



Designation: D6615 – 22

# Standard Specification for Jet B Wide-Cut Aviation Turbine Fuel<sup>1</sup>

This standard is issued under the fixed designation D6615; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope\*

1.1 This specification covers the use of purchasing agencies in formulating specifications for purchases of aviation turbine fuel under contract.

1.2 This specification defines one specific type of aviation turbine fuel for civil use. This fuel has advantages for operations in very low temperature environments compared with other fuels described in Specification D1655. This fuel is intended for use in aircraft that are certified to use such fuel.

1.3 This specification does not define the quality assurance testing and procedures necessary to ensure that fuel in the distribution system continues to comply with this specification after batch certification. Such procedures are defined elsewhere, for example in ICAO 9977, EI/JIG Standard 1530, JIG 1, JIG 2, API 1543, API 1595, and ATA-103.

1.4 *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:<sup>2</sup>

- D86 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure
- D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
- D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)
- D381 Test Method for Gum Content in Fuels by Jet Evaporation
- D1094 Test Method for Water Reaction of Aviation Fuels

<sup>1</sup> 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.J0.01 on Jet Fuel Specifications.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- 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
- D1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
- D1322 Test Method for Smoke Point of Kerosene and Aviation Turbine Fuel
- D1655 Specification for Aviation Turbine Fuels
- D1660 Method of Test for Thermal Stability of Aviation Turbine Fuels (Withdrawn 1992)<sup>3</sup>
- D1840 Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry
- D2276 Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling
- D2386 Test Method for Freezing Point of Aviation Fuels
- 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
- D3227 Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosene, Aviation Turbine, and Distillate Fuels (Potentiometric Method)
- D3240 Test Method for Undissolved Water In Aviation Turbine Fuels
- D3241 Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels
- D3338/D3338M Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
- D3948 Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separator
- 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
- D4171 Specification for Fuel System Icing Inhibitors
- D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

\*A Summary of Changes section appears at the end of this standard

- D4176** Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
- 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
- D4529** Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
- D4809** Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
- D4865** Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
- D4952** Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)
- D5001** Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)
- D5006** Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
- D5191** Test Method for Vapor Pressure of Petroleum Products and Liquid Fuels (Mini Method)
- D5452** Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
- D5453** Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
- D5972** Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)
- D6379** Test Method for Determination of Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates—High Performance Liquid Chromatography Method with Refractive Index Detection
- E29** Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

## 2.2 *EI Standard*.<sup>4</sup>

**EI/JIG 1530** Quality Assurance Requirements for the Manufacture, Storage and Distribution of Aviation Fuels to Airports

## 2.3 *API Standards*.<sup>5</sup>

**API 1543** Documentation, Monitoring and Laboratory Testing of Aviation Fuel During Shipment from Refinery to Airport

**API 1595** Design, Construction, Operation, Maintenance, and Inspection of Aviation Pre-Airfield Storage Terminals<sup>5</sup>

## 2.4 *Joint Inspection Group Standards*.<sup>6</sup>

**JIG 1** Aviation Fuel Quality Control & Operating Standards for Into-Plane Fuelling Services

**JIG 2** Aviation Fuel Quality Control & Operating Standards for Airport Depots & Hydrants<sup>6</sup>

## 2.5 *Military Standard*.<sup>7</sup>

**MIL-DTL-5624** Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8 ST

## 2.6 *Other Standards and Guidance Material*:

**ATA-103** Standard for Jet Fuel Quality Control at Airports<sup>8</sup>

**CAN/CGSB 3.22-97** “Aviation Turbine Fuel, Wide Cut Type” includes grade Jet B and NATO grade F-40 fuel<sup>9</sup>

**ICAO 9977** Manual on Civil Aviation Jet Fuel Supply<sup>10</sup>

## 3. Terminology

3.1 For definitions of terms used in this specification, refer to Terminology **D4175**.

## 4. General

4.1 This specification, unless otherwise provided, prescribes the required properties of Jet B wide-cut aviation turbine fuel at the time and place of delivery.

## 5. Classification

5.1 One type of aviation turbine fuel is provided, as follows:

5.1.1 *Jet B*—A relatively wide boiling range volatile distillate.

## 6. Materials and Manufacture

6.1 Aviation turbine fuel, except as otherwise specified in this specification, shall consist of blends of refined hydrocarbons (see **Note 1**) derived from conventional sources, including crude oil, natural gas liquid condensates, heavy oil, shale oil, and oil sands. The use of jet fuel blends, containing components from other sources, is permitted only on a specific individual basis.

