



## Standard Specification for Fuel Oils<sup>1</sup>

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

### 1. Scope

1.1 This specification (**Note 1**) covers grades of fuel oil intended for use in various types of fuel-oil-burning equipment under various climatic and operating conditions. These grades are described as follows:

1.1.1 Grades 1, 1 Low Sulfur, 2, and 2 Low Sulfur are middle distillate fuels for use in domestic and small industrial burners. Grades 1 and 1 Low Sulfur are particularly adapted to vaporizing type burners or where storage conditions require low pour point fuel.

1.1.2 Grades 4 (Light) and 4 are heavy distillate fuels or distillate/residual fuel blends used in commercial/industrial burners equipped for this viscosity range.

1.1.3 Grades 5 (Light), 5 (Heavy), and 6 are residual fuels of increasing viscosity and boiling range, used in industrial burners. Preheating is usually required for handling and proper atomization.

**NOTE 1**—For information on the significance of the terminology and test methods used in this specification, see **Appendix X1**.

**NOTE 2**—A more detailed description of the grades of fuel oils is given in **X1.3**.

1.2 This specification is for the use of purchasing agencies in formulating specifications to be included in contracts for purchases of fuel oils and for the guidance of consumers of fuel oils in the selection of the grades most suitable for their needs.

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

1.4 All values are stated in SI units and are regarded as standard.

**NOTE 3**—The generation and dissipation of static electricity can create problems in the handling of distillate burner fuel oils. For more information on the subject, see Guide D 4865 **D 4865**.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee **D02** on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee **D02.E0** on Burner, Diesel, Non-Aviation Gas Turbine, and Marine Fuels.

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### 2. Referenced Documents

#### 2.1 ASTM Standards:

- D 56** Test Method for Flash Point by Tag Closed Tester<sup>2</sup>
- D 86** Test Method for Distillation of Petroleum Products at Atmospheric Pressure<sup>2</sup>
- D 93** Test Methods for Flash Point by Pensky-Martens Closed Cup Tester<sup>2</sup>
- D 95** Test Method for Water in Petroleum Products and Bituminous Materials by Distillation<sup>2</sup>
- D 97** Test Method for Pour Point of Petroleum Products<sup>2</sup>
- D 129** Test Method for Sulfur in Petroleum Products (General Bomb Method)<sup>2</sup>
- D 130** Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test<sup>2</sup>
- D 445** Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity)<sup>2</sup>
- D 473** Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method<sup>2</sup>
- D 482** Test Method for Ash from Petroleum Products<sup>2</sup>
- D 524** Test Method for Ramsbottom Carbon Residue of Petroleum Products<sup>2</sup>
- D 975** Specification for Diesel Fuel Oils<sup>2</sup>
- D 1266** Test Method for Sulfur in Petroleum Products (Lamp Method)<sup>2</sup>
- D 1298** Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method<sup>2</sup>
- D 1552** Test Method for Sulfur in Petroleum Products (High-Temperature Method)<sup>2</sup>
- D 2500** Test Method for Cloud Point of Petroleum Products<sup>2</sup>
- D 2622** Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry<sup>2</sup>
- D 2709** Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge<sup>2</sup>

<sup>2</sup> Annual Book of ASTM Standards, Vol 05.01.

- D 3245 Test Method for Pumpability of Industrial Fuel Oils<sup>3</sup>
- D 3828 Test Methods for Flash Point by Small Scale Closed Tester<sup>3</sup>
- D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter<sup>3</sup>
- D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products<sup>3</sup>
- D 4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectrometry<sup>3</sup>
- D 4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems<sup>3</sup>
- D 5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by Ultraviolet Fluorescence<sup>4</sup>
- D 5949 Test Method for Pour Point of Petroleum Products (Automatic Pressure Pulsing Method)<sup>4</sup>
- D 5950 Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)<sup>4</sup>
- D 5985 Test Method for Pour Point of Petroleum Products (Rotational Method)<sup>4</sup>
- D 6469 Guide to Microbial Contamination in Fuels and Fuel Systems<sup>5</sup>

#### 2.2 Other Documents:<sup>6</sup>

- 26 CFR Part 48 Diesel Fuel Excise Tax; Dye Color and Concentration
- 40 CFR Part 80 Regulation of Fuel and Fuel Additives

### 3. General Requirements

3.1 The grades of fuel oil specified herein shall be homogeneous hydrocarbon oils, free from inorganic acid, and free from excessive amounts of solid or fibrous foreign matter.

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

### 4. Detailed Requirements

4.1 The various grades of fuel oil shall conform to the limiting requirements shown in **Table 1**. A representative sample shall be taken for testing in accordance with Practice D 4057D 4057.

