Designation: D396 – 10

Standard Specification for Fuel Oils[1]

This standard is issued under the fixed designation D396; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification (see 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 No. 1 S5000, No. 1 S500, No. 2 S5000, and No. 2 S500 are middle distillate fuels for use in domestic and small industrial burners. Grades No. 1 S5000 and No. 1 S500 are particularly adapted to vaporizing type burners or where storage conditions require low pour point fuel.

1.1.2 Grades No. 4 (Light) and No. 4 are heavy distillate fuels or middle distillate/residual fuel blends used in commercial/industrial burners equipped for this viscosity range.

1.1.3 Grades No. 5 (Light), No. 5 (Heavy), and No. 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 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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 D4865.

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 at Atmospheric Pressure
D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D97 Test Method for Pour Point of Petroleum Products
D129 Test Method for Sulfur in Petroleum Products (General Bomb Method)
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)
D473 Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method
D482 Test Method for Ash from Petroleum Products
D524 Test Method for Ramsbottom Carbon Residue of Petroleum Products
D975 Specification for Diesel Fuel Oils
D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
D1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
D1552 Test Method for Sulfur in Petroleum Products (High-Temperature Method)
D2500 Test Method for Cloud Point of Petroleum Products
D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
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

[1] 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] 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.**

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
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
D5842 Practice for Sampling and Handling of Fuels for Volatility Measurement
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)
D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
D6749 Test Method for Pour Point of Petroleum Products (Automatic Air Pressure Method)
D6751 Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels
D6892 Test Method for Pour Point of Petroleum Products (Robotic Tilt Method)
D7039 Test Method for Sulfur in Gasoline and Diesel Fuel by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry

2.2 *Other Documents:*

26 CFR Part 48 Diesel Fuel Excise Tax; Dye Color and Concentration[3]
40 CFR Part 80 Regulation of Fuel and Fuel Additives[3]
EN 14078 Determination of fatty acid methyl ester (FAME) content in middle distillates — Infrared spectrometry method[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *biodiesel*, *n*—fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100.

3.1.2 *biodiesel blend (BXX)*, *n*—blend of biodiesel fuel with fuel oils.

3.1.2.1 *Discussion*—In the abbreviation BXX, the XX represents the volume percentage of biodiesel fuel in the blend.

4. General Requirements

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

4.2 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.

4.3 *Fuels Blended with Biodiesel*—The detailed requirements for fuels blended with biodiesel shall be as follows:

4.3.1 *Biodiesel for Blending*—If biodiesel is a component of any fuel oil, the biodiesel shall meet the requirements of Specification D6751.

4.3.2 Fuel oil containing up to 5 vol% biodiesel shall meet the requirements for the appropriate grade No. 1 or No. 2 fuel as listed in Table 1.

4.3.3 Test Method EN 14078 shall be used for determination of the vol% biodiesel in a biodiesel blend.

4.3.4 Fuel oils containing more than 5 vol% biodiesel component are not included in this specification.

4.3.5 Biodiesel blends with Grades 4, 5, or 6 are not covered by this specification.

5. Detailed Requirements

5.1 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 D4057.

5.2 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.

6. Sampling, Containers, and Sample Handling

6.1 The reader is strongly advised to review all intended test methods prior to sampling in order to understand the importance and effects of sampling technique, proper containers, and special handling required for each test method.

6.2 Correct sampling procedures are critical to obtaining a sample representative of the fuel oil to be tested. Refer to X1.4 for recommendations. The recommended procedures or practices provide techniques useful in the proper sampling or handling of fuels oils.

7. Test Methods

7.1 The requirements enumerated in this specification shall be determined in accordance with the following ASTM test methods,[5] except as may be required under 7.1.1.

[3] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

[4] Available from the National CEN members listed on the CEN website (www.cenorm.be) or from the CEN/TC 19 Secretariat (astm@nen.nl).

[5] 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., NW, Washington, DC 20005.