**NOTE 1**—Conventionally refined jet fuel contains trace levels of materials which are not hydrocarbons including oxygenates, organosulfur, and nitrogenous compounds.

6.1.1 Fuels used in certified engines and aircraft are ultimately approved by the certifying authority subsequent to formal submission of evidence to the authority as part of the type certification program for that aircraft and engine model. Additives to be used as supplements to an approved fuel must also be similarly approved on an individual basis (see **X1.2.4** and **X1.12.1**).

6.2 *Additives*—May be added to each type of aviation turbine fuel in the amount and of the composition specified in **Table 2** or the following list of approved material:<sup>11</sup>

<sup>7</sup> Available from Dept. of Defense Single Stock Point, Bldg 4D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

<sup>8</sup> Available from Air Transport Association of America, Inc. (ATA) d/b/a Airlines for America, 1301 Pennsylvania Ave. NW, Suite 1100, Washington, D.C. 20004, <http://www.airlines.org>.

<sup>9</sup> Available from the Canadian General Standards Board (CGSB), Ottawa, Canada K1A 1G6.

<sup>10</sup> Available from International Civil Aviation Organization (ICAO), 999 University St., Montreal, Quebec H3C 5H7, Canada, <http://www.icao.int>.

<sup>11</sup> Supporting data (guidelines for approval or disapproval of additives) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1125. Contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org).

<sup>4</sup> Available from Energy Institute, 61 New Cavendish St., London, W1G 7AR, U.K., <http://www.energyinst.org.uk>.

<sup>5</sup> Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, <http://www.api.org>.

<sup>6</sup> Available from Joint Inspection Group (JIG), <http://www.jigonline.com>.

**TABLE 1 Detailed Requirements of Aviation Turbine Fuels<sup>A</sup>**

Property		Jet B	ASTM Test Method <sup>B</sup>
1. Aromatics, volume percent	max	25	D1319
2. Aromatics, volume percent	max	26.5	D6379
Sulfur, mercaptan, <sup>C</sup> mass percent	max	0.003	D3227
Sulfur, total mass percent	max	0.30	D1266, D2622, D4294, or D5453
Distillation temperature, °C:			
20 % recovered, temperature	min	90	D86
20 % recovered, temperature	max	145	
50 % recovered, temperature	min	110	
50 % recovered, temperature	max	190	
90 % recovered, temperature	max	245	
Distillation residue, percent	max	1.5	
Distillation loss, percent	max	1.5	
Density at 15 °C, kg/m <sup>3</sup>		751 to 802	D1298 or D4052
Vapor pressure, 38 °C, kPa		14 to 21	D323 or D5191 <sup>D</sup>
Freezing point, °C	max	-50 <sup>E</sup>	D2386 or D5972 <sup>F</sup>
Net heat of combustion, MJ/kg	min	42.8 <sup>G</sup>	D4529, D3338/D3338M, or D4809
One of the following requirements shall be met:			
(1) Smoke point, mm, or	min	25	D1322
(2) Smoke point, mm, and	min	18	D1322
Naphthalenes, vol, percent	max	3.0	D1840
Copper strip, 2 h at 100 °C		No. 1	D130
Thermal Stability:			
(2.5 h at control temperature of 260 °C min):			
Filter pressure drop, mm Hg	max	25	D3241 <sup>H,I</sup>
Tube deposits less than		3	
		No Peacock or Abnormal Color Deposits	
Existent gum, mg/100 mL	max	7	D381
ADDITIVES		See 6.2	
Electrical conductivity, pS/m		J	D2624
Microseparator Rating <sup>K</sup>			D3948
Without electrical conductivity additive	min	85	
With electrical conductivity additive	min	70	

<sup>A</sup> For compliance of test results against the requirements of Table 1, see 7.2.

<sup>B</sup> The test methods indicated in this table are referred to in Section 11.

<sup>C</sup> The mercaptan sulfur determination may be waived if the fuel is considered sweet by the doctor test described in Test Method D4952.

<sup>D</sup> Cyclohexane and toluene, as cited in 7.2 and 7.7 of Test Method D5191, shall be used as calibrating reagents. Test Method D5191 shall be the referee method.

<sup>E</sup> Other freezing points may be agreed upon between supplier and purchaser.

