gas turbine fuel oils at the time and place of delivery.

1.4 Nothing in this specification shall preclude observance of federal, state, or local regulations which may be more restrictive.

1.5 *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

D56 Test Method for Flash Point by Tag Closed Cup Tester

D86 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure

D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester

D97 Test Method for Pour Point of Petroleum Products

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

- D129 Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device Method)
- D396 Specification for Fuel Oils
- D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
- D482 Test Method for Ash from Petroleum Products
- D524 Test Method for Ramsbottom Carbon Residue of Petroleum Products
- D975 Specification for Diesel Fuel
- D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
- D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
- D1552 Test Method for Sulfur in Petroleum Products by High Temperature Combustion and Infrared (IR) Detection or Thermal Conductivity Detection (TCD)
- D1796 Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)
- D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
- D2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
- D2709 Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge
- D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
- D3605 Test Method for Trace Metals in Gas Turbine Fuels by Atomic Absorption and Flame Emission Spectroscopy
- D3828 Test Methods for Flash Point by Small Scale Closed Cup Tester
- 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
- D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
- D4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
- D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
- D4308 Test Method for Electrical Conductivity of Liquid Hydrocarbons by Precision Meter
- D4418 Practice for Receipt, Storage, and Handling of Fuels for Gas Turbines
- D4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
- D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
- D5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
- D5949 Test Method for Pour Point of Petroleum Products (Automatic Pressure Pulsing Method)
- D5950 Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)
- D5985 Test Method for Pour Point of Petroleum Products (Rotational Method)
- D6079 Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR)
- D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
- D6728 Test Method for Determination of Contaminants in Gas Turbine and Diesel Engine Fuel by Rotating Disc Electrode Atomic Emission Spectrometry
- D6749 Test Method for Pour Point of Petroleum Products (Automatic Air Pressure Method)
- D7039 Test Method for Sulfur in Gasoline, Diesel Fuel, Jet Fuel, Kerosine, Biodiesel, Biodiesel Blends, and Gasoline-Ethanol Blends by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry
- D7042 Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
- D7094 Test Method for Flash Point by Modified Continuously Closed Cup (MCCCFP) Tester
- D7220 Test Method for Sulfur in Automotive, Heating, and Jet Fuels by Monochromatic Energy Dispersive X-ray Fluorescence Spectrometry
- D7344 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Mini Method)
- D7345 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation Method)
- D7346 Test Method for No Flow Point and Pour Point of Petroleum Products and Liquid Fuels
- D7688 Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR) by Visual Observation
- D7945 Test Method for Determination of Dynamic Viscosity and Derived Kinematic Viscosity of Liquids by Constant Pressure Viscometer
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- 2.2 *Other Documents:*³
- 26 CFR Part 48 Diesel Fuel Excise Tax; Dye Color and Concentration
- 40 CFR Part 80 Regulation of Fuels and Fuel Additives

3. Terminology

3.1 Definitions:

3.1.1 *contamination, n*—any process which introduces contaminants into the fuel.

3.1.2 *fuel contaminant, n*—material not intended to be present in a fuel, whether introduced during manufacture, handling, distribution or storage, that makes the fuel less suitable for the intended use.

3.1.2.1 *Discussion*—Contaminants, which can be soluble in the fuel or insoluble (suspended liquid droplets or solid or semi-solid particles), can be the result of improper processing or contamination by a wide range of materials including water,

³ Available from Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

rust, airblown dust, deterioration of internal protective coatings on pipes or vessels and products of fuel degradation and microbial growth.

3.1.2.2 *Discussion*—Solid or semisolid contaminants can be referred to as silt or sediment.

3.1.3 *hydrocarbon oil, n*—a homogeneous mixture with elemental composition primarily of carbon and hydrogen that may also contain sulfur, oxygen, or nitrogen from residual impurities and contaminants associated with the fuel's raw materials and manufacturing processes and excluding added oxygenated materials.

3.1.3.1 *Discussion*—Neither macro nor micro emulsions are included in this definition since neither are homogeneous mixtures.

3.1.3.2 *Discussion*—Examples of excluded oxygenated materials are alcohols, esters, ethers, and triglycerides.

3.1.3.3 *Discussion*—The hydrocarbon oil may be manufactured from a variety of raw materials, for example, petroleum (crude oil), oil sands, natural gas, coal and biomass. **Appendix X3** discusses some matters for consideration regarding the use of fuel oils from feedstocks other than petroleum.

