Designation: D 6615 – 02

An American National Standard

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

This standard is issued under the fixed designation D 6615; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This specification 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 to other fuels described in Specification D 1655. This fuel is intended for use in aircraft which are certified to use such fuel.

NOTE 1—The technical requirements of this product, at the time of the first publication of this specification, are substantially identical to the requirements of Jet B in Specification D 1655.

2. Referenced Documents

2.1 *ASTM Standards:*

D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure[2]

D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test[2]

D 156 Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)[2]

D 323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)[2]

D 381 Test Method for Gum Content in Fuels by Jet Evaporation[2]

D 1094 Test Method for Water Reaction of Aviation Fuels[2]

D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)[2]

D 1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method[2]

D 1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption[2]

D 1322 Test Method for Smoke Point of Aviation Turbine Fuels[2]

D 1552 Test Method for Sulfur in Petroleum Products (High-Temperature Method)[2]

D 1660 Test Method for Thermal Stability of Aviation Turbine Fuels[3]

D 1655 Specification for Aviation Turbine Fuels[2]

D 1840 Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry[2]

D 2276 Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling[2]

D 2386 Test Method for Freezing Point of Aviation Fuels[2]

D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry[2]

D 2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels[2]

D 3227 Test Method for Mercaptan Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method)[2]

D 3240 Test Method for Undissolved Water in Aviation Turbine Fuels[4]

D 3241 Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels (JFTOT Procedure)[4]

D 3338 Test Method for Estimation of Heat of Combustion of Aviation Fuels[4]

D 3948 Test Methods for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer[4]

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter[4]

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products[4]

D 4171 Specification for Fuel System Icing Inhibitors[4]

D 4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)[4]

D 4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectroscopy[4]

D 4305 Test Method for Filter Flow of Aviation Fuels at Low Temperatures[4]

D 4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination[4]

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[1] 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 Turbine Fuel Specifications.

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[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] Discontinued—Replaced by D 3241—See *1993 Annual Book of ASTM Standards*, Vol 05.02.

[4] *Annual Book of ASTM Standards*, Vol 05.02.

D 4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels[4]

D 4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Intermediate Precision Method)[4]

D 4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems[4]

D 4952 Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)[4]

D 5001 Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-On-Cylinder Lubricity Evaluator (BOCLE)[4]

D 5006 Test Method for Determination of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels[4]

D 5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)[4]

D 5452 Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration[5]

D 5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by Ultraviolet Fluorescence[5]

D 5901 Test Method for Freezing Point of Aviation Fuels (Automated Optical Method)[5]

D 5972 Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)[5]

E 29 Practice for Using Significant Digits In Test Data to Determine Conformance with Specifications[6]

2.2 *IP Standards:*[7]

225 Copper Content of Aviation Turbine Fuel

227 Silver Corrosion of Aviation Turbine Fuel

2.3 *Other Standard:*[8]

CAN/CGSB 3.22-97 "Aviation Turbine Fuel, Wide Cut Type" includes grade Jet B and NATO grade F-40 fuel

2.4 *Military Standard:*[9]

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

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 herein, shall consist of blends of refined hydrocarbons derived from crude petroleum, natural gasoline, or blends thereof with synthetic hydrocarbons.

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 X1.11.1).

5.2 *Additives*—May be added to each type of aviation turbine fuel in the amount and of the composition specified in the following list of approved material:[10]

5.2.1 *Antioxidants*—In amounts not to exceed 24.0 mg/L active ingredients (not including weight of solvent):

5.2.1.1 2,6-ditertiary-butyl phenol.

5.2.1.2 2,6-ditertiary-butyl-4-methyl phenol.

5.2.1.3 2,4-dimethyl-6-tertiary-butyl phenol.

5.2.1.4 75 % min. 2,6-ditertiary-butyl phenol, plus 25 % max. mixed tertiary and tritertiary-butyl phenols.

5.2.1.5 55 % min. 2,4-dimethyl-6-tertiary-butyl phenol, plus 15 % min. 2,6-ditertiary-butyl-4-methyl phenol, remainder as monomethyl and dimethyl tertiary-butyl phenols.

5.2.1.6 72 % min. 2,4-dimethyl-6tertiary-butyl phenol, 28 % max. monomethyl and dimethyl-tertiary-butyl phenols.

5.2.2 *Metal Deactivator*, in amount not to exceed 5.7 mg/L (not including weight of solvent):

5.2.2.1 *N,N* -disalicylidene-1,2-propane diamine.

5.2.3 *Electrical Conductivity Additive*—Stadis 450[11] not to exceed 3 mg/L.

5.2.3.1 When loss of fuel conductivity necessitates retreatment with electrical conductivity additive, the following concentration limits apply:

At Manufacture:	
Stadis 450	3 mg/L, max
Retreatment	
Stadis 450	cumulative total 5 mg/L, max

5.2.4 *Leak Detection Additive*—Tracer A[12] may be added to the fuel in amounts not to exceed 1 mg/kg.

5.2.5 Other additives are permitted under 5.1 and Section 7. These include fuel system icing inhibitor, other anti-oxidants, inhibitors, and special purpose additives. 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.

5.2.5.1 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.

5.2.5.2 *Fuel System Icing Inhibitor*:

(1) Diethylene Glycol Monomethyl Ether (DIEGME), conforming to the requirements of Specification D 4171, Type III,

[5] *Annual Book of ASTM Standards*, Vol 05.03.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] Available from Directorate of Standardization, Stan 1, Room 5131, Kentigern House, 65 Brown St., Glasgow, G2 8EX, United Kingdom.

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

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

[10] 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.

[11] Stadis 450 is a registered trademark marketed by Octel America, 200 Executive Dr., Newark, DE 19702.

[12] Tracer A (LDTA-A) is a registered trademark of Tracer Research Corp., 3755 N. Business Center Dr., Tucson, AZ 85705.

may be used in concentrations of 0.10 to 0.15 volume %.

(2) Test Method D 5006 may be used to determine the concentration of DIEGME in aviation fuels.

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 E 29. Where multiple determinations are made, the average result, rounded in accordance with Practice E 29, shall be used.

7. Workmanship, Finish, and Appearance

7.1 The aviation turbine fuel herein specified 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 herein.

8. Sampling

8.1 Because of the importance of proper sampling procedures in establishing fuel quality, use the appropriate procedures in Practice D 4057.

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 D 4306.

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

TABLE 1 Detailed Requirements of Aviation Turbine Fuels[A]

Property		Jet B	ASTM Test Method[B]
Aromatics, vol %	max	25	D 1319
Sulfur, mercaptan,[C] mass %	max	0.003	D 3227
Sulfur, total mass %	max	0.3	D 1266, D 1552, D 2622, D 4294, or D 5453
Distillation temperature, °C:			
20 % recovered, temperature	max	145	D 86
50 % recovered, temperature	max	190	
90 % recovered, temperature	max	245	
Distillation residue, %	max	1.5	
Distillation loss, %	max	1.5	
Density at 15°C, kg/m^3		751 to 802	D 1298 or D 4052
Vapor pressure, 38°C, kPa		14 to 21	D 323 or D 5191[D]
Freezing point, °C	max	−50[E]	D 2386, D 4305[F], D 5901, or D 5972[G]
Net heat of combustion, MJ/kg	min	42.8[H]	D 4529, D 3338, or D 4809
One of the following requirements shall be met:			
(*1*) Smoke point, mm, or	min	25	D 1322
(*2*) Smoke point, mm, and	min	18	D 1322
Naphthalenes, vol, %	max	3.0	D 1840
Copper strip, 2 h at 100°C		No. 1	D 130
Thermal Stability:			
Filter pressure drop, mm Hg	max	25[I]	D 3241[J]
Tube deposits less than		Code 3	
Existent gum, mg/100 mL	max	7	D 381
Water reaction:			
Interface rating	max	1b	D 1094
ADDITIVES		See 5.2	
Electrical conductivity, pS/m		[K]	D 2624

[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 D 4952.

[D] Cyclohexane and toluene, as cited in 7.2 and 7.7 of Test Method D 5191, shall be used as calibrating reagents. Test Method D 5191 shall be the referee method.

[E] Other freezing points may be agreed upon between supplier and purchaser.

[F] When using Test Method D 4305, use Procedure A only, do not use Procedure B. Test Method D 4305 shall not be used on samples with viscosities greater than 5.0 mm^2/s at -20°C. If the viscosity of the sample is not known and cannot be obtained by means of the batch certificate(s), then it shall be measured. The viscosity shall be reported when reporting the Test Method D 4305 results. In case of dispute, Test Method D 2386 shall be the referee method.

[G] Test Method D 5972 may produce a higher (warmer) result than that from Test Method D 2386 on wide-cut fuels such as Jet B or JP-4. In case of dispute, Test Method D 2386 shall be the referee method.

[H] Use either Eq 1 or Table 1 in Test Method D 4529 or Eq 2 in Test Method D 3338. Test Method D 4809 may be used as an alternative. In case of dispute, Test Method D 4809 shall be used.

[I] Preferred SI units are 3.3 kPa, max.

[J] Thermal stability test (JFTOT) shall be conducted for 2.5 h at a control temperature of 260°C, but if the requirements of Table 1 are not met, the test may be conducted at 245°C. Results at both temperatures shall be reported in this case. Tube deposits shall always be reported by the Visual Method; a rating by the Tube Deposit Rating (TDR) optical density method is desirable but not mandatory.

[K] If electrical conductivity additive is used, the conductivity shall not exceed 450 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 450 pS/m under the conditions at point of delivery.

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

aviation turbine fuels is given in Appendix X3 of Specification D 1655.

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 D 1298 or D 4052.

10.1.2 *Distillation*—Test Method D 86.

10.1.3 *Vapor Pressure*—Test Methods D 323 or D 5191. Test Method D 5191 shall be the referee test method.

10.1.4 *Freezing Point*—Test Methods D 2386, D 4305, D 5901, or D 5972. Test Method D 2386 shall be the referee test method.

10.1.5 *Net Heat of Combustion*—Test Methods D 4529, D 3338, or D 4809.

10.1.6 *Corrosion (Copper Strip)*—Test Method D 130.

10.1.7 *Sulfur*—Test Methods D 1266, D 1552, D 2622, D 4294, or D 5453.

10.1.8 *Mercaptan Sulfur*—Test Method D 3227.

10.1.9 *Water Reaction*—Test Method D 1094.

10.1.10 *Existent Gum*—Test Method D 381.

10.1.11 *Thermal Stability*—Test Method D 3241.

NOTE 2—Table 1 requires the measurement of thermal stability at a tube temperature of 260°C, but permits a retest at 245°C if the first test fails. This two tier system was developed to resolve a dispute over the equivalence of results by Test Method D 3241 compared to Test Method D 1660, the original thermal stability method. A more detailed discussion of test conditions is found in X1.3.2.

10.1.12 *Aromatics*—Test Method D 1319.

10.1.13 *Smoke Point*—Test Method D 1322.

10.1.14 *Naphthalene Content*—Test Method D 1840.

10.1.15 *Electrical Conductivity*—Test Method D 2624.

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.[13]

X1.2 Significance and Use

X1.2.1 Specification D 6615 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 149°C (300°F). Such fuels have been demonstrated to have inherent storage stability.

X1.3.2 Originally, thermal stability was measured by Test Method D 1660, known as the ASTM Coker. When this test was replaced by Test Method D 3241, the JFTOT, a correlation study was conducted between the two methods. (CRC Report 450, dated 1969 and revised in 1972. See also Bert and Painter's SAE paper 730385.[14]) It was concluded that, on average, a Test Method D 3241 test at 245°C was equivalent to the original Test Method D 1660 requirement of 300°F/400°F/5 lbs/h (149°C/204.5°C/2.27 kg/h). However, the data scatter about the best fit line was such that users insisted on the initial test of 260°C as a safety margin but permitted a retest at 245°C.

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

[13] ASTM Manual 1, *Manual on Significance of Tests for Petroleum Products*, ASTM International, 1993.

[14] 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	Existant 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

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.[15]

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 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 D 4529 for the purposes of this specification. An alternative calculation, Test Method D 3338, 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 D 4809, is normally used only as a referee method in cases of dispute.

[15] 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.

X1.6 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 D 1094 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 D 3948. 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 D 4176 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 D 2276 and D 5452.

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 D 2276 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 D 3240 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 D 4865.

X1.11 Fuel Lubricity

X1.11.1 Aircraft/engine fuel system components and fuel control units rely on the fuel to lubricate their moving 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. Certain additives, for example, corrosion inhibitors, can improve the lubricity and are widely used in military fuels. They have been used occasionally in civil jet fuel to overcome aircraft problems but only as a temporary remedy while improvements to the fuel system components or changes to fuel were achieved. Because of their polar nature, these additives can have adverse effects on ground base filtration systems and on fuel water separation characteristics.

X1.11.3 Some modern aircraft fuel system components have been designed to operate on low lubricity fuel. Other aircraft may have fuel system components which are sensitive to fuel lubricity. In these cases, the manufacturer can advise precautionary measures, such as the use of an approved lubricity additive to enhance the lubricity of a particular fuel. Problems are more likely to occur when aircraft operations are confined to a single refinery source where fuel is severely hydroprocessed and where there is no co-mingling with fuels from other sources during distribution between refinery and aircraft.

X1.11.4 Test Method D 5001 (BOCLE) is a test for assessing fuel lubricity and 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.

X1.12 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 5.2.5.2 shall conform to the requirements shown in Specification D 4171.

X1.12.2 *Sample Containers*—A practice for sampling aviation fuel for tests affected by trace contamination can be found in Practice D 4306.

X1.12.3 *Leak Detection Additive*—Addition of leak detection additive, approved in 5.2.4, should be added to the fuel in accordance with the Tracer Tight[16] 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.

[16] 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 fuels is an essential performance requirement to minimize long term problems, such as wear, corrosion, or plugging of filters or orifices (cleanliness here is defined as the relative absence of free water and solid particulates). However, unlike many other fuel properties, fuel cleanliness changes during transportation. Jet fuel should be maintained in as clean a condition as possible right up to and in airport storage. Airport control of cleanliness must be such as to ensure that only clean fuel is delivered into aircraft.

X2.2 Cleanliness at Time of Fuel Custody Transfer at the Airport

X2.2.1 Because Specification D 6615 is primarily used in the sale and purchase of aviation turbine fuel, the point of custody transfer best describes the location at which cleanliness should be checked. The test methods in X2.3 have proven beneficial in evaluating the cleanliness of aviation turbine fuel.

X2.3 Test Methods

X2.3.1 *Particulate Contaminents*—Test Methods D 2276 and D 5452.

X2.3.2 *Membrane Color*—Appendix X1 of Test Method D 2276.

X2.3.3 *Water Separation Rating*—Test Methods D 3948.

X3. FORM FOR REPORTING INSPECTION DATA ON AVIATION TURBINE FUELS

X3.1 See Specification D 1655 for guidance on the form for reporting inspection data.