Designation: D 1655 – 03a

An American National Standard

Standard Specification for Aviation Turbine Fuels[1]

This standard is issued under the fixed designation D 1655; 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 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 D 6615 to replace Specification D 1655 as the specification for Jet B and refers users to this standard for reference.

[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 on Aviation Fuels.

Current edition approved ~~Aug. 10,~~ Dec. 1, 2003. Published ~~September 2003.~~ January 2004. Originally approved in 1959. Last previous edition approved in 200~~2~~3 as D 1655–0~~2~~3.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 56 Test Method for Flash Point by Tag Closed Tester
D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure
D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)
D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test
D 156 Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)
D 240 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter
D 323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)
D 381 Test Method for Existent Gum in Fuels by Jet Evaporation
D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (The Calculation of Dynamic Viscosity)
D 1094 Test Method for Water Reaction of Aviation Fuels
D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
D 1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
D 1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
D 1322 Test Method for Smoke Point of Kerosine and Aviation Turbine Fuels
D 1405 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D 1552 Test Method for Sulfur in Petroleum Products (High-Temperature Method)
D 1660 Test Method for Thermal Stability of Aviation Turbine Fuels[3]
D 1840 Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry
D 2276 Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling
D 2386 Test Method for Freezing Point of Aviation Fuels
D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry
D 2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
D 2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
D 3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
D 3227 Test Method for Mercaptan Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method)
D 3240 Test Method for Undissolved Water in Aviation Turbine Fuels
D 3241 Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels (JFTOT Procedure)
D 3242 Test Method for Acidity in Aviation Turbine Fuel
D 3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D 3343 Test Method for Estimation of Hydrogen Content of Aviation Fuels
D 3701 Test Method for Hydrogen Content of Aviation Turbine Fuels by Low Resolution Nuclear Magnetic Resonance Spectrometry
D 3828 Test Methods for Flash Point by Small Scale Closed Tester
D 3948 Test Methods for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer
D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter
D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D 4171 Specification for Fuel System Icing Inhibitors
D 4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
D 4294 Test Method for Sulfur in Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectroscopy
D 4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
D 4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D 4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
D 4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
D 4952 Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)
D 4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)
D 5001 Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-On-Cylinder Lubricity Evaluator (BOCLE)
D 5006 Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards*, ~~Vol 05.01.~~ volume information, refer to the standard's Document Summary page on the ASTM website.

~~[3] Discontinued and replaced by Test Method D 3241. See 1993 *Annual Book of ASTM Standards*, Vol 05.02.~~

[3] Withdrawn.

D 5190 Test Method for Vapor Pressure of Petroleum Products (Automatic Method)
D 5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)
D 5452 Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
D 5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by Ultraviolet Fluorescence
D 5972 Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)
D 6045 Test Method for Color of Petroleum Products by the Automatic Tristimulus Method
D 6469 Guide for Microbial Contamination in Fuels and Fuel Systems
D 6615 Specification for Jet B Wide-Cut Aviation Turbine Fuel
E 29 Practice for Using Significant Digits In Test Data to Determine Conformance with Specifications

2.2 ~~*IP*~~*Energy Institute Standards:*[4]
IP 225 Copper Content of Aviation Turbine Fuel
IP 227 Silver Corrosion of Aviation Turbine Fuel

2.3 *ANSI Standard:*[5]
ANSI 863 Report of Test Results

2.4 *Other Standard:*
Defence Standard 91-91 Issue 4 (DERD 2494) Turbine Fuel, Aviation Kerosine Type, Jet A-1[6]

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 Three~~
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.
~~4.1.2 *Jet B*—A relatively wide boiling range volatile distillate.~~
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 D 6615.

5. Materials and Manufacture

5.1 Aviation turbine fuel, except as otherwise specified herein, shall consist of refined hydrocarbons 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, are only permitted on a specific, individual basis (see Annex A1).