<sup>F</sup> Test Method D5972 may produce a higher (warmer) result than that from Test Method D2386 on wide-cut fuels such as Jet B or JP-4. In case of dispute, Test Method D2386 shall be the referee method.

<sup>G</sup> Use either Eq 1 or Table 1 in Test Method D4529 or Eq 2 in Test Method D3338/D3338M. Test Method D4809 may be used as an alternative. In case of dispute, Test Method D4809 shall be used.

<sup>H</sup> D3241 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241 testing requires that heater tubes (test coupons) meet the requirements of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM). A test protocol to demonstrate equivalence of heater tubes from other suppliers is on file at ASTM International Headquarters and can be obtained by requesting Research Report RR:D02-1550. Heater tubes and filter kits, manufactured by the OEM (PAC, 8824 Fallbrook Drive, Houston, TX 77064) were used in the development of the D3241 test method. Heater tube and filter kits, manufactured by Falex (Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585) were demonstrated to give equivalent results (see D3241 for research report references). These historical facts should not be construed as an endorsement or certification by ASTM International.

<sup>I</sup> Tube deposits shall always be reported by the Visual Method.

<sup>J</sup> If electrical conductivity additive is used, the conductivity shall not exceed 600 pS/m at the point of use of the fuel. When electrical conductivity additive is specified by the purchaser, the conductivity shall be 50 pS/m to 600 pS/m under the conditions at point of delivery.

$$1 \text{ pS/m} = 1 \times 10^{-12} \Omega^{-1} m^{-1}$$

<sup>K</sup> At point of manufacture.

6.2.1 Other additives are permitted under 6.1 and Section 8.1. These include fuel performance enhancing additives and fuel handling and maintenance additives as found in Table 2. The quantities and types must be declared by the fuel supplier and agreed to by the purchaser. Only additives approved by the aircraft certifying authority are permitted in the fuel on which an aircraft is operated.

6.2.1.1 Biocidal additives are available for controlled usage. Where such an additive is used in the fuel, the approval status of the additive and associated conditions must be checked for the specific aircraft and engines to be operated.

6.2.1.2 Fuel System Icing Inhibitor:

(1) Diethylene Glycol Monomethyl Ether (DIEGME), conforming to the requirements of Specification D4171, Type III, may be used in concentrations of 0.10 % to 0.15 % by volume.

(2) Test Method D5006 may be used to determine the concentration of DIEGME in aviation fuels.

6.3 Guidance material is presented in Appendix X3 concerning the need to control processing additives in jet fuel production.

## 7. Detailed Requirements

7.1 The aviation turbine fuel shall conform to the requirements prescribed in Table 1.

**TABLE 2 Detailed Requirements for Additives in Aviation Turbine Fuels**

Additive	Dosage
Fuel Performance Enhancing Additives	
Antioxidants <sup>A,B</sup> max <sup>C</sup> <i>One of the following:</i> 2,6-ditertiary-butyl phenol 2,6-ditertiary-butyl-4-methyl phenol 2,4-dimethyl-6-tertiary-butyl phenol 75 % minimum 2,6-ditertiary-butyl phenol, plus 25 % maximum mixed tertiary and tritertiary-butyl phenols 55 % minimum 2,4-dimethyl-6-tertiary-butyl phenol, plus 15 % minimum 2,6 ditertiary-butyl-4-methyl phenol, remainder as monomethyl and dimethyl tertiary-butyl phenols 72 % minimum 2,4-dimethyl-6-tertiary-butyl phenol plus 28 % maximum monomethyl and dimethyl-tertiary-butyl phenols	24.0 mg/L
Metal Deactivator <sup>A</sup> N,N-disalicylidene-1,2-propane diamine On initial blending After field reblending, cumulative concentration	2.0 mg/L max <sup>C,D</sup> 5.7 mg/L max
Fuel System Icing Inhibitor <sup>E</sup> Diethylene Glycol Monomethyl Ether (see Specification <b>D4171</b> ) max	0.10 % by volume min 0.15 % by volume
Fuel Handling and Maintenance Additives	
Electrical Conductivity Improver <sup>F</sup> Stadis 450 <sup>G</sup> On initial blending After field reblending, cumulative concentration If the additive concentration is unknown at time of retreatment Additional concentration is restricted to 2 mg/L max	3 mg/L max 5 mg/L max
Leak Detection Additive Tracer A (LDTA-A) <sup>H</sup>	1 mg/kg max
Biocidal Additives <sup>E,I,K</sup> Biobore JF Kathon FP1.5	
Corrosion Inhibitor/Lubricity Improvers <sup>J</sup> <i>One of the following:</i> HiTEC 580 Octel DCI-4A Nalco 5403	23 mg/L max 23 mg/L max 23 mg/L max

<sup>A</sup> The active ingredient of the additive must meet the composition specified.