TABLE 1 Detailed Requirements for Fuel Oils[A]

Property	ASTM Test Method[B]	No. 1 S500[B]	No. 1 S5000[B]	No. 2 S500[B]	No. 2 S5000[B]	No. 4 (Light)[B]	No. 4	No. 5 (Light)	No. 5 (Heavy)	No. 6
Flash Point, °C, min	D93 – Proc. A	38	38	38	38	38	...	...	...	...
	D93 – Proc. B	...	...	...	...	...	55	55	55	60
Water and sediment, % vol, max	D2709	0.05	0.05	0.05	0.05	...	...	...	...	...
	D95 + D473	...	...	...	...	(0.50)[C]	(0.50)[C]	(1.00)[C]	(1.00)[C]	(2.00)[C]
Distillation Temperature, °C	D86									
10 % volume recovered, max		215	215	...	...					
90 % volume recovered, min		...	...	282	282					
90 % volume recovered, max		288	288	338	338					
Kinematic viscosity at 40°C, mm^2/s	D445									
min		1.3	1.3	1.9	1.9	1.9	>5.5	...	...	...
max		2.4	2.4	4.1	4.1	5.5	24.0[D]			
Kinematic viscosity at 100°C, mm^2/s	D445									
min		...	...	...	...	...	...	5.0	9.0	15.0
max		...	...	...	...	...	...	8.9[D]	14.9[D]	50.0[D]
Ramsbottom carbon residue on 10 % distillation residue % mass, max	D524	0.15	0.15	0.35	0.35	...	...	...	...	...
Ash, % mass, max	D482	...	...	...	...	0.05	0.10	0.15	0.15	...
Sulfur, % mass max[E]	D129	...	0.5	...	0.5	...	...	...	...	...
	D2622	0.05	...	0.05	...					
Copper strip corrosion rating, max, 3 h at a minimum control temperature of 50°C	D130	No. 3	No. 3	No. 3	No. 3	...	...	...	...	...
Density at 15°C, kg/m^3	D1298									
min		...	...	...	...	>876[F]	...	...	...	...
max		850	850	876	876	...	...	...	...	...
Pour Point °C, max[G]	D97	–18	–18	–6	–6	–6	–6	...	...	[H]

[A] 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.

[B] Under United States regulations, Grades No. 1 S5000, No. 1 S500, No. 2 S5000, No. 2 S500, 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.

[C] The amount of water by distillation by Test Method D95 plus the sediment by extraction by Test Method D473 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 %.

[D] 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.

[E] Other sulfur limits may apply in selected areas in the United States and in other countries.

[F] This limit ensures a minimum heating value and also prevents misrepresentation and misapplication of this product as Grade No. 2.

[G] 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^2/s and the minimum 90 % recovered temperature shall be waived.

[H] 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.

7.1.1 *Flash Point*—Test Method D93 (Procedure A) for Grades No. 1 S5000, No. 1 S500, No. 2 S5000, No. 2 S500, and No. 4 (Light), and Test Method D93 (Procedure B) for Grades No. 4, No. 5 (Light), No. 5 (Heavy), and No. 6, except where other methods are prescribed by law. For Grades No. 1 S5000, No. 1 S500, No. 2 S5000, No. 2 S500, and No. 4 (Light), Test Methods D3828 may be used as an alternate with the same limits. For Grades No. 1, No. 1 Low Sulfur, No. 2, and No. 2 Low Sulfur, Test Method D56 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^2/s at 40°C. This test method will give slightly lower values. In cases of dispute, Test Method D93, with the appropriate procedure, shall be used as the referee method.

7.1.2 *Pour Point*—Test Method D97. For all grades, the automatic Test Methods D5949, D5950, D5985, D6749, and D6892 can be used as alternates with the same limits. In case of dispute, Test Method D97 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.

7.1.3 *Water and Sediment*—The water and sediment in Grade No. 1 S500, No. 1 S5000, No. 2 S500, and No. 2 S5000 shall be determined in accordance with Test Method D2709 and in Grade Nos. 4, 5, and 6 by Test Method D95 and Test Method D473. A density of 1.0 kg/L shall be used for the Test Method D95 water.

7.1.4 *Carbon Residue*—Test Method D524.

7.1.5 *Ash*—Test Method D482.

7.1.6 *Distillation*—Distillation of Grade No. 1 and No. 2 oils shall be determined in accordance with Test Methods D86 or D2887.[6] Results from Test Method D2887 shall be reported as "Predicted D86" results by application of the correlation in Appendix X5 Test Method D2887 to convert the values. In case of dispute, Test Method D86 shall be used as the referee test method.

7.1.7 *Viscosity*—Viscosity shall be determined in accordance with Test Method D445.

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1553.