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:[7]

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 % minimum 2,6-ditertiary-butyl phenol, plus 25 % max. mixed tertiary and tritertiary-butyl phenols.
5.2.1.5 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.
5.2.1.6 72 % minimum 2,4-dimethyl-6–tertiary-butyl phenol, 28% maximum monomethyl and dimethyl-tertiary-butyl phenols.

5.2.2 *Metal Deactivator Additive (MDA)*, in amount not to exceed 2.0 mg/L (not including weight of solvent) on initial fuel manufacture at the refinery. Higher initial concentrations are permitted in circumstances where copper contamination is suspected

~~*Annual Book*~~
[4] Available from Directorate of ~~ASTM Standards, Vol 05.02.~~ Standardization, Stan 1, Room 5131, Kentigern House, 65 Brown St., Glasgow, G2 8EX, United Kingdom.
~~*Annual Book of ASTM*~~
[5] Available from American National Standards~~, Vol 05.03.~~ Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.
~~*Annual Book*~~
[6] Available from Procurement Executive DFS (Air), Ministry of ~~ASTM Standards, Vol 05.04.~~ Defence, St. Giles Court 1, St. Giles High St., London WC2H 8LD.
~~*Annual Book*~~
[7] Supporting data (Guidelines for Approval or Disapproval of Additives) have been filed at ASTM ~~Standards, Vol 14.02.~~ International Headquarters and may be obtained by requesting Research Report RR: D02-1125.

to occur during distribution. Cumulative concentration of MDA when retreating the fuel shall not exceed 5.7 mg/L.

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

5.2.3 *Electrical Conductivity Additive* —Stadis 450[8] 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 (LDTA-A)[9] 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~~ 7.1. These include fuel system icing inhibitor, other antioxidants, 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, 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 aviation turbine fuels is given in Appendix X3.

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 D 1298 or D 4052.

10.1.2 *Distillation*—Test Method D 86. For Jet A and Jet A-1, Test Method D 2887 can be used as an alternate with the limits listed in Table 1. In case of dispute, Test Method D 86 shall be the referee method (see X1.6.1.1).

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

~~10.1.4 *Flash Point*—Test Method D 56 or D 3828.~~

10.1.5~~4~~ *Freezing Point*—Test Method D 2386 or D 5972. Test Method D 2386 shall be the referee test method.

10.1.6~~5~~ *Viscosity*—Test Method D 445.

10.1.7~~6~~ *Net Heat of Combustion*—Test Method D 4529, D 3338, or D 4809.

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

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

~~[9] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.~~

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

TABLE 1 Detailed Requirements of Aviation Turbine Fuels[A]