<sup>B</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1125.

<sup>C</sup> Active ingredient (not including weight of solvent).

<sup>D</sup> If copper contamination is suspected, initial treatment may exceed 2.0 mg/L but cumulative total must be below 5.7 mg/L.

<sup>E</sup> The quantity must be declared by the fuel supplier and agreed to by the purchaser.

<sup>F</sup> If electrical conductivity improver is used, the conductivity shall not exceed 600 pS/m at the point of use of the fuel. When electrical conductivity additive is specified by the purchaser, the conductivity shall be 50 pS/m to 600 pS/m under the conditions at point of delivery.

$$1 \text{ pS/m} = 1 \times 10^{-12} \Omega^{-1} \text{m}^{-1} \quad (1)$$

<sup>G</sup> Stadis 450 is a registered trademark marketed by Innospec Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EH, UK.

<sup>H</sup> Tracer A (LDTA-A) is a registered trademark of Tracer Research Corp., 3755 N. Business Center Dr., Tucson, AZ 85705.

<sup>I</sup> Biocidal additives are available for controlled usage. Where such an additive is used in the fuel, the approval status of the additive and associated conditions must be checked for the specific aircraft and engines to be operated.

<sup>J</sup> More information concerning minimum treat rates of corrosion inhibitor/lubricity improver additives is contained in **X1.11**.

<sup>K</sup> Refer to the Aircraft Maintenance Manual (AMM) to determine if either biocide is approved for use and for their appropriate use and dosage.

7.2 Test results shall not exceed the maximum or be less than the minimum values specified in **Table 1**. No allowance shall be made for the precision of the test methods. To determine conformance to the specification requirement, a test result may be rounded to the same number of significant figures as in **Table 1** using Practice **E29**. Where multiple determina-

tions are made, the average result, rounded in accordance with Practice **E29**, shall be used.

## 8. Workmanship, Finish, and Appearance

8.1 The aviation turbine fuel specified in this specification shall be visually free of undissolved water, sediment, and



suspended matter. The odor of the fuel shall not be nauseating or irritating. No substance of known dangerous toxicity under usual conditions of handling and use shall be present, except as permitted in this specification.

## 9. Sampling

9.1 Because of the importance of proper sampling procedures in establishing fuel quality, use the appropriate procedures in Practice **D4057** to obtain a representative sample from the batch of fuel for specification compliance testing. This requirement is met by producing fuel as a discrete batch, then testing it for specification compliance. This requirement is not satisfied by averaging online analysis results.

9.2 A number of jet fuel properties, including thermal stability, water separation, electrical conductivity, and others, are very sensitive to trace contamination, which can originate from sample containers. For recommended sample containers, refer to Practice **D4306**.

## 10. Report

10.1 The type and number of reports to ensure conformance with the requirements of this specification shall be mutually agreed upon by the seller and the purchaser of the aviation turbine fuel.

10.2 A suggested form for reporting inspection data on aviation turbine fuels is given in Appendix X4 of Specification **D1655**.

## 11. Test Methods

11.1 Determine the requirements enumerated in this specification in accordance with the following ASTM test methods.

11.1.1 *Density*—Test Methods **D1298** or **D4052**.

11.1.2 *Distillation*—Test Method **D86**.

11.1.3 *Vapor Pressure*—Test Methods **D323** or **D5191**. Test Method **D5191** shall be the referee test method.

11.1.4 *Freezing Point*—Test Methods **D2386** or **D5972**. Test Method **D2386** shall be the referee test method.

11.1.5 *Net Heat of Combustion*—Test Methods **D4529**, **D3338/D3338M**, or **D4809**.

11.1.6 *Corrosion (Copper Strip)*—Test Method **D130**.

11.1.7 *Sulfur*—Test Methods **D1266**, **D2622**, **D4294**, or **D5453**.

11.1.8 *Mercaptan Sulfur*—Test Method **D3227**.

