



## Standard Specification for Aviation Turbine Fuels<sup>1</sup>

This standard is issued under the fixed designation D1655; 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.

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

### 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 specific types of aviation turbine fuel for civil use in the operation and certification of aircraft and describes fuels found satisfactory for the operation of aircraft and engines. The specification can be used as a standard in describing the quality of aviation turbine fuels from the refinery to the aircraft.

1.3 This specification does not include all fuels satisfactory for aviation turbine engines. Certain equipment or conditions of use may permit a wider, or require a narrower, range of characteristics than is shown by this specification.

1.4 Aviation turbine fuels defined by this specification may be used in other than turbine engines that are specifically designed and certified for this fuel.

1.5 This specification no longer includes wide-cut aviation turbine fuel (Jet B). FAA has issued a Special Airworthiness Information Bulletin which now approves the use of Specification **D6615** to replace Specification D1655 as the specification for Jet B and refers users to this standard for reference.

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

### 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

**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

**D129** Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device Method)

**D130** Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

**D156** Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)

**D240** Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter

**D323** Test Method for Vapor Pressure of Petroleum Products (Reid Method)

**D381** Test Method for Gum Content in Fuels by Jet Evaporation

**D445** Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

**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 Kerosine and Aviation Turbine Fuel

**D1405** Test Method for Estimation of Net Heat of Combustion of Aviation Fuels

**D1660** Method of Test for Thermal Stability of Aviation Turbine Fuels (Withdrawn 1992)<sup>3</sup>

<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.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.

<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

- 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
- D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
- D2892 Test Method for Distillation of Crude Petroleum (15-Theoretical Plate Column)
- D3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
- D3227 Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosine, 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
- D3242 Test Method for Acidity in Aviation Turbine Fuel
- D3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
- D3343 Test Method for Estimation of Hydrogen Content of Aviation Fuels
- D3701 Test Method for Hydrogen Content of Aviation Turbine Fuels by Low Resolution Nuclear Magnetic Resonance Spectrometry
- D3828 Test Methods for Flash Point by Small Scale Closed Cup Tester
- D3948 Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer
- 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
- 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)
- D4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)
- 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
- D5190 Test Method for Vapor Pressure of Petroleum Products (Automatic Method) (Withdrawn 2012)<sup>3</sup>
- D5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method) [9406-13e9159c4f1/astm-d1655-13](http://www.astm.org/standards/d1655-13)
- 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)
- D6045 Test Method for Color of Petroleum Products by the Automatic Tristimulus 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
- D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
- D6615 Specification for Jet B Wide-Cut Aviation Turbine Fuel
- D6751 Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels
- D7153 Test Method for Freezing Point of Aviation Fuels (Automatic Laser Method)
- D7154 Test Method for Freezing Point of Aviation Fuels (Automatic Fiber Optical Method)
- D7524 Test Method for Determination of Static Dissipater Additives (SDA) in Aviation Turbine Fuel and Middle Distillate Fuels—High Performance Liquid Chromatograph (HPLC) Method
- D7566 Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- 2.2 *Energy Institute Standards:*<sup>4</sup>
- IP 225 Copper Content of Aviation Turbine Fuel
- IP 227 Silver Corrosion of Aviation Turbine Fuel
- IP 540 Determination of the existent gum content of aviation turbine fuel — Jet evaporation method
- IP 585 Determination of fatty acid methyl esters (FAME), derived from bio-diesel fuel, in aviation turbine fuel — GC-MS with

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

selective ion monitoring/scan detection method

IP 590 Determination of fatty acid methyl esters (FAME) in aviation fuel—HPLC evaporative light scattering detector method

2.3 *ANSI Standard:*<sup>5</sup>

ANSI 863 Report of Test Results

2.4 *Other Standards:*

Defence Standard (Def Stan) 91-91 Turbine Fuel, Aviation Kerosine Type, Jet A-1<sup>6</sup>

IATA Guidance Material on Microbiological Contamination in Aircraft Fuel Tanks Ref. No: 9680-02<sup>7</sup>

EN14214 Automotive fuels - Fatty acid methyl esters (FAME) for diesel engines - Requirements and test methods<sup>8</sup>

### 3. General

3.1 This specification, unless otherwise provided, prescribes the required properties of aviation turbine fuel at the time and place of delivery.