Property		Jet A or Jet A-1	~~Jet B~~	ASTM Tes
COMPOSITION				
Acidity, total mg KOH/g	max	0.10	~~...~~	D 3242
Aromatics, vol %	max	25	~~25~~	D 1319
Sulfur, mercaptan,[C] weight %	max	0.003	~~0.003~~	D 3227
Sulfur, total weight %	max	0.30	~~0.3~~	D 1266, D
VOLATILITY				
Distillation: one of the following requirements shall be met.				
1. Physical Distillation				D 86
Distillation temperature, °C:				
10 % recovered, temperature	max	205	~~...~~	
20 % recovered, temperature	max	...	~~145~~	
50 % recovered, temperature	max	report	~~190~~	
90 % recovered, temperature	max	report	~~245~~	
Final boiling point, temperature	max	300	~~...~~	
Distillation residue, %	max	1.5	~~...~~	
Distillation loss, %	max	1.5	~~...~~	
2. Simulated Distillation[D]				D 2887
Distillation temperature, °C				
10% recovered, temperature	max	185		
50 % recovered, temperature		report		
90 % recovered, temperature		report		
Final boiling point, temperature	max	340		
Flash point, °C	min	38[E]	~~...~~	D 56 or D
Density at 15°C, kg/m^3		775 to 840	~~751 to 802~~	D 1298 or
~~Vapor pressure, 38°C, kPa~~				
FLUIDITY				
~~Freezing point, °C~~	~~max~~	~~−40 Jet A[G]~~	~~−50[G]~~	D 2386 or
Freezing point, °C	max	−40 Jet A[G] −47 Jet A-1[G]	~~−50[G]~~	D 2386 or
~~Viscosity − 20°C, mm^2/s[I]~~	~~max~~	~~8.0~~		~~D 445~~
Viscosity −20°C, mm^2/s[H]	max	8.0		D 445
COMBUSTION				
~~Net heat of combustion, MJ/kg~~	~~min~~	~~42.8[J]~~	~~42.8[J]~~	D 4529, D
Net heat of combustion, MJ/kg	min	42.8[I]	~~42.8[J]~~	D 4529, D
One of the following requirements shall be met:				
(*1*) Smoke point, mm, or	min	25	~~25~~	D 1322
(*2*) Smoke point, mm, and	min	18	~~18~~	D 1322
Naphthalenes, vol, %	max	3.0	~~3.0~~	D 1840
CORROSION				
Copper strip, 2 h at 100°C	max	No. 1	~~No. 1~~	D 130
THERMAL STABILITY				
~~JFTOT (2.5 h at control temperature of 260°C min)[K]~~				
JFTOT (2.5 h at control temperature of 260°C min)				
~~Filter pressure drop, mm Hg~~	~~max~~	~~25[L]~~	~~25[L]~~	D 3241K
Filter pressure drop, mm Hg	max	25[J]	~~25[L]~~	D 3241
~~Tube deposits less than~~		~~3[M]~~	~~3[M]~~	
Tube deposits less than		3[K]	~~3[M]~~	
		No *Peacock* or *Abnormal* Color Deposits		
CONTAMINANTS				
Existent gum, mg/100 mL	max	7	~~7~~	D 381
Water reaction:				
Interface rating	max	1b	~~1b~~	D 1094
ADDITIVES		See 5.2	~~See 5.2~~	
~~Electrical conductivity, pS/m~~		~~[N]~~	~~N~~	D 2624
Electrical conductivity, pS/m		[L]	~~N~~	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] Test Method D 2887 can not be used for Jet B.

[E] A higher minimum flash point specification may be agreed upon between purchaser and supplier.

[F] Results obtained by Test Methods D 3828 may be up to 2°C lower than those obtained by Test Method D 56, which is the preferred method. In case of dispute, Test Method D 56 will apply.

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

[H] 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. ^{2} /s = 1 cSt.

[I] 1 mm^2 /s = 1 cSt.

[J] For all grades 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.

[K] If the requirements of Table 1 are not met on retesting after it leaves the refinery, the test may be conducted for 2.5 h at 245°C but results at both temperatures shall be reported in this case. This footnote shall expire on December 31, 2001.

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

~~[M] Tube deposit ratings shall always be reported by the Visual Method; a rating by the Tube Deposit Rating (TDR) optical density method is desirable but not mandatory.~~

~~[N] 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.~~

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

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 vol % min
Diethylene Glycol Monomethyl Ether (see Specification D 4171)	0.15 vol %max
Fuel Handling and Maintenance Additives	
Electrical Conductivity Improver[F]	
Stadis 450[8]	
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)[9]	
Biocidal Additives[E,G]	

[A] The active ingredient of the additive must meet the composition specified.

[B] Supporting data (a list of proprietary products meeting the composition requirements for oxidation inhibitors) 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 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.

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

[G] 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.

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

10.1.98 *Total Acidity*—Test Method D 3242.

10.1.109 *Sulfur*—Test Method D 1266, D 1552, D 2622, D 4294, or D 5453.

10.1.110 *Mercaptan Sulfur*—Test Method D 3227.

10.1.121 *Water Reaction*—Test Method D 1094.

10.1.132 *Existent Gum*—Test Method D 381.

10.1.143 *Thermal Stability*—Test Method D 3241. ~~NOTE 1—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.~~

~~10.1.15~~

10.1.14 *Aromatics*—Test Method D 1319.