4.2 Modifications of limiting requirements to meet special operating conditions agreed upon between the purchaser, the seller, and the supplier shall fall within limits specified for each grade, except as stated in supplementary footnotes for **Table 1**.

### 5. Test Methods

5.1 The requirements enumerated in this specification shall be determined in accordance with the following ASTM test methods,<sup>7</sup> except as may be required under 5.1.1.

5.1.1 *Flash Point*—Test Method D 93D 93, except where other methods are prescribed by law. For all grades, Test Method D 3828D 3828 may be used as an alternate with the same limits. For Grades No. 1 and No. 2, Test Method D 56D 56 may be used as an alternate with the same limits, provided the flash point is below 93°C and the viscosity is below 5.5 mm<sup>2</sup>/s at 40°C. This test method will give slightly lower values. In cases of dispute, Test Method D 93D 93 shall be used as the referee method.

5.1.2 *Pour Point*—Test Method D 97D 97. For all grades, the automatic Test Methods D 5949D 5949, D 5950D 5950, and D 5985D 5985 can be used as alternates with the same limits. In case of dispute, Test Method 97D 97 shall be used as the referee method. Alternative test methods that indicate flow point properties can be used for low sulfur residual fuels by agreement between purchaser and supplier.

5.1.3 *Water and Sediment*—The water and sediment in Grade Nos. 1 and 2 shall be determined in accordance with Test Method D 2709D 2709 and in Grade Nos. 4, 5, and 6 by Test Method D 95D 95 and Test Method D 473D 473. A density of 1.0 kg/L shall be used for the Test Method D 95D 95 water.

5.1.4 *Carbon Residue*—Test Method D 524D 524.

5.1.5 *Ash*—Test Method D 482D 482.

5.1.6 *Distillation*—Distillation of Grade No. 1 and No. 2 oils shall be determined in accordance with Test Method D 86D 86.

5.1.7 *Viscosity*—Viscosity shall be determined in accordance with Test Method D 445D 445.

5.1.8 *Density*—Practice D 1298D 1298. Test Method D 4052D 4052 can be used as an alternate with the same limits. In case of dispute, Practice D 1298D 1298 shall be used as the referee method.

5.1.9 *Corrosion*—Test Method D 130D 130, 3 h test at 50°C.

5.1.10 *Sulfur*—Test Method D 129D 129 for Grades 1, 2, 4, 5, and 6 and Test Method D 2622D 2622 for Grades 1 Low Sulfur and 2 Low Sulfur. Test Methods D 1552, D 2622D 2622, and D 4294D 1552D 2622D 4294 can also be used for all grades. In addition, Test Method D 1266D 1266 can be used for Grades 1 and 1 Low Sulfur, but only with samples having sulfur contents of 0.4 mass % and less (down to 0.01 %). Test Method D 5453D 5453 can be used for Grades 1 and 2 fuel oils, but only with samples having sulfur contents of 0.8 mass % and less (down to 0.001 %). In case of dispute, Test Method D 129D 129 is the referee test method for Grades 1, 2, 4, 5, and 6 of this specification and Test Method D 2622D 2622 is the referee test method for Grades 1 Low Sulfur and 2 Low Sulfur.

<sup>3</sup> Annual Book of ASTM Standards, Vol 05.02.

<sup>4</sup> Annual Book of ASTM Standards, Vol 05.03.

<sup>5</sup> Annual Book of ASTM Standards, Vol 05.04.

<sup>6</sup> Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

<sup>7</sup> For information on the precision of the ASTM test methods for fuel oils refer to "An Evaluation of Methods for Determination of Sulfur in Fuel Oils" by A. R. Crawford, Esso Mathematics and Systems Inc. and G. V. Dyroff, Esso Research and Engineering Co., 1969. This document is available from the Publications Section, API Library, American Petroleum Institute, 1220 L St., N.W., Washington, DC 20005.