### 4. Classification

4.1 Two types of aviation turbine fuels are provided, as follows:

4.1.1 *Jet A and Jet A-1*—Relatively high flash point distillates of the kerosine type.

4.2 Jet A and Jet A-1 represent two grades of kerosine fuel that differ in freezing point. Other grades would be suitably identified.

4.3 This specification previously cited the requirements for Jet B. Requirements for Jet B fuel now appear in Specification D6615.

### 5. Materials and Manufacture

5.1 Aviation turbine fuel is a complex mixture predominantly composed of hydrocarbons and varies depending on crude source and manufacturing process. Consequently, it is impossible to define the exact composition of Jet A/A-1. This specification has therefore evolved primarily as a performance specification rather than a compositional specification. It is acknowledged that this largely relies on accumulated experience; therefore the specification limits aviation turbine fuels to those made from conventional sources or by specifically approved processes.

5.1.1 Aviation turbine fuel, except as otherwise specified in this specification, shall consist predominantly 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 in accordance with **Annex A1**.

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

5.1.2 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 **X1.15.1**).

5.2 *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:

5.2.1 Other additives are permitted under **5.1** and **7.1**. These include fuel performance enhancing additives and fuel handling and maintenance additives as found under **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.

5.2.1.1 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.

5.2.1.2 *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 volume %.

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

5.3 *Incidental Materials*—Incidental materials are chemicals and compositions that can occur in turbine fuels as a result of production, processing, distribution, or storage. **Table 3** lists specific materials that have an agreed limit. Specification D1655 does not require that each batch of fuel be analyzed for incidental materials where there is essentially no risk of contamination exceeding **Table 3** limits. Where a supplier risk assessment suggests that incidental materials could exceed **Table 3** limits, jet fuel should be

<sup>5</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

<sup>6</sup> Available from Procurement Executive DFS (Air), Ministry of Defence, St. Giles Court 1, St. Giles High St., London WC2H 8LD.

<sup>7</sup> Available from International Air Transport Association (IATA), (Head Office) 800 Place Victoria, PO Box 113, Montreal, H4Z 1M1, Quebec, Canada. [www.iataonline.com](http://www.iataonline.com).

<sup>8</sup> Available from European Committee for Standardization (CEN), 36 rue de Stassart, B-1050, Brussels, Belgium, <http://www.cenorm.be>.

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

Property		Jet A or Jet A-1	ASTM Test Method <sup>B</sup>
<b>COMPOSITION</b>			
Acidity, total mg KOH/g	max	0.10	D3242
1. Aromatics, vol %	max	25	D1319
2. Aromatics, vol %	max	26.5	D6379
Sulfur, mercaptan, <sup>C</sup> mass %	max	0.003	D3227
Sulfur, total mass %	max	0.30	D1266, D2622, D4294, or D5453
<b>VOLATILITY</b>			
Distillation temperature, °C:			D86, <sup>D</sup> D2887 <sup>E</sup>
10 % recovered, temperature	max	205	
50 % recovered, temperature		report	
90 % recovered, temperature		report	
Final boiling point, temperature	max	300	
Distillation residue, %	max	1.5	
Distillation loss, %	max	1.5	
Flash point, °C	min	38 <sup>F</sup>	D56, D93, or D3828 <sup>G</sup>
Density at 15°C, kg/m <sup>3</sup>		775 to 840	D1298 or D4052
<b>FLUIDITY</b>			
Freezing point, °C	max	-40 Jet A <sup>H</sup> -47 Jet A-1 <sup>H</sup>	D5972, D7153, D7154, or D2386
Viscosity -20°C, mm <sup>2</sup> /s <sup>I</sup>	max	8.0	D445
<b>COMBUSTION</b>			
Net heat of combustion, MJ/kg	min	42.8 <sup>J</sup>	D4529, D3338, 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, %	max	3.0	D1840
<b>CORROSION</b>			
Copper strip, 2 h at 100°C	max	No. 1	D130
<b>THERMAL STABILITY</b>			
(2.5 h at control temperature of 260°C min)			
Filter pressure drop, mm Hg	max	25	D3241
Tube deposits less than		3 <sup>K</sup>	
		No Peacock or Abnormal Color Deposits	
<b>CONTAMINANTS</b>			
Existent gum, mg/100 mL	max	7	D381, IP 540
Microseparator, <sup>L</sup> Rating			D3948
Without electrical conductivity additive	min	85	
With electrical conductivity additive	min	70	
<b>ADDITIVES</b>			
Electrical conductivity, pS/m		See 5.2 M	D2624