TABLE 2 Sulfur Test Methods

Sulfur Test Method	Range	Grades	Units Used to Report Results
D129 (referee)	>0.1 mass%	No. 1 S5000, No. 2 S5000, No. 4 (Light), No. 5 (Heavy), No. 6	mass%
D1266	0.01 to 0.4 mass%	No. 1 S500, No. 2 S500	mass%
D1552	>0.06 mass%	No. 1 S5000, No. 2 S5000, No. 4 (Light), No. 4, No. 5 (Light), No. 5 (Heavy), No. 6	mass%
D2622 (referee for S500 grades)	0.0003 to 5.3 mass%	All Grades	mass%
D4294	0.0150 to 5.00 mass%	All Grades	mass%
D5453	1.0 to 8000 mg/kg (0.0001 to 0.8 mass%)	All Grades	mg/kg
D7039	4 to 17 mg/kg (0.0004 to 0.0017 mass%)	S500 grades only if the sulfur result is less than 17 mg/kg	mg/kg

7.1.8 *Density*—Test Method D1298. Test Method D4052 can be used as an alternate with the same limits. In case of dispute, Test Method D1298 shall be used as the referee method.

7.1.9 *Corrosion*—Test Method D130, 3-h test at a minimum control temperature of 50°C.

7.1.10 *Sulfur*—Table 2 shows the referee test methods and alternate test methods for sulfur, the range over which each test applies, and the corresponding fuel grades.

8. Keywords

8.1 biodiesel; biodiesel blend; 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 residuals. The distillates consist of overhead or distilled fractions. The residuals are bottoms remaining from the distillation, or blends of these bottoms with distillates. In this specification, Grades No. 1 and No. 2 are distillates and the grades from No. 4 to No. 6 are usually residual, although some heavy distillates can be sold as Grade No. 4.

X1.3 Grades

X1.3.1 *Grades No. 1 S5000 and No. 1 S500* are middle distillates intended for use in burners of the vaporizing type in which the oil is converted to a vapor by contact with a heated surface or by radiation. High volatility is necessary to ensure that evaporation proceeds with a minimum of residue. The low sulfur grade S500 may be specified by federal, state, or local regulations and can result in reduced deposits on ferrous heat exchanger surfaces compared to Grade No. 1 S5000 when burned under similar conditions.

X1.3.2 *Grades No. 2 S5000 and No. 2 S500* are middle distillates somewhat heavier than grades No. 1 S5000 and No. 1 S500. They are intended for use in atomizing type burners which spray the oil into a combustion chamber where the tiny droplets burn while in suspension. These grades of oil are used in most domestic burners and in many medium capacity commercial-industrial burners where ease of handling and ready availability sometimes justify higher cost over the residual fuels. The low sulfur grade S500 may be specified by federal, state, or local regulations and can result in reduced deposits on ferrous heat exchanger surfaces compared to Grade No. 2 S5000 when burned under similar conditions.

X1.3.3 *Grade No. 4 (Light)* is a heavy distillate fuel or distillate/residual fuel blend meeting the specification viscosity range. It is intended for use both in pressure-atomizing commercial-industrial burners not requiring higher cost distillates and in burners equipped to atomize oils of higher viscosity. Its permissible viscosity range allows it to be pumped and atomized at relatively low-storage temperatures.

X1.3.4 *Grade No. 4* is usually a heavy distillate/residual fuel blend but can be a heavy distillate fuel meeting the specification viscosity range. It is intended for use in burners equipped with devices that atomize oils of higher viscosity than domestic burners can handle. Its permissible viscosity range allows it to be pumped and atomized at relatively low storage temperatures. Thus, in all but extremely cold weather it requires no preheating for handling.

X1.3.5 *Grade No. 5 (Light)* is residual fuel of intermediate viscosity for burners capable of handling fuel more viscous

than grade No. 4 without preheating. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.6 *Grade No. 5 (Heavy)* is a residual fuel more viscous than Grade No. 5 (Light) and is intended for use in similar service. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.7 *Grade No. 6*, sometimes referred to as Bunker C, is a high-viscosity oil used mostly in commercial and industrial heating. It requires preheating in the storage tank to permit pumping, and additional preheating at the burner to permit atomizing. The extra equipment and maintenance required to handle this fuel usually preclude its use in small installations.