**TABLE 1 Detailed Requirements for Fuel Oils<sup>A</sup>**

Property	ASTM Test Method <sup>B</sup>	No. 1 Low Sulfur <sup>C</sup>	No. 1 <sup>C</sup>	No. 2 Low Sulfur <sup>C</sup>	No. 2 <sup>C</sup>	Grade No. 4 (Light) <sup>C</sup>	No. 4	No. 5 (Light)	No. 5 (Heavy)	No. 6
Flash Point °C, min	D 93D 93	38	38	38	38	38	55	55	55	60
Water and sediment, % vol, max	D 2709	0.05	0.05	0.05	0.05	...	...	...	...	...
	D 95D 95 + D 473 ...	...	...	...	...	(0.50) <sup>D</sup>	(0.50) <sup>D</sup>	(1.00) <sup>D</sup>	(1.00) <sup>D</sup>	(2.00) <sup>D</sup>
Distillation temperature °C	D 86D 86									
10 % volume recovered, max		215	215	...	...	...	...	...	...	...
90 % volume recovered, min		...	...	282	282	...	...	...	...	...
90 % vol recovered, max		288	288	338	338	...	...	...	...	...
Kinematic viscosity at 40°C, mm <sup>2</sup> /s	D 445									
min		1.3	1.3	1.9	1.9	1.9	>5.5	...	...	...
max		2.1	2.1	3.4	3.4	5.5	24.0 <sup>E</sup>	...	...	...
Kinematic viscosity at 100°C, mm <sup>2</sup> /s	D 445									
min		...	...	...	...	...	...	5.0	9.0	15.0
max		...	...	...	...	...	...	8.9 <sup>E</sup>	14.9 <sup>E</sup>	50.0 <sup>E</sup>
Ramsbottom carbon residue on 10 % distillation residue % mass, max	D 524	0.15	0.15	0.35	0.35	...	...	...	...	...
Ash, % mass, max	D 482	...	...	...	...	0.05	0.10	0.15	0.15	...
Sulfur, % mass max <sup>F</sup>	D 129	...	0.50	...	0.50	...	...	...	...	...
	D 2622	0.05	...	0.05	...	...	...	...	...	...
Copper strip corrosion rating, max, 3 h at 50°C	D 130	No. 3	No. 3	No. 3	No. 3	...	...	...	...	...
Density at 15°C, kg/m <sup>3</sup>	D 1298									
min		...	...	...	...	>876 <sup>G</sup>	...	...	...	...
max		850	850	876	876	...	...	...	...	...
Pour Point °C, max <sup>H</sup>	D 97D 97	-18	-18	-6	-6	-6	-6	...	...	<sup>I</sup>

<sup>A</sup> It is the intent of these classifications that failure to meet any requirement of a given grade does not automatically place an oil in the next lower grade unless in fact it meets all requirements of the lower grade. However, to meet special operating conditions, modifications of individual limiting requirements may be agreed upon among the purchaser, seller, and manufacturer.

<sup>B</sup> The test methods indicated are the approved referee methods. Other acceptable methods are indicated in Section 2 and 5.1.

<sup>C</sup> Under United States regulations, Grades No. 1, No. 1 Low Sulfur, No. 2, No. 2 Low Sulfur, and No.4 (Light) are required by 40 CFR Part 80 to contain a sufficient amount of the dye Solvent Red 164 so its presence is visually apparent. At or beyond terminal storage tanks, they are required by 26 CFR Part 48 to contain the dye Solvent Red 164 at a concentration spectrally equivalent to 3.9 lb per thousand barrels of the solid dye standard Solvent Red 26.

<sup>D</sup> The amount of water by distillation by Test Method D 95D 95 plus the sediment by extraction by Test Method D 473D 473 shall not exceed the value shown in the table. For Grade No. 6 fuel oil, the amount of sediment by extraction shall not exceed 0.50 mass %, and a deduction in quantity shall be made for all water and sediment in excess of 1.0 mass %.

<sup>E</sup> Where low sulfur fuel oil is required, fuel oil falling in the viscosity range of a lower numbered grade down to and including No. 4 can be supplied by agreement between the purchaser and supplier. The viscosity range of the initial shipment shall be identified and advance notice shall be required when changing from one viscosity range to another. This notice shall be in sufficient time to permit the user to make the necessary adjustments.

<sup>F</sup> Other sulfur limits may apply in selected areas in the United States and in other countries.

<sup>G</sup> This limit ensures a minimum heating value and also prevents misrepresentation and misapplication of this product as Grade No. 2.

<sup>H</sup> Lower or higher pour points can be specified whenever required by conditions of storage or use. When a pour point less than -18°C is specified, the minimum viscosity at 40°C for grade No. 2 shall be 1.7 mm<sup>2</sup>/s and the minimum 90 % recovered temperature shall be waived.

<sup>I</sup> Where low sulfur fuel oil is required, Grade No. 6 fuel oil will be classified as Low Pour (+15°C max) or High Pour (no max). Low Pour fuel oil should be used unless tanks and lines are heated.

## 6. Keywords

6.1 burner fuels; fuel oils; furnace oils; petroleum and petroleum products

## APPENDIX

### (Nonmandatory Information)

#### X1. SIGNIFICANCE OF ASTM SPECIFICATION FOR FUEL OILS

##### X1.1 Scope

X1.1.1 This specification divides fuel oils into grades based upon the types of burners for which they are suitable. It places limiting values on several of the properties of the oils in each grade. The properties selected for limitation are those that are believed to be of the greatest significance in determining the

performance characteristics of the oils in the types of burners in which they are most commonly used.

##### X1.2 Classes

X1.2.1 Because of the methods employed in their production, fuel oils fall into two broad classifications: distillates and