<sup>A</sup> For compliance of test results against the requirements of Table 1, see 6.2.

<sup>B</sup> The test methods indicated in this table are referred to in Section 10.

<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> D86 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.

<sup>E</sup> D2887 results shall be converted to estimated D86 results by application of the correlation in Appendix X5 on Correlation for Jet and Diesel Fuel in Test Method D2887. Distillation residue and loss limits provide control of the distillation process during the use of Test Method D86, and they do not apply to Test Method D2887. Distillation residue and loss shall be reported as "not applicable" (N/A) when reporting D2887 results.

<sup>F</sup> A higher minimum flash point specification may be agreed upon between purchaser and supplier.

<sup>G</sup> Results - Aviation turbine fuel results obtained by Test Method D93 may be up to 1°C higher than those obtained by Test Method D56. Results obtained by Test Method D3828 may be up to 2°C lower than those obtained by Test Method D56, which is the preferred method. In case of dispute, Test Method D56 shall apply.

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

<sup>I</sup> 1 mm<sup>2</sup>/s = 1 cSt.

<sup>J</sup> For all grades use either Eq 1 or Table 1 in Test Method D4529 or Eq 2 in Test Method D3338. Test Method D4809 may be used as an alternative. In case of dispute, Test Method D4809 shall be used.

<sup>K</sup> Tube deposit ratings shall always be reported by the Visual Method.

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

<sup>M</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 to 600 pS/m under the conditions at point of delivery.

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

confirmed to comply with Table 3 limits prior to airport supply because airports generally are not equipped to mitigate incidental material content that exceeds specification limits. Further guidance concerning these materials is presented in X1.16.

5.4 Guidance material is presented in Appendix X2 concerning the need to control processing additives in jet fuel production.

## 6. Detailed Requirements

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

6.2 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

**TABLE 2 Detailed Information for Additives for Aviation Turbine Fuels**

Additive	Dosage
<b>Fuel Performance Enhancing Additives</b>	
Antioxidants <sup>A,B</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 max <sup>C</sup>
Metal Deactivator (MDA) <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 D4171)	0.10 vol % min 0.15 vol % max
<b>Fuel Handling and Maintenance Additives</b>	
Electrical Conductivity Improver <sup>F</sup> Stadis 450 <sup>G,H</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>I</sup>	1 mg/kg max
Biocidal Additives <sup>E,J,K</sup> Biobor JF <sup>L</sup> Kathon FP1.5 <sup>M</sup>	
Corrosion Inhibitor/Lubricity Improvers <sup>N</sup> <i>One of the following:</i> HiTEC 580 Innospec 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 MDA may be added to fuel to counteract the effects of metals known to be deleterious to thermal stability, such as Copper, Cadmium, Iron, Cobalt and Zinc, provided that the nature of the contamination is reported. Where metallic contamination is unproven, an MDA may be used to recover thermal stability provided that the Thermal Stability Test (in accordance with Table 2) is determined before and after MDA addition and reported on the test certificate. Initial addition of more than 2.0 mg/L MDA is permitted when fuel will be transported in supply chains where copper contamination may occur; the maximum cumulative addition in Table 2 below 5.7 mg/L still applies. Note that fuel containing MDA has been shown to promote the dissolution of copper and may exacerbate thermal stability problems.