3.1.4 *S(numerical specification maximum), n*—a part of the grade name that states the maximum sulfur content in ppm by mass (mg/kg) allowed by this specification and formatted as S followed with no space by the numerical sulfur maximum.

3.1.4.1 *Discussion*—Of the eleven fuel grades specified in this specification, nine have important distinguishing maximum sulfur regulatory requirements: Grades 0-GT S5000, 0-GT S500, 0-GT S15; No. 1-GT S5000, No. 1-GT S500, No. 1-GT S15; No. 2-GT S5000, No. 2-GT S500, and No. 2-GT S15. The remaining grades are distinguished from these grades by other major properties in addition to sulfur (unregulated levels), and therefore are not included in this designation system.

3.1.4.2 *Discussion*—mg/kg is equivalent to $\mu\text{g/g}$, $1 \times 10^{-4} \%$ by mass, and mass fraction 0.000001.

3.1.4.3 *Discussion*—Most, but not all, test methods to determine sulfur content mentioned in this specification produce results in units of mg/kg. Consult the test method in use to determine units for a particular result.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fuel entering the combustor(s), n*—the fuel that is actually burned in the gas turbine. Fuel may be sampled at a point upstream from the point of entry into the combustor(s), provided the sample is representative of the fuel actually entering the combustor(s).

4. General Requirements

4.1 The grades of gas turbine fuels herein specified shall be hydrocarbon oils with the use of additives to enhance performance properties, if required. The hydrocarbon oils shall be free of inorganic acid, and free of excessive amounts of solid or fibrous foreign matter likely to make frequent cleaning of suitable strainers necessary.

NOTE 3—Additives are generally included in finished gas turbine fuel oil to improve performance properties (corrosion and anti-corrosion, and so forth).

4.2 All grades containing residual components shall remain homogeneous in normal storage and not separated by gravity into light and heavy oil components outside the viscosity limits for the grade.

5. Detailed Requirements

5.1 The various grades of gas turbine fuel oil shall conform to the limiting requirements shown in **Tables 1 and 2**. As noted in the supplementary footnotes to **Table 1**, the requirements for Grade Nos. 1-GT and 2-GT conform in most respects to corresponding Grade Nos. 1 and 2 fuels in Specification **D396**, and to Grade Nos. 1-D and 2-D in Specification **D975**. The viscosity range of Grade Nos. 3-GT and 4-GT fuel brackets the Grade Nos. 4, 5, and 6 of Specification **D396** and Grade No. 4-D of Specification **D975**. It is the intent that fuels meeting Specification **D396** and **D975** requirements may also be supplied under these specifications provided they meet the requirements listed in **Tables 1 and 2**.

5.2 Modifications of limiting requirements and the inclusion of fuel additives to meet special operating conditions may be agreed upon between the interested parties.

5.3 The properties listed in this specification are those of greatest significance in obtaining acceptable performance of the turbine. However, trace metals, even in fractional parts per million, are detrimental to gas turbine service life. Information on the maximum concentration of critical metallic elements in the fuel as it enters the turbine combustor(s) is provided in **Appendix X2**. Distillate fuels are usually of satisfactory purity as refined, but suppliers rarely have control over possible contamination by trace metals in distribution and storage. The limits in **Appendix X2**, although required as the fuel enters the combustor(s), do not apply to the fuel as delivered unless mutually agreed upon by the interested parties. Fuels may, therefore, require on-site clean-up, quality control procedures, special handling, or other arrangements.

6. Test Methods

6.1 The requirements enumerated in this specification shall be determined in accordance with the following ASTM methods except as noted:

6.1.1 *Flash Point*—Test Methods **D93**, except where other methods are prescribed by law. For all grades, Test Method **D3828** and **D7094** may be used as an alternative with the same limits. For Grades No. 1-GT and No. 2-GT, Test Method **D56**⁴ may be used as an alternative with the same limits provided the flash point is below 93 °C and the viscosity is below 5.5 mm²/s at 40 °C. This test method will give slightly lower values. In case of dispute, Test Method **D93** shall be used as the referee method.

6.1.2 *Pour Point*—Test Method **D97**. For all grades, the automatic Test Methods **D5949**, **D5950**, **D5985**, or **D7346** may be used as alternates with the same limits. In case of dispute, Test Method **D97** shall be used as the referee method.

6.1.3 *Water and Sediment*—Test Method **D2709** is used for Grades 0-GT, 1-GT, and 2-GT. Test Method **D1796** is used for Grades 3-GT and 4-GT.

⁴ Other mutually acceptable methods may be used.