Standard Specification for Jet B Wide-Cut Aviation Turbine Fuel[1]

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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D86 Test Method for Distillation of Petroleum Products 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

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

D1655 Specification for Aviation Turbine Fuels

D1660 Method of Test for Thermal Stability of Aviation Turbine Fuels (Withdrawn 1992)[3]

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, 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

D3338 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 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

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.J0.01 on Jet Fuel Specifications.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

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 (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 *IP Standard:*[4]

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

2.3 *API Standards:*[5]

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[5]

2.4 *Joint Inspection Group Standards:*[6]

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[6]

2.5 *Military Standard:*[7]

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[8]
CAN/CGSB 3.22-97 "Aviation Turbine Fuel, Wide Cut Type" includes grade Jet B and NATO grade F-40 fuel[9]
ICAO 9977 Manual on Civil Aviation Jet Fuel Supply[10]

3. General

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

4. Classification

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

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

5. Materials and Manufacture

5.1 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 nitrogeneous compounds.

5.1.1 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).

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:[11]

5.2.1 Other additives are permitted under 5.1 and Section 7.1. 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.

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 %.

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

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

[6] Available from Joint Inspection Group (JIG), http://www.jigonline.com.

[7] Available from Dept. of Defense Single Stock Point, Bldg 4D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

[8] 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.

[9] Available from the Canadian General Standards Board (CGSB), Ottawa, Canada K1A 1G6.

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

[11] 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.

TABLE 1 Detailed Requirements of Aviation Turbine Fuels[A]

Property		Jet B	ASTM Test Method[B]
1. Aromatics, volume percent	max	25	D1319
2. Aromatics, volume percent	max	26.5	D6379
Sulfur, mercaptan,[C] 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^3		751 to 802	D1298 or D4052
Vapor pressure, 38 °C, kPa		14 to 21	D323 or D5191[D]
Freezing point, °C	max	–50[E]	D2386 or D5972[F]
Net heat of combustion, MJ/kg	min	42.8[G]	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, 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[H,I]
Tube deposits less than		3	
	No *Peacock* or *Abnormal* Color Deposits		
Existent gum, mg/100 mL	max	7	D381
ADDITIVES		See 5.2	
Electrical conductivity, pS/m		[J]	D2624
Microseparometer Rating[K]			D3948
Without electrical conductivity additive	min	85	
With electrical conductivity additive	min	70	

[A] For compliance of test results against the requirements of Table 1, see 6.2.
[B] The test methods indicated in this table are referred to in Section 10.
[C] The mercaptan sulfur determination may be waived if the fuel is considered sweet by the doctor test described in Test Method D4952.
[D] 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.
[E] Other freezing points may be agreed upon between supplier and purchaser.
[F] 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.
[G] 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.
[H] 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.
[I] Tube deposits shall always be reported by the Visual Method.
[J] 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.

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

[K] At point of manufacture.

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

5.3 Guidance material is presented in Appendix X3 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 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. No substance of known dangerous toxicity under usual conditions of handling and use shall be present, except as permitted in this specification.

TABLE 2 Detailed Requirements for Additives in Aviation Turbine Fuels

Additive	Dosage
Fuel Performance Enhancing Additives	
Antioxidants[A,B]	24.0 mg/L
max[C]	
One of the following:	
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	
Metal Deactivator[A]	
N,N-disalicylidene-1,2-propane diamine	
On initial blending	2.0 mg/L max[C,D]
After field reblending, cumulative concentration	5.7 mg/L max
Fuel System Icing Inhibitor[E]	0.10 volume percent min
Diethylene Glycol Monomethyl Ether (see Specification D4171)	0.15 volume percent
max	
Fuel Handling and Maintenance Additives	
Electrical Conductivity Improver[F]	
Stadis 450[G]	
On initial blending	3 mg/L max
After field reblending, cumulative concentration	5 mg/L max
If the additive concentration is unknown at time of retreatment	
Additional concentration is restricted to 2 mg/L max	
Leak Detection Additive	1 mg/kg max
Tracer A (LDTA-A)[H]	
Biocidal Additives[E,I,K]	
Biobore JF	
Kathon FP1.5	
Corrosion Inhibitor/Lubricity Improvers[J]	
One of the following:	
HiTEC 580	23 mg/L max
Octel DCI-4A	23 mg/L max
Nalco 5403	23 mg/L max

[A] The active ingredient of the additive must meet the composition specified.
[B] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1125.
[C] Active ingredient (not including weight of solvent).
[D] If copper contamination is suspected, initial treatment may exceed 2.0 mg/L but cumulative total must be below 5.7 mg/L.
[E] The quantity must be declared by the fuel supplier and agreed to by the purchaser.
[F] 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.