X1.3.8 Residual fuel oil supplied to meet regulations requiring low sulfur content can differ from the grade previously supplied. It may be lower in viscosity (and fall into a different grade number). If it must be fluid at a given temperature, Test Method D97 need not accurately reflect the pour point which can be expected after a period of storage. It is suggested that the purchaser and supplier discuss the proper handling and operating techniques for a given low-sulfur residual fuel oil in the installation where it is to be used.

X1.4 Sampling, Containers, and Sample Handling

X1.4.1 *Introduction*—This appendix section provides guidance on methods and techniques for the proper sampling of fuel oils. As fuel oil specifications become more stringent, and contaminants and impurities become more tightly controlled, even greater care needs to be taken in collecting and storing samples for quality assessment.

X1.4.2 *Sampling, Containers, and Sample Handling Recommendations*:

X1.4.2.1 Appropriate manual method sampling procedures found in Practice D4057, and automatic method sampling is covered in Practice D4177.

X1.4.2.2 The correct sample volume and appropriate container selection are important decisions that can impact test results. Refer to Practice D4306 for aviation fuel container selection for tests sensitive to trace contamination. Refer to Practice D5854 for procedures on container selection and sample mixing and handling.

X1.4.2.3 For volatility determination of a sample, refer to Practice D5842 for special precautions recommended for representative sampling and handling instructions.

X1.5 Significance of Test Methods

X1.5.1 The significance of the properties of fuel oil on which limitations are placed by the specification is as follows:

X1.5.1.1 *Flash Point*—The flash point of a fuel oil is an indication of the maximum temperature at which it can be stored and handled without serious fire hazard. The minimum permissible flash point is usually regulated by federal, state, or municipal laws and is based on accepted practice in handling and use.

X1.5.1.2 *Reduced Temperature Properties*—The fuel's cloud and pour points are good measures for determining low temperature operability with a batch of fuel oil. It is especially important to consider these fuel properties if the heating oil will be subjected to low ambient temperatures at time of use. Fuel temperatures can fluctuate markedly in small, residential, outdoor, above ground tanks compared with indoor, basement tanks, or underground tanks. A decrease or stoppage of fuel flow can occur in small transfer lines used for residential heating applications because the fuel line temperature will fluctuate with ambient temperature faster than will bulk tank contents. Fuel oils purchased during the summer, but not used until the cold heating season arrives, can be a serious source of problems. This is because when these fuels are produced they are intended for use during the warm season and thus typically have higher cloud and pour points than fuels produced for use during the cold season. Fuels can be produced for use at low temperatures with lower cloud and pour points by blending with low paraffin fuels, such as kerosine or No. 1 fuel, and additives, or a combination thereof, to improve low temperature operability. The key to effective treatment is routine monitoring of incoming and stored fuels, and testing of the treated fuels. Although this specification only sets maximum limits for the pour point, the recommendations for cloud point of distillate fuels in Specification D975 may be applied to heating fuels under extreme cold conditions. Some pipeline companies or local specifications have included requirements for both cloud and pour points for certain grades of fuel oil.

(1) Pour Point—The pour point is an indication of the lowest temperature at which a fuel oil is capable of flowing under very low forces. The pour point is prescribed in accordance with the conditions of storage and use. Higher pour point fuels are permissible where heated storage and adequate piping facilities are provided. An increase in pour point can occur when residual fuel oils are subjected to cyclic temperature variations that can occur in the course of storage or when the fuel is preheated and returned to storage tanks.

(2) Cloud Point (Test Method D2500)—The cloud point defines the temperature at which a cloud or haze of wax crystals appears in the oil under prescribed test conditions which generally relates to the temperature at which wax crystals begin to precipitate from the oil in use. It is generally observed that cloud point temperature of a fuel oil is higher than its pour point by several degrees Celsius. Fuel oils stored at, or below, their cloud point temperature can have suspended wax crystals that may cause operability problems due to plugging. Examples are when fuels are pumped through small openings or passageways, that is, oil-line filters, burner nozzles, and pump strainers. The plugging is reversible when the fuel is warmed.

X1.5.1.3 *Water and Sediment*—Appreciable amounts of water and sediment in a fuel oil tend to cause fouling of facilities for handling it, and to give trouble in burner mechanisms. Sediment may accumulate in storage tanks and on filter screens or burner parts, resulting in obstruction to flow of oil from the tank to the burner. Water in distillate fuels can cause corrosion of tanks and equipment and it can cause emulsions in residual fuels.