<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 to 600 pS/m under the conditions at point of delivery.

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

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

<sup>H</sup> Stadis 450 content can be analyzed by Test Method D7524.

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

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

<sup>L</sup> Biobor JF is a registered trademark of Hammonds Technical Services, Inc. 910 Rankin Rd., Houston, TX 77073.

<sup>M</sup> Kathon FP1.5 KATHON is a registered trademark of Fuel Quality Services, Inc., P.O. Box 1380, Flowery Branch, GA 30542; trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow, 2030 Dow Center, Midland, MI 48674.

<sup>N</sup> More information concerning minimum treat rates of corrosion inhibitor/lubricity improver additives is contained in X1.10.2.

to the same number of significant figures as in Table 1 using Practice E29. Where multiple determinations are made, the average result, rounded in accordance with Practice E29, shall be used.

## 7. Workmanship, Finish, and Appearance

7.1 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. If the fuel has an odor similar to that of "rotten egg," please refer

**TABLE 3 Incidental Materials**

Material	Permitted Level	Test Method
Fatty Acid Methyl Ester (FAME) <sup>A</sup>	<5 mg/kg max <sup>B</sup>	IP 585–10, IP 590–10

<sup>A</sup>For the purpose of meeting this requirement FAME is defined as material meeting the limits of EN14214 or Specification **D6751**. Fatty acid methyl esters that fail to meet the biodiesel quality standards are not permitted in aviation turbine fuel.

<sup>B</sup>FAME is not approved as an additive for jet fuel. This level is accepted by approval authorities as the functional definition of “nil addition.” The aviation industry is currently applying the additive approval process to evaluate the possible allowance of the presence of up to 100 mg/kg of FAME in aviation turbine fuel to facilitate the distribution of aviation turbine fuel in systems containing multiple products.

to **X1.12.5** for further discussion. No substance of known dangerous toxicity under usual conditions of handling and use shall be present, except as permitted in this specification.

## 8. Sampling

8.1 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.

iTech Standards  
(<https://standards.iteh.ai>)  
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[ASTM D1655-13](#)

<https://standards.iteh.ai/catalog/standards/sist/00fd93c2-25c2-4f7a-9406-13e9159cf4f1/astm-d1655-13>

8.2 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](#).

## 9. Report

9.1 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.

9.2 A suggested form for reporting inspection data on aviation turbine fuels is given in [Appendix X3](#) as [Fig. X3.1](#). This form is optimized for electronic data entry.

9.3 When [Table 1](#) test results and [Table 2](#) additive additions are reported at the point of batch origination or at full certification in a form commonly known as a “Certificate of Quality” or “Certificate of Analysis,” at least the following should be included:

9.3.1 The designation of each test method used,

9.3.2 The limits from [Table 1](#) and [Table 2](#) for each item reported with units converted as appropriate to those measured and reported, and

9.3.3 The designation of the quality system used by the reporting test laboratory. If no quality system is used then this shall be reported as “None.”

9.4 A suggested, nonmandatory form for reporting inspection data in a Certificate of Quality or Analysis format is given in [Appendix X3](#) as [Fig. X3.2](#).

NOTE 2—This form is appropriate for reporting complete certification results. A different form (not reproduced here) showing original and retest results is more appropriate for reporting test results intended to assess if a specific batch of fuel has changed as it moves through the distribution system.

## 10. Test Methods

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

10.1.1 *Density*—Test Method [D1298](#) or [D4052](#).