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

[G] Stadis 450 is a registered trademark marketed by Innospec Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EH, UK.
[H] Tracer A (LDTA-A) is a registered trademark of Tracer Research Corp., 3755 N. Business Center Dr., Tucson, AZ 85705.
[I] 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.
[J] More information concerning minimum treat rates of corrosion inhibitor/lubricity improver additives is contained in X1.11.
[K] Refer to the Aircraft Maintenance Manual (AMM) to determine if either biocide is approved for use and for their appropriate use and dosage.

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.

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 X4 of Specification D1655.

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 Methods D1298 or D4052.

10.1.2 *Distillation*—Test Method D86.

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

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

10.1.5 *Net Heat of Combustion*—Test Methods D4529, D3338, or D4809.

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

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

10.1.8 *Mercaptan Sulfur*—Test Method D3227.

10.1.9 *Water Reaction*—Test Method D1094.

10.1.10 *Existent Gum*—Test Method D381.

10.1.11 *Thermal Stability*—Test Method D3241.

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

10.1.13 *Smoke Point*—Test Method D1322.

10.1.14 *Naphthalene Content*—Test Method D1840.

10.1.15 *Electrical Conductivity*—Test Method D2624.

11. Keywords

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

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.[12] 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*[13] and the *Handbook of Aviation Fuel Properties*.[14]

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 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.[15]) Today, a single pass/fail run with the tube temperature controlled at 260 °C is used to ensure compliance

[12] ASTM MNL 1, *Manual on Significance of Tests for Petroleum Products*, ASTM International, W. Conshohocken, 1993.

[13] 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.

[14] *Handbook of Aviation Fuel Properties*, Fourth Edition (2014), CRC Report 663, Coordinating Research Council, Alpharetta, GA, 30022.

[15] 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
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
Fuel atomization	Distillation	X1.6.1
	Vapor pressure	X1.6.2
Fluidity at low temperature	Freezing point	X1.7.1
Compatibility with elastomer and the metals in the fuel system and turbine	Mercaptan sulfur	X1.8.1
	Sulfur	X1.8.2
	Copper strip corrosion	X1.8.3
Fuel storage stability	Existent gum	X1.9.1
Fuel cleanliness, handling	Water reaction	X1.10.1
	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
Static electricity	Conductivity	X1.10.7
Fuel lubricating ability (lubricity)	Fuel lubricity	X1.11
Miscellaneous	Additives	X1.12.1
	Sample containers	X1.12.2
	Leak detection additive	X1.12.3
	Color	X1.12.4

with the specifications 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.[16]

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

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

[16] 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.

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.

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 kerosine-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 container. It also provides a means for checking the performance of fuel filter-separators. Test Method D3240 describes this test method.

X1.10.7 *Static Electricity*—The generation and dissipation of static electricity can create problems in the handling of aviation fuels. Electrical conductivity additives can be added to dissipate charge more rapidly. This is most effective when the fuel conductivity is in the range from 50 to 450 pS/m. Studies have shown that when fuels treated with conductivity additive are commingled with non-additized fuel resulting in a low conductivity fuel, that fuel blend does not exhibit unusual static behavior. For more information on this subject, see Guide D4865.

X1.11 Fuel Lubricity

X1.11.1 Aircraft/engine fuel system components and fuel control units rely on the fuel to lubricate their sliding parts. The effectiveness of a jet fuel as a lubricant in such equipment is referred to as its *lubricity*. Differences in fuel system component design and materials result in varying degrees of equipment sensitivity to fuel lubricity. Similarly, jet fuels vary in their level of lubricity. In-service problems experienced have ranged in severity from reductions in pump flow to unexpected mechanical failure leading to in-flight engine shutdown.

X1.11.2 The chemical and physical properties of jet fuel cause it to be a relatively poor lubricating material under high temperature and high load conditions. Severe hydroprocessing removes trace components resulting in fuels that tend to have lower lubricity than straight-run or wet-treated fuels. Corrosion inhibitor/lubricity improver additives (see Table 2) are routinely used to improve the lubricity of military fuels and may be used in civil fuels. These additives vary in efficacy and may be depleted by adsorption on tank and pipe surfaces, so treat rates should be set with care. Because of their polar nature, these additives can have adverse effects on filtration systems and on fuel water separation characteristics. For this reason, it is preferable to avoid adding more of these additives than needed. When adequate jet fuel lubricity performance is achieved solely by additive use (without BOCLE testing or commingling with higher lubricity fuels), the additive concentration should be used at no less than its Minimum Effective Concentration (MEC) from the military Qualified Products List (QPL-25017). These levels are:

CI/LI Additive	MEC
HiTEC 580	15 g/m^3
Octel DCI-4A	9 g/m^3
Nalco 5403	12 g/m^3

X1.11.3 Most modern aircraft fuel system components have been designed to operate on low lubricity fuel (Test Method D5001 (BOCLE) wear scar diameter up to 0.85 mm). Other aircraft may have fuel system components that are more sensitive to fuel lubricity. Because low lubricity fuels are commingled with high lubricity fuels in most distribution systems, the resultant fuels no longer have low lubricity. However, problems have occurred when severely hydroprocessed fuel from a single source was the primary supply for sensitive aircraft. Where there are concerns about fuel lubricity, the air frame manufacturer can advise precautionary measures, such as the use of an approved lubricity additive to enhance the lubricity of the fuel.

X1.11.4 Test Method D5001 (BOCLE) is a test for assessing fuel lubricity where lower lubricity fuels give larger BOCLE wear scar diameters. BOCLE is used for in-service trouble shooting, lubricity additive evaluation, and in the monitoring of low lubricity test fluid during endurance testing of equipment. However, because the BOCLE may not accurately model all types of wear that cause in-service problems, other methods may be developed to better simulate the type of wear most commonly found in the field.

X1.11.5 Regulations are requiring increased production and distribution of ultralow sulfur diesel fuel (15 ppm maximum sulfur content). Diesel fuels are desulfurized to these low levels by severe hydroprocessing, sometimes resulting in very low lubricity fuels. Jet fuel lubricity may be impacted by the increased use of low sulfur diesel fuel, because batches of jet fuel may be made to these ultralow sulfur levels to maintain efficient production and distribution.

X1.12 Miscellaneous

X1.12.1 *Additives*—Antioxidants and metal deactivators are used to prevent the formation of oxidation deposits in aircraft engine fuel systems, to counteract the catalytic effects of active metals in fuel systems, and to improve the oxidation stability of fuels in storage. Other additives are available to inhibit the corrosion of steel in fuel systems, to improve the fuel lubricity, to increase the electrical conductivity of fuel, to combat microbiological organisms, to prevent the formation of ice in fuel systems containing water, and to assist in detecting leaks in fuel storage, delivery, and dispensing systems. The chemical names of approved additives and the maximum quantities permitted are shown in the specifications.

X1.12.1.1 *Fuel System Icing Inhibitor,* diethylene glycol monomethyl ether approved in 5.2.1.2 shall conform to the requirements shown in Specification D4171.

X1.12.2 *Sample Containers*—A practice for sampling aviation fuel for tests affected by trace contamination can be found in Practice D4306.

X1.12.3 *Leak Detection Additive*—Addition of leak detection additive, approved in Table 2, should be added to the fuel in accordance with the Tracer Tight[17] technology.

X1.12.4 *Color*—While this specification does not have a color requirement, color can be a useful indicator of fuel quality. Normally, fuel color ranges from water white (colorless) to a straw/pale yellow. Other fuel colors may be the result of crude oil characteristics or refining processes. Darkening of fuel or a change in fuel color may be the result of product contamination and may be an indicator that the fuel is off-specification, which could render it unfit and not acceptable for aircraft/engine use. Fuel having various shades of color, that is, pink, red, green, blue, or a change in color from the supply source should be investigated to determine the cause of color change to ensure suitability for aircraft/engine use and should be documented prior to final delivery to airport storage.

[17] Tracer Tight is a registered trademark of Tracer Research Corp., 3755 N. Business Center Dr., Tucson, AZ 85705.

X2. CLEANLINESS GUIDELINES

X2.1 Introduction

X2.1.1 The cleanliness of aviation turbine fuel is an essential performance requirement. Cleanliness requires the relative absence of free water and solid particulates. Water, or dirt, or both, contamination in fuel on-board an aircraft represents a threat to flight safety and can cause longer term problems in areas such as wear, corrosion, and plugging of filters and other narrow tolerance parts.

X2.1.2 The cleanliness of aviation turbine fuel is protected in part by allowing time for dirt and water to settle during fuel distribution and by the routine use of effective filtration that removes both dirt and water. Generally the fuel handling system filters the fuel several times between manufacture and use with the final filtration occurring as the fuel is loaded onto an aircraft.

X2.1.3 A key element in preventing contamination is to minimize or eliminate surfactants, which can compromise the ability of fuel handling systems to remove dirt and water. For example, surfactants can reduce the particle size of suspended solid and water droplets, which slows removal by settling. Surfactants can disperse dirt and water so finely that they pass through filters. Surfactants can adsorb on the surfaces of filter/coalescers interfering with water removal. Surfactants can also lift rust from surfaces increasing the solids level in the fuel.

X2.1.4 Unlike most other fuel properties, fuel cleanliness is dynamic; constantly changing during transportation and distribution. Jet fuel should be maintained in as clean a condition as possible right up to and in airport storage to ensure that possible failures of individual filtration components will not result in an unsafe condition. Airport control of cleanliness should be such as to ensure that only fuel relatively absent of free water and solid particulates is delivered into aircraft.

X2.2 Surfactant Cleanliness

X2.2.1 The presence of surfactants in aviation turbine fuel specified by Specification D1655 is controlled at the point of manufacture by the Test Method D3948 performance requirement listed in Table 1. To determine if surfactant contamination occurs during transportation, the fuel should also be tested downstream of the point of manufacture as appropriate.

X2.2.2 Results of downstream Test Method D3948 testing are not to be used as the sole reason for rejection of fuel, but they can indicate a mandatory need for further diligent investigation or remedial action, or both, such as passing the fuel through a clay adsorption unit to remove surfactants. However, the fuel may be rejected in the absence of satisfactory Test Method D3948 testing results if no documented evidence is presented that a detailed investigation was carried out which demonstrated that the fuel was free of excess water and dirt and can be delivered into aircraft in a clean condition.

X2.2.3 Because distribution systems can be complex and employ a variety of methods of transporting the fuel, sampling points and methodologies should be established as a result of a technical assessment designed to ensure that fuel cleanliness is maintained throughout the system to the point of delivery into aircraft. Since transport systems vary in their basic nature, for example, a multi-product pipeline versus a dedicated pipeline, and also in their detailed operating conditions, the parties assuming custody of the fuel should evaluate their particular systems and establish suitable testing requirements.

X2.3 Cleanliness at Time of Fuel Custody Transfer at the Airport

X2.3.1 Airport fueling is the most critical location for controlling dirt and water cleanliness. Into-airport storage is thus an important point for controlling surfactant contamination so as to protect out-of-storage and into-plane dirt and water filtration.

X3. CONTROL OF PROCESSING ADDITIVES AND DISTRIBUTION

X3.1 Experience has shown that refinery processing additives, such as corrosion inhibitors, might be carried over in trace quantities into aviation fuel during refinery production. In some cases, this has resulted in operational problems in aircraft fuel systems. Moreover, these additives can cause problems at levels that may not be detected by the standard specification testing detailed in Table 1. While the specification (in 5.1.1) requires that only approved additives are used, confirming that non-approved additives are absent is difficult, given that:

X3.1.1 The analytical target may be uncertain, since there is a wide range of (often proprietary) materials involved,

X3.1.2 There is no industry-agreed upon basis for determining the required analysis sensitivity, and

X3.1.3 There usually are no available data, relating processing additive concentration to aircraft system performance, to set no-harm levels (to define analysis sensitivity).

X3.2 It is therefore not practical for this specification to require detailed chemical analysis of each production batch of aviation fuel beyond the requirements listed in Table 1. Instead, each manufacturing location should ensure that procedures are in place to control processing additive use and impact on product performance. One acceptable approach to do this is to implement a management of change procedure that evaluates the impact of processing changes (including process additives) on finished product quality. Other approaches may also be acceptable.

X3.3 *Distribution Control*—Although the application of Specification D6615 extends from jet fuel manufacture to the wing tip, Specification D6615 does not define quality assurance testing and handling procedures appropriate for maintaining the quality of the fuel through the distribution system. Standards for such procedures were originally developed and maintained by fuel suppliers/handlers. Recent initiatives in response to field incidents have resulted in the industry publishing ICAO 9977 to provide guidance for jet fuel handling. ICAO 9977 calls out EI/JIG 1530, JIG 1, JIG 2, API 1543, API 1595, and other standards for producing, handling, and supplying aviation fuels. Changes in the fuel handling systems should be subject to a formal risk and management of change assessment to ensure product quality is maintained.

X4. FORM FOR REPORTING INSPECTION DATA ON AVIATION TURBINE FUELS

X4.1 See Specification D1655 for guidance on the form for reporting inspection data.

SUMMARY OF CHANGES

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D6615 – 15) that may impact the use of this standard. (Approved Sept. 1, 2015.)

(1) Added new footnote H to Table 1.

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D6615 – 14a) that may impact the use of this standard. (Approved July 1, 2015.)

(1) Revised X1.1.1.

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D6615 – 14) that may impact the use of this standard. (Approved May 15, 2014.)

(1) Revised Section 5 and subsection X1.11.
(2) Added new Table 2, Detailed Requirements for Additives in Aviation Turbine Fuels.

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D6615 – 11a) that may impact the use of this standard. (Approved May 1, 2014.)

(1) Added new subsection 1.3.
(2) Added new references ICAO 9977, EI/JIG Standard 1530, JIG 1, JIG 2, API 1543, API 1595, EI/JIG 1530, and ATA-103 to Section 2, Referenced Documents.
(3) Added X3.3.