X1.5.1.4 *Carbon Residue*—The carbon residue of a fuel is a measure of the carbonaceous material left after all the volatile components are vaporized in the absence of air. It is a rough approximation of the tendency of a fuel to form deposits in

vaporizing burners, such as pot-type and sleeve-type burners, where the fuel is vaporized in an air-deficient atmosphere.

X1.5.1.4.1 To obtain measurable values of carbon residue in the lighter distillate fuel oils, it is necessary to distill the oil to remove 90 % of it in accordance with Section 9 of Test Method D524, and then determine the carbon residue concentrated in the remaining 10 % bottoms.

X1.5.1.5 *Ash*—The amount of ash is the quantity of non-combustible material in an oil. Excessive amounts can indicate the presence of materials that cause high wear of burner pumps and valves, and contribute to deposits on boiler heating surfaces.

X1.5.1.6 *Distillation*—The distillation test shows the volatility of a fuel and the ease with which it can be vaporized. The test is of greater significance for oils that are to be burned in vaporizing type burners than for the atomizing type. For example, the maximum 10 % and 90 % distilled temperatures are specified for grade No. 1 fuel. The limiting 10 % value ensures easy starting in vaporizing type burners and the 90 % limit excludes heavier fractions that would be difficult to vaporize.

(1) The limits specified for grade No. 2 heating oil define a product that is acceptable for burners of the atomizing type in household heating installations. Distillation limits are not specified for fuel oils of grades Nos. 4, 5, and 6.

X1.5.1.7 *Viscosity Limits for Grades Nos. 1 and 2*—The viscosity of an oil is a measure of its resistance to flow. In fuel oil it is highly significant since it indicates both the relative ease with which the oil will flow or can be pumped, and the ease of atomization.

(1) Viscosity limits for No. 1 and No. 2 grades are specified to help maintain uniform fuel flow in appliances with gravity flow, and to provide satisfactory atomization and constant flow rate through the small nozzles of household burners. For the heavier grades of industrial and bunker fuel oils, viscosity is of major importance, so that adequate preheating facilities can be provided to permit them to be pumped to the burner and to provide good atomization. However, it is equally important that the maximum viscosity under the existing conditions be such that the oil can be pumped satisfactorily from the storage tank to the preheater.

X1.5.1.8 *Density*—Density alone is of little significance as an indication of the burning characteristics of fuel oil. However, when used in conjunction with other properties, it is of value in mass-volume relationships and in calculating the specific energy (heating value) of an oil.

X1.5.1.9 *Corrosion*—The corrosion test serves to indicate the presence or absence of materials that could corrode copper, brass, and bronze components of the fuel system. This property is specified only for Nos. 1 and 2 distillate fuel oils.

X1.5.1.10 Limited sulfur content of fuel oil can be required for special uses in connection with heat treatment, nonferrous metal, glass, and ceramic furnaces or to meet federal, state, or local legislation or regulations.

X1.5.1.11 *Nitrogen*—Nitrogen oxide emission regulations have been imposed on certain combustion facilities as a function of fuel nitrogen content. For purposes of these regulations, distillate fuels, low nitrogen residual fuels, and high nitrogen residual fuels have been defined by their nitrogen content. Installations are required to meet different emission standards according to the classification of the fuel being used. When regulations require such a distinction to be made, fuel nitrogen specifications can be needed in the contractual agreement between the purchaser and the supplier.

X1.6 Other

X1.6.1 *Microbial Contamination*—Refer to Guide D6469 for a discussion of this form of contamination.

SUMMARY OF CHANGES

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D396–09a) that may impact the use of this standard. (Approved Oct. 1, 2010.)

(*1*) Removed Test Method D3245 from the Referenced Documents and the standard text.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D396–09) that may impact the use of this standard. (Approved Oct. 1, 2009.)

(*1*) Added Test Method D7039 to Referenced Documents and 7.1.10.
(*2*) Revised 7.1.10.
(*3*) Revised Table 1.
(*4*) Added Table 2.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D396–08c) that may impact the use of this standard. (Approved April 1, 2009.)

(*1*) Added Test Method D6749 and Test Method D6892 to the Referenced Documents and 7.1.2.