10.1.165 *Smoke Point*—Test Method D 1322.

10.1.176 *Naphthalene Content*—Test Method D 1840.

10.1.187 *Electrical Conductivity*—Test Method D 2624.

11. Keywords

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

ANNEX

(Mandatory Information)

A1. FUELS FROM NON-CONVENTIONAL SOURCES

A1.1 Introduction

A1.1.1 Jet fuels containing synthetic hydrocarbons have been previously allowed under Specification D 1655. However, the fraction of these hydrocarbons was not limited, and there were no requirements or restrictions placed on either these hydrocarbons or the final blend. It has been recognized that synthetic blends represent a potential departure from experience and from key assumptions on which the fuel property requirements defined in Table 1 have been based.

A1.1.2 The longer term strategy is to revise Specification D 1655 to fully encompass fuels from non-conventional sources, but this has yet to be defined. 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.

A1.2 *Acceptable Fuels from Non-conventional Sources*—The SASOL semi-synthetic fuel, a blend of conventionally produced kerosine and a synthetic kerosine and specified in Defence Standard 91-91/Issue 4, dated June 14, 2002, is recognized as meeting the requirements of Specification D 1655.

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.[10]

X1.2 Significance and Use

X1.2.1 Specification D 1655 defines two types 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.[11]) 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 lb/h (149°C/204.5°C/2.27 kg/h). However, the data scattered 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.

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[10] Available from Procurement Executive DFS (Air), Ministry
[10] *Manual on Significance of Defence, St. Giles Court Tests for Petroleum Products* , MNL 1, St. Giles High St., London WC2H 8LD. ASTM International, 1993.
[11] Supporting data (Guidelines for Approval or Disapproval of Additives) have been filed at ASTM International Headquarters
[11] Bert, J. A., and may be obtained by requesting Painter, L., "A New Fuel Thermal Stability Test (A Summary of Coordinating Research Report RR: D02-1125. 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~~
	~~Viscosity~~	~~X1.6.3~~
	Viscosity	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
	Acidity	X1.8.4
Fuel storage stability	Existent gum	X1.9.1
Fuel cleanliness, handling	Flash point	X1.10.1
	Water reaction	X1.10.2
	Water separation characteristics	X1.10.3
	Free water and particulate contamination	X1.10.4
	Particulate matter	X1.10.5
	Membrane color ratings	X1.10.6
	Undissolved water	X1.10.7
Fuel lubricating ability (lubricity)	Fuel lubricity	X1.11
Miscellaneous	Additives	X1.12.1
	Sample containers	X1.12.2

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: luminometer number, smoke point, percent naphthalenes, and percent aromatics.[12]

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

[12] ~~S~~A task force studied the pos~~450~~sible 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 Inter~~k m~~national Headquar~~k~~ters and may be obtained by ~~Octel America, 200 Executive Dr., Newark, DE 19702.~~ requesting Research Report RR: D02-1258.

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.

X1.6 Fuel Atomization

X1.6.1 *Distillation*— The fuel volatility and ease of vaporization at different temperatures are determined by distillation. The 10 % distilled temperatures are limited to ensure easy starting. The 90 % limit excludes heavier fractions that would be difficult to vaporize.

X1.6.1.1 Test Method D 86 is the referee method for measuring distillation properties; Test Method D 2887 is approved as an alternate method. However, Test Method D 86 and Test Method 2887 do not give the same numerical results, thus the different limits listed in Table 1. Test Method D 2887 always starts at a lower temperature and ends at a higher temperature than Test Method D 86. Caution should be used when using distillation properties to estimate other fuel properties, for example, flash point. A correlation equation giving a quantitative estimate of a fuel property based on Test Method D 86 data should not be used with Test Method D 2887 data.

X1.6.2 ~~*Vapor Pressure*— The Reid 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.~~

~~X1.6.3~~ *Viscosity*—The viscosity of a fuel is closely related to pumpability over the temperature range and consistency of nozzle spray patterns. The ability of fuel to lubricate a pump may also be related to the viscosity.