11.1.9 *Water Reaction*—Test Method **D1094**.

11.1.10 *Existent Gum*—Test Method **D381**.

11.1.11 *Thermal Stability*—Test Method **D3241**.

11.1.12 *Aromatics*—Test Methods **D1319** or **D6379**. Test Method **D1319** shall be the referee test method.

11.1.13 *Smoke Point*—Test Method **D1322**.

11.1.14 *Naphthalene Content*—Test Method **D1840**.

11.1.15 *Electrical Conductivity*—Test Method **D2624**.

## 12. Keywords

12.1 aviation turbine fuel; avtag; Jet B; jet fuel; turbine fuel; wide-cut

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**Document Review**

## APPENDIXES

### (Nonmandatory Information)

## X1. PERFORMANCE CHARACTERISTICS OF AVIATION TURBINE FUELS

### X1.1 Introduction

X1.1.1 This appendix describes the performance characteristics of aviation turbine fuels. A more detailed discussion of the individual test methods and their significance is found in ASTM Manual No. 1.<sup>12</sup> Additional information on aviation turbine fuel and its properties is found in ASTM's MNL 37, *Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing*<sup>13</sup> and the *Handbook of Aviation Fuel Properties*.<sup>14</sup>

### X1.2 Significance and Use

X1.2.1 Specification D6615 defines one type of jet fuel for civil use. Limiting values for the two types of fuel covered are placed on fuel properties believed to be related to the performance of the aircraft and engines in which they are most commonly used.

X1.2.2 The safe and economical operation of aircraft requires fuel that is essentially clean and dry and free of any contamination prior to use. It is possible to measure a number of jet fuel characteristics related to quality.

X1.2.3 The significance of standard tests for fuel properties may be summarized for convenience in terms of the technical relationships with performance characteristics as shown in **Table X1.1**.

X1.2.4 The acceptability of additives for use must ultimately be determined by the engine and aircraft type certificate holder and must be approved by his certifying authority. In the United States of America, the certifying authority is the Federal Aviation Administration.

### X1.3 Thermal Stability

X1.3.1 Stability to oxidation and polymerization at the operating temperatures encountered in certain jet aircraft is an important performance requirement. The thermal stability measurements are related to the amount of deposits formed in the engine fuel system on heating the fuel in a jet aircraft. Commercial jet fuels should be thermally stable at fuel

<sup>12</sup> ASTM MNL 1, *Manual on Significance of Tests for Petroleum Products*, ASTM International, W. Conshohocken, 1993.

<sup>13</sup> MNL 37, *Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing*, Eds., Totten, G. E., Westbrook, S. R., and Shah, R. J., ASTM International, W. Conshohocken, PA, 2003.

<sup>14</sup> *Handbook of Aviation Fuel Properties*, Fourth Edition (2014), CRC Report 663, Coordinating Research Council, Alpharetta, GA, 30022.

**TABLE X1.1 Performance Characteristics of Aviation Turbine Fuels**

Performance Characteristics	Test Method	Sections
Engine fuel system deposits and coke	Thermal stability	X1.3
Combustion properties	Smoke point	X1.4.2.1
	Aromatics	X1.4.2.2
	Percent naphthalenes	X1.4.2.3
Fuel metering and aircraft range	Density	X1.5.1
	Net heat of combustion	X1.5.2
	Distillation	X1.6.1
Fuel atomization	Vapor pressure	X1.6.2
	Freezing point	X1.7.1
Fluidity at low temperature	Mercaptan sulfur	X1.8.1
	Sulfur	X1.8.2
	Copper strip corrosion	X1.8.3
Compatibility with elastomer and the metals in the fuel system and turbine	Existent gum	X1.9.1
	Water reaction	X1.10.1
Fuel storage stability	Water separation characteristics	X1.10.2
	Free water and particulate contamination	X1.10.3
	Particulate matter	X1.10.4
	Membrane color ratings	X1.10.5
	Undissolved water	X1.10.6
	Conductivity	X1.10.7
	Fuel lubricity	X1.11
Fuel cleanliness, handling	Additives	X1.12.1
	Sample containers	X1.12.2
Static electricity	Leak detection additive	X1.12.3
	Color	X1.12.4
	Fuel lubricating ability (lubricity)	
Miscellaneous		

temperature as high as 163 °C (325 °F). Such fuels have been demonstrated to have inherent storage stability.

X1.3.2 In 1973, Test Method **D3241** replaced Method of Test **D1660**, known as the ASTM Coker for the determination of oxidative thermal stability. (See CRC Report 450, dated 1969 and revised in 1972. See also Bert and Painter's SAE paper 730385.<sup>15</sup>) Today, a single pass/fail run with the tube temperature controlled at 260 °C is used to ensure compliance with the specification's minimum requirements. For a more complete characterization of a fuel's thermal stability, a *breakpoint* can be obtained. The breakpoint is the highest tube temperature at which the fuel still passes the specification requirements of the tube deposit color and pressure differential. Normally, obtaining a breakpoint requires two or more runs at differing tube temperatures. Breakpoints are therefore not used for quality control, but they serve mostly for research purposes.

## X1.4 Combustion

X1.4.1 Jet fuels are continuously burned in a combustion chamber by injection of liquid fuel into the rapidly flowing stream of hot air. The fuel is vaporized and burned at near stoichiometric conditions in a primary zone. The hot gases so produced are continuously diluted with excess air to lower their temperature to a safe operating level for the turbine. Fuel combustion characteristics relating to soot formation are emphasized by current specification test methods. Other fuel combustion characteristics not covered in current specifications are burning efficiency and flame-out.

X1.4.2 In general, paraffin hydrocarbons offer the most desirable combustion cleanliness characteristics for jet fuels. Naphthenes are the next most desirable hydrocarbons for this

use. Although olefins generally have good combustion characteristics, their poor gum stability usually limits their use in aircraft turbine fuels to about 1 % or less. Aromatics generally have the least desirable combustion characteristics for aircraft turbine fuel. In aircraft turbines, they tend to burn with a smoky flame and release a greater proportion of their chemical energy as undesirable thermal radiation than the other hydrocarbons. Naphthalenes or bicyclic aromatics produce more soot, smoke, and thermal radiation than monocyclic aromatics and are, therefore, the least desirable hydrocarbon class for aircraft jet fuel use. All of the following measurements are influenced by the hydrocarbon composition of the fuel and, therefore, pertain to combustion quality: luminometer number, smoke point, percent naphthalenes, and percent aromatics.<sup>16</sup>

X1.4.2.1 *Smoke Point*—This method provides an indication of the relative smoke-producing properties of jet fuels and is related to the hydrocarbon-type composition of such fuels. Generally, the more highly aromatic the jet fuel, the more smoky the flame. A high smoke point indicates a fuel of low smoke-producing tendency.

X1.4.2.2 *Aromatics*—The combustion of highly aromatic jet fuels generally results in smoke and carbon or soot deposition, and it is therefore desirable to limit the total aromatic content as well as the naphthalenes in jet fuels.

X1.4.2.3 *Percent Naphthalenes*—This method covers measurement of the total concentration of naphthalene, acenaphthene, and alkylated derivatives of these hydrocarbons in jet fuels containing no more than 5 % of such compounds and having boiling points below 600 °F (316 °C).

<sup>15</sup> Bert, J. A., and Painter, L., "A New Fuel Thermal Stability Test (A Summary of Coordinating Research Council Activity)," SAE Paper 730385, Society of Automotive Engineers, Warrendale, PA, 1973.

<sup>16</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1258. A task force studied the possible use of hydrogen content as an alternative to aromatics content and completed the report in 1989.

## X1.5 Fuel Metering and Aircraft Range

X1.5.1 *Density*—Density is a property of a fluid and is of significance in metering flow and in mass-volume relationships for most commercial transactions. It is particularly useful in empirical assessments of heating value when used with other parameters, such as aniline point or distillation. A low density may indicate low heating value per unit volume.

X1.5.2 *Net Heat of Combustion*—The design of aircraft and engines is based on the convertibility of heat into mechanical energy. The net heat of combustion provides a knowledge of the amount of energy obtainable from a given fuel for the performance of useful work; in this instance, power. Aircraft design and operation are dependent upon the availability of a certain predetermined minimum amount of energy as heat. Consequently, a reduction in heat energy below this minimum is accompanied by an increase in fuel consumption with corresponding loss of range. Therefore, a minimum net heat of combustion requirement is incorporated in this specification. The determination of net heat of combustion is time consuming and difficult to conduct accurately. This led to the development and use of the aniline point and density relationship to estimate the heat of combustion of the fuel. This relationship is used along with the sulfur content of the fuel to obtain the net heat of combustion by Test Method [D4529](#) for the purposes of this specification. An alternative calculation, Test Method [D3338/D3338M](#), is based on correlations of aromatics content, gravity, volatility, and sulfur content. This method may be preferred at refineries where all these values are normally obtained and the necessity to obtain the aniline point is avoided. The direct measurement method, Test Method [D4809](#), is normally used only as a referee method in cases of dispute.