10.1.2 *Distillation*—Test Method [D86](#). For Jet A and Jet A-1, Test Method [D2887](#) can be used as an alternate. Results from Test Method [D2887](#) shall be reported as estimated [D86](#) results by application of the correlation in [Appendix X5](#) on Correlation for Jet and Diesel Fuel in Test Method [D2887](#). In case of dispute, Test Method [D86](#) shall be the referee method (see [X1.6.1.1](#)).

10.1.3 *Flash Point*—Test Method [D56](#), [D93](#), or [D3828](#). Test Method [D56](#) is the referee method.

10.1.4 *Freezing Point*—Test Method [D5972](#), [D7153](#), [D7154](#), or [D2386](#). Any of these test methods can be used to certify and recertify jet fuel. However, Test Method [D2386](#) is the referee method. An interlaboratory study (RR: D02-1572<sup>9</sup>) that evaluated the ability of freezing point methods to detect jet fuel contamination by diesel fuel determined that Test Methods [D5972](#) and [D7153](#) provided significantly more consistent detection of freeze point changes caused by contamination than Test Methods [D2386](#) and [D7154](#). It is recommended to certify and recertify jet fuel using either Test Method [D5972](#) or Test Method [D7153](#), or both, on the basis of the reproducibility and cross-contamination detection reported in RR:D02-1572.<sup>9</sup> The cause of freezing point results outside specification limits by automated methods should be investigated, but such results do not disqualify the fuel from aviation use if the results from the referee method (Test Method [D2386](#)) are within the specification limit.

10.1.5 *Viscosity*—Test Method [D445](#).

10.1.6 *Net Heat of Combustion*—Test Method [D4529](#), [D3338](#), or [D4809](#).

10.1.7 *Corrosion (Copper Strip)*—Test Method [D130](#).

10.1.8 *Total Acidity*—Test Method [D3242](#).

10.1.9 *Sulfur*—Test Method [D1266](#), [D2622](#), [D4294](#), or [D5453](#).

10.1.10 *Mercaptan Sulfur*—Test Method [D3227](#).

10.1.11 *Water Separation*—Test Method [D3948](#).

10.1.12 *Existent Gum*—Test Method [D381](#) or IP 540. Test Method [D381](#), using steam jet operating conditions, shall be the referee test method.

10.1.13 *Thermal Stability*—Test Method [D3241](#).

10.1.14 *Aromatics*—Test Method [D1319](#) or [D6379](#). Test Method [D1319](#) shall be the referee test method.

10.1.15 *Smoke Point*—Test Method [D1322](#).

10.1.16 *Naphthalene Content*—Test Method [D1840](#).

10.1.17 *Electrical Conductivity*—Test Method [D2624](#).

## 11. Keywords

11.1 aviation turbine fuel; avtur; Jet A; Jet A-1; jet fuel; turbine fuel

<sup>9</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1572.

**A1. FUELS FROM NON-CONVENTIONAL SOURCES**
**A1.1 Introduction**

A1.1.1 Jet fuel has contained synthesized hydrocarbons since the inception of Specification D1655. However, these synthesized materials are generated from petroleum, oil sand or shale derived feedstocks in the refinery and exhibit properties substantially similar to historically refined kerosine. The fuel property requirements defined in Specification D1655, **Table 1** are batch-to-batch quality control tests which historically have provided fit-for-purpose jet fuel but assume that the jet fuel has a composition that is substantially similar to historical compositions. There is no basis to assume that fuels having novel compositions provide fit-for-purpose performance in current aviation hardware even if they appear to satisfy Specification D1655, **Table 1** requirements. While the use of synthesized hydrocarbons is known and an acceptable practice, the use of synthesized hydrocarbons from new sources requires specific guidance that is currently outside the scope of Specification D1655. This guidance is found in Specification **D7566**.