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.

X1.8.4 *Total Acidity*— Some petroleum products are treated with mineral acid or caustic, or both, as part of the refining procedure. Any residual mineral acid or caustic is undesirable. Neither impurity is likely to be present. However, a determination of acidity confirms this when inspecting new or unused fuel. It also measures organic acids if present.

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 *Flash Point*— The flash point is an indication of the maximum temperature for fuel handling and storage without serious fire hazard. The shipment, storage, and handling precautions regulated by municipal, state, or federal laws and insurance requirements are a function of the flash point for the particular fuel being utilized.

X1.10.2 *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.

X1.10.3 *Water Separation Characteristics* —The ease of coalescence of water from fuels as influenced by surface active agents (surfactants) is assessed by Test Methods D 3948 and 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.

X1.10.4 *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. Other following methods permit quantitative determinations.

X1.10.5 *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. Test Methods D 2276 and D 5452 describe a suitable technique.

X1.10.6 *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 on Filter Membrane Color Ratings for Fuels of Test Method D 2276 describes a suitable technique.

X1.10.7 *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.

X1.10.8 *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.

X1.10.9 *Microbial Contamination*—Uncontrolled microbial contamination in fuel systems may cause or contribute to a variety of problems including corrosion, odor, filter plugging, decreased stability, and deterioration of fuel/water separation characteristics. In addition to system component damage, off-specification fuel can result.

X1.10.9.1 Guide D 6469 provides personnel with limited microbiological background an understanding of the symptoms, occurrence, and consequences of chronic microbial contamination. The guide also suggests means for detection and control. Biocides used in aviation fuels must follow engine and airframe manufacturer's approval guidelines.

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 that 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 commingling 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 or registered trade 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[13] methodology.

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.

[13] Tracer ~~A (LDTA-A)~~ 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 1655 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 Contaminants*—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 Introduction

X3.1.1 Many airlines, government agencies, and petroleum companies make detailed studies of inspection data provided on production aviation turbine fuels. Because a large number of inspections or inspection locations, or both, is generally involved, these studies are frequently made with the aid of a computer. Without a standardized form for reporting data from different sources, transcribing the reported data for computer programming is laborious. An individual must search each different data sheet for desired information because of the random ordering of results by different reporting laboratories. One objective, therefore, of a standard reporting form is to provide a precise ordering of inspection test data being reported.

X3.1.2 The inspection form shown in Fig. X3.1 incorporates the requirements of the most commonly used international fuel specifications, including Test Method D 1655, British specification DERD 2494, and the Guidance Material published by the International Air Transport Association (IATA).

X3.1.3 Specific users of aviation turbine fuels sometimes find it necessary to specify properties that are not included in Specification D 1655, which are provided as a basis for formulating their own specifications. Another objective of a standard form is to list all tests that might be included in the large number of individual aviation turbine fuel specifications. The fact that a particular test is listed in the standard reporting form does not in itself indicate that there is a universal need for a specification limit. For example, a high-performance military aircraft might have fuel requirements not applicable to subsonic commercial aircraft.

X3.1.4 The third objective~~, to~~ in meeting future electronic commerce needs, is to establish the industry standard to be used to electronically transmit aviation turbine fuel quality data from one location to another. This form will serve as the template for mapping to ANSI 863 for aviation fuels.

INSPECTION DATA ON AVIATION TURBINE FUEL

(Items in **bold** type are referenced in the specification)

MANUFACTURER/SUPPLIER _____
PRODUCT CODE/GRADE _____
SPECIFICATION _____
SAMPLE NUMBER _____
DATE SAMPLED _____
SAMPLING LOCATION _____
BATCH NO. _____
QUANTITY LITERS @ 15°C _____
QUANTITY U.S. GALLONS @ 60°F _____
LABORATORY _____

DATE SAMPLED _____
DATE RECEIVED AT LAB _____
CONTRACT NO. _____
ORDER NO. _____
TANK NO. _____
DESTINATION _____
CRUDE SOURCE _____
PROCESSING METHOD _____
REMARKS _____

Method			Result
		APPEARANCE	
010	D 156	Color (Saybolt)	◊◊◊
020	D 6045	Color (Saybolt)	◊◊◊
030	D 4176	Visual ("Pass" or "Fail")	◊◊◊◊
		COMPOSITION	
100C	**D 3242**	**Acidity, Total (mgKOH/g)**	◊•◊◊◊
110	**D 1319**	**Aromatics (vol %)**	◊◊•◊
115	D 1319	Olefins (vol %)	◊•◊
120	**D 1840**	**Naphthalene (vol%)**	◊•◊◊
130	**D 3227**	**Sulfur, Mercaptan (mass %)**	◊•◊◊◊◊
140	D 4952	Doctor Test (P = pos, N = neg)	◊
150A	D 129	Sulfur, Total (mass %)	◊•◊◊
150B	**D 1266**	**Sulfur, Total (mass %)**	◊•◊◊
150C	**D 1552**	**Sulfur, Total (mass %)**	◊•◊◊
150D	**D 2622**	**Sulfur, Total (mass %)**	◊•◊◊
150E	D 3120	Sulfur, Total (ppm)	◊◊◊◊
150F	**D 4294**	**Sulfur, Total (mass %)**	◊•◊◊
150G	**D 5453**	**Sulfur, Total (ppm)**	◊◊◊◊
160A	D 3343	Hydrogen Content (mass %)	◊◊•◊◊
160B	D 3701	Hydrogen Content (mass %)	◊◊•◊◊
		VOLATILITY	
200A	**D 86**	**Distillation by Auto/Manual (°C)**	◊
200B	D 2887	Distillation by GC (°C)	◊
201		" Initial BP(°C)	◊◊◊•◊
202		" **10 % Rec(°C)**	◊◊◊•◊
203		" **20 % Rec(°C)**	◊◊◊•◊
204		" **50 % Rec(°C)**	◊◊◊•◊
205		" **90 % Rec(°C)**	◊◊◊•◊
206		" 95 % Rec(°C)	◊◊◊•◊
211		" **Final BP(°C)**	◊◊◊•◊
213		Residue (vol %)	◊•◊
214		Loss (vol %)	◊•◊
220A	**D 56**	**Flash Point, Tag Closed (°C)**	◊◊•◊
220B	D 93	Flash Point, PM Closed (°C)	◊◊•◊
220C	**D 3828**	**Flash Point, Setaflash (°C), Meth A**	◊◊•◊
220D	D 3828	Flash Point, Setaflash (°C), Meth B	◊◊•◊
221	D 3828	Flash Point, Setaflash (Flash/No Flash)	◊
230A	**D 1298**	**Density @ 15°C (kg/m³)**	◊◊◊•◊
230B	**D 4052**	**Density @ 15°C (kg/m³)**	◊◊◊•◊
231A	D 1298	API Gravity @ 60°F	◊◊•◊
240A	D 323	Vapor Pressure, Reid (kPa)	◊◊•◊
240B	D 4953	Vapor Pressure, Dry Method (kPa)	◊◊•◊
240C	D 5190	Vapor Pressure, Automatic Method (kPa)	◊◊•◊
240D	D 5191	Vapor Pressure, Mini Method (kPa)	◊◊•◊
		FLUIDITY	
300A	**D 2386**	**Freezing Point (°C)**	-◊◊•◊◊
300B	**D 5901**	**Freezing Point (°C)**	-◊◊•◊◊
300C	**D 5972**	**Freezing Point (°C)**	-◊◊•◊◊
300D	**D4305**	**Freezing Point (°C)**	-◊◊•◊◊
310	**D 445**	**Viscosity @ -20°C (mm²/s)**	◊◊•◊◊◊
311	D 445	Viscosity at other Temp (mm²/s)	◊◊•◊◊◊
312	D445	Temp (°C) of Item 311	◊◊◊◊

Method			Result
		COMBUSTION	
400A	D 240	Net Heat of Combustion (MJ/kg)	◊◊•◊◊◊
400B	D 1405	Net Heat of Combustion (MJ/kg)	◊◊•◊◊◊
400C	**D 3338**	**Net Heat of Combustion (MJ/kg)**	◊◊•◊◊◊
400D	**D 4529**	**Net Heat of Combustion (MJ/kg)**	◊◊•◊◊◊
400E	**D 4809**	**Net Heat of Combustion (MJ/kg)**	◊◊•◊◊◊
410	**D 1740**	**Luminometer No.**	◊◊
420	**D 1322**	**Smoke Point (mm)**	◊◊•◊
		CORROSION	
500	**D 130**	**Copper Strip.**	◊◊
510	IP 227	Silver Strip	◊
		STABILITY	
601A	**D 3241**	**JFTOT ΔP (mm Hg) @ other Temp**	◊◊•◊
602A	**D 3241**	**JFTOT Tube Deposit @ other Temp**	◊◊◊◊
603A	**D 3241**	**JFTOT TDR Spun Rating @ other Temp.**	◊◊
604A		**Temperature (°C) of above JFTOT**	◊◊◊◊
601B	**D 3241**	**JFTOT ΔP (mm Hg) @ 260°C**	◊◊•◊
602B	**D 3241**	**JFTOT Tube Deposit Rating @ 260°C**	◊◊◊◊
603B	**D 3241**	**JFTOT TDR Spun Rating @ 260°C**	◊◊
		CONTAMINANTS	
700	IP 225	Copper Content (mg/kg)	◊•◊◊
710	**D 381**	**Existent Gum (mg/100 mL)**	◊◊◊
720A	D 2276	Particulate (mg/L)	◊•◊◊
720B	D 5452	Particulate (mg/L)	◊•◊◊
730		Filtration Time (minutes)	◊◊
740	**D 1094**	**Water Reaction Interface Rating**	◊◊
750	D 3948	MSEP (With SDA)	◊◊◊
751	D 3948	MSEP (Without SDA)	◊◊◊

	ADDITIVES	**Brand**	
800	Antioxidant (mg/L)	[ ]	◊◊•◊
810	Metal Deactivator (mg/L)	[ ]	◊•◊
820	Static Dissipator Additive (mg/L)	[ ]	◊•◊
830A (D5006)	FSII (vol%)	[ ]	◊•◊◊◊
830B (FTM5327)	FSII (vol%)	[ ]	◊•◊◊◊
830C (FTM5340)	FSII (vol%)	[ ]	◊•◊◊◊
840	Corrosion Inhibitor (mg/L)	[ ]	◊◊•◊

Method			Result
		OTHER TESTS	
900	**D 2624**	**Conductivity (pS/m)**	◊◊◊◊
901	**D 2624**	**Conductivity Test Temperature (°C)**	◊◊◊

Comments and/or Additional Tests:

_____
_____
_____
_____

CERTIFIED BY _____

FIG. X3.1 Standard Form for Reporting Inspection Data on Aviation Turbine Fuels

X3.2 Dimensions of Standard Form

X3.2.1 A standard reporting form for aviation turbine fuels is shown in Fig. X3.1.

X3.2.2 Earlier versions of this form were available from ASTM as Adjunct 12-416552-00 and were sized so that the forms could be used in a standard typewriter. Because of decreased use, the form is now presented only as an example of a suitable data reporting sheet and is no longer available from ASTM as an adjunct.

X3.3 Description of Standard Form

X3.3.1 The top of the form (Header Section) provides a method for entering pertinent information regarding description and identity of the fuel being tested and the laboratory performing the tests. Items in italic print are mandatory items. Fill in only those data elements necessary to cover the individual testing situation. Explanation of non-self-explanatory Entries is provided below:

X3.3.1.1 *Manufacturer/Supplier*—Agency or activity who has possession of the fuel to be tested.

X3.3.1.2 *Product Code/Grade*—Accepted code for product being tested.

X3.3.1.3 *Sampling Location*—Place where sample was collected, as specific as possible.

X3.3.1.4 *Batch Number*— If sample was taken from the storage tank, this number should be the batch number of the product in the tank. If the sample is a composite of a shipment, this number should be the batch number or cargo number that represents the shipment.

X3.3.1.5 *Destination*— Location to which the product will be shipped. If more than one location, write *Multiple* in this block and list locations in the *Comments* block at the bottom of the form.

X3.3.1.6 *Crude Source*— If required by contract or other agreement, list the crude(s) and percentages used to refine the product. This is done in an attempt to correlate fuel properties with types of crudes.

X3.3.1.7 *Processing Method*—If required by contract or other agreement, list the crude processing technique(s) used to refine the product. Examples are hydrotreating, caustic wash, hydrocracking, merox, and so forth. (All assume atmospheric distillation.) Used in conjunction with the crude source, this information can be used to correlate fuel properties with crude processing technique.

X3.3.2 The body of the form provides for entering test results. There are four columns provided for each test.

X3.3.2.1 The first column shows the item number or code assigned to each specific test result. The number assignment for each grouping of fuel characteristics is as follows:

10–99	Appearance
100–199	Composition
200–299	Volatility
300–399	Fluidity
400–499	Combustion
500–599	Corrosion
600–699	Stability
700–799	Contaminants
800–899	Additives
900–999	Other Tests

The code designations are derived from a master list of codes assigned to tests performed for all products. Under these general categories, item numbers or codes increase either by one unit, five units, ten units, or an alpha character. For each property to be measured under a category, the code increases by five or ten units, depending on the number of characteristics that fall under that general category. The alpha codes represent the various methods allowed by specification to measure that characteristic. This may be a change of test method (see total sulfur as an example) or a change in test conditions (see JFTOT as an example). When the code varies by one unit, this is intended to indicate more than one reported measurement or evaluation for that particular test method (see distillation and water reaction as examples). This system allows for the coding of test methods with their equivalents and for the introduction of newly approved methods systematically into the standardization data sheet.

X3.3.2.2 The second column lists the applicable ASTM method number. Where there is no ASTM method number, the applicable IP number (Institute of Petroleum) is shown.

X3.3.2.3 The third column presents word descriptors for each test.

X3.3.2.4 The fourth column presents diamonds for entering the results of each test with location of the decimal point shown where applicable.

X3.3.3 The lower right-hand part of the form provides space for comments or for entering other test results that are not listed in the main body of the form.

X3.4 Instructions for Executing Column 4

X3.4.1 *General Instructions*:

X3.4.1.1 This form is intended for use with both naphtha and kerosene based aviation fuels and provides choice of test methods. Individual laboratory analysis reports should cite only the required or relevant data for the top of the form and reference the assigned item number or code for each characteristic analyzed. Number of decimal places or significant figures, or both, is meant to reflect that which is appropriate for the test method. When determining compliance of the data reported with the requirements of the cited specification, however, the specification values (and rules cited for rounding, if any) shall prevail. If a

characteristic is determined by a method not cited in the standard form, enter the method identification and result in *Comments and/or Additional Tests* section.

X3.4.2 *Detailed Instructions*:

X3.4.2.1 *Items 10 and 20, Color (Saybolt)* —Enter either a (+) or a (−) sign in the first square. *Example:* +15.

X3.4.2.2 *Item 30, Visual*— According to Test Method D 4176, report result as *Pass* or *Fail*, using the criteria outlined in the test method.

X3.4.2.3 *Item 200, Distillation*—This method has both a choice of methods and more than one measurement to be made per run. Selection of *A* or *B* for item 200 selects which method is used. All of the subsequent measurements will be referenced to the selected method. Select, using an *x* in the appropriate *A* or *B* item, which test method is used, and