## X1.6 Fuel Atomization

X1.6.1 *Distillation*—The fuel volatility and ease of vaporization at different temperatures are determined by distillation. The 90 % limit excludes heavier fractions that would be difficult to vaporize.

X1.6.2 *Vapor Pressure*—The vapor pressure serves as a criterion of freedom from foaming, fuel slugging, and losses of light ends through aircraft tank vents at high altitude. This is of significance with respect to Jet B fuel because of its higher volatility in comparison to kerosene-type jet fuels.

## X1.7 Fluidity at Low Temperatures

X1.7.1 *Freezing Point*—The freezing point is particularly important and must be sufficiently low to preclude interference with flow of fuel through filter screens to the engine at temperatures prevailing at high altitudes. The temperature of fuel in an aircraft tank decreases at a rate proportional to the duration of flight. The maximum freezing point allowed for the fuel is therefore related to the type of flight. For example, long duration flights would require fuel of lower freezing point than short duration flights.

## X1.8 Compatibility with Elastomer and the Metals in the Fuel System and Turbine

X1.8.1 *Mercaptan Sulfur*—Mercaptans are known to be reactive with certain elastomers. A limitation in mercaptan

content is specified to preclude such reactions and to minimize the unpleasant mercaptan odor.

X1.8.2 *Sulfur*—Control of sulfur content is significant for jet fuels because the sulfur oxides formed during combustion may be corrosive to turbine metal parts.

X1.8.3 *Copper Strip Corrosion*—A requirement that jet fuel must pass the copper strip test ensures that the fuel will not corrode copper or any copper-base alloys in various parts of the fuel system.

## X1.9 Fuel Storage Stability

X1.9.1 *Existent Gum*—Gum is a nonvolatile residue left on evaporation of fuel. A steam jet is used as an evaporating agent for fuels that are to be used in aircraft equipped with turbine engines. The amount of gum present is an indication of the condition of the fuel at the time of test only. Large quantities of gum are indicative of contamination of fuel by higher boiling oils or particulate matter and generally reflect poor fuel handling practices.

## X1.10 Fuel Cleanliness and Handling

X1.10.1 *Water Reaction*—The Test Method [D1094](#) water reaction test method provides a means to determine the presence of materials that react with water and form an insoluble scum at the fuel/water interface in the test.

X1.10.2 *Water Separation Characteristics*—The ease of coalescence of water from fuels, as influenced by surface active agents (surfactants), is assessed by Test Method [D3948](#). This test method is designed to be used as a field or laboratory method. A high rating suggests a fuel free of surfactants; a low rating indicates that surfactants are present. Surfactants, which may be contaminants or deliberately added materials, may gradually disarm filter coalescers, allowing fine water droplets and particulate contaminants to pass separators in ground handling equipment.

X1.10.3 *Free Water and Particulate Contamination in Distillate Fuels (Clear and Bright Pass/Fail Procedures)*—The procedures in Test Method [D4176](#) provide rapid but nonquantitative methods for detecting contamination in a distillate fuel. The methods described in [X1.10.4](#) and [X1.10.6](#) permit quantitative determinations.

X1.10.4 *Particulate Matter*—The presence of adventitious solid particulate contaminants such as dirt and rust may be detected by filtration of the jet fuel through membrane filters under prescribed conditions. Suitable techniques are described in Test Methods [D2276](#) and [D5452](#).

X1.10.5 *Membrane Color Ratings*—Filtering the fuel through a membrane and rating the color of the deposits against a standard color scale offers a qualitative assessment of particulate contaminant levels in fuels or of changes in fuel contaminant levels at a particular location. Appendix XI of Test Method [D2276](#) describes a suitable technique.

X1.10.6 *Undissolved Water*—The test method for undissolved water provides a quantitative means for measuring the amount of undissolved or free water in flowing fuel streams without exposing the sample to the atmosphere or to a sample