A1.1.2 Specification **D7566** was developed by Subcommittee D02.J0 to provide control for jet fuel produced with non-petroleum, non-shale, non-oil sands derived synthesized components. This specification guides the preparation of fuel blends that are compositionally similar to the refined fuels generated to Specification D1655 and can be controlled thereby in the distribution system. Aviation turbine fuels with synthetic components produced in accordance with Specification **D7566** meet the requirements of Specification D1655. Specification **D7566** does not yet include all fuels from non-conventional sources, so as an interim solution, it has been deemed necessary to recognize, on an individual basis, fuels from non-conventional sources whose performance complies with the intent of this specification and that have been approved by a coordinated specification authority.

**A1.2 Acceptable Fuels from Non-Conventional Sources**

A1.2.1 The SASOL semi-synthetic fuel, a blend of conventionally produced kerosine and a synthetic Iso-Paraffinic Kerosine by itself or as combined with SASOL heavy naphtha #1 and specified in Defence Standard (Def Stan) 91-91, is recognized as meeting the requirements of Specification D1655.

A1.2.2 The SASOL fully synthetic fuel, a blend of up to five synthetic streams, specified in D.4.3 of Defence Standard (Def Stan) 91-91, is recognized as meeting the requirements of Specification D1655.

**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>10</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>11</sup> and the *Handbook of Aviation Fuel Properties*.<sup>12</sup>

<sup>10</sup> *Manual on Significance of Tests for Petroleum Products*, MNL 1, ASTM International, 2003.

<sup>11</sup> MNL 37, *Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing*, Eds., Totten, George E., Westbrook, Steven R., and Shah, Rajesh J., ASTM International, W. Conshohocken, PA, 2003.

<sup>12</sup> *Handbook of Aviation Fuel Properties*, Third Edition, *CRC Report 635*, Coordinating Research Council, Atlanta, GA, 2004.



## X1.2 Significance and Use

X1.2.1 Specification D1655 defines two grades of jet fuel for civil use. Limiting values for the two grades 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 a fuel 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>13</sup>). Today, a single pass/fail run with the tube temperature controlled at 260°C is used to ensure compliance with the specification 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 tube deposit

[ASTM D1655-13](https://standards.iteh.ai/catalog/standards/sist/00fd93c2-25c2-4f7a-9406-13e9159c44f1/astm-d1655-13)

<https://standards.iteh.ai/catalog/standards/sist/00fd93c2-25c2-4f7a-9406-13e9159c44f1/astm-d1655-13>

<sup>13</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.

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

Performance Characteristics	Test Method	Sections
Engine fuel system deposits and coke	Thermal stability	X1.3
	Smoke point	X1.4.2.1
Combustion properties	Aromatics	X1.4.2.2
	Percent naphthalenes	X1.4.2.3
	Density	X1.5.1
Fuel metering and aircraft range	Net heat of combustion	X1.5.2
	Distillation	X1.6.1
Fuel atomization	Viscosity	X1.6.2
	Freezing point	X1.7.1
Fluidity at low temperature	Mercaptan sulfur	X1.8.1
	Sulfur	X1.8.2
Compatibility with elastomer and the metals in the fuel system and turbine	Copper strip corrosion	X1.8.3
	Acidity	X1.8.4
Fuel storage stability	Existent gum	X1.9.1
	Flash point	X1.11.1
Fuel handling	Static Electricity	X1.11.2
	Water separation characteristics	X1.13.2
	Free water and particulate contamination	X1.12.3
	Particulate matter	X1.12.4
	Membrane color ratings	X1.12.4.1
	Undissolved water	X1.12.2
	Fuel lubricity	X1.10
	Additives	X1.15.1
	Sample containers	X1.15.3
	Fuel lubricating ability (lubricity)	
Miscellaneous		

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 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: smoke point, percent naphthalenes, and percent aromatics.<sup>14</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).

## X1.5 Fuel Metering and Aircraft Range

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<https://standards.iteh.ai/catalog/standards/sist/00fd93c2-25c2-4f7a-9406-13e9159c44f1/astm-d1655-13>

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](#), 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.

<sup>14</sup> A task force studied the possible use of hydrogen content as an alternative to aromatics content. Supporting data (a report of these studies completed in 1989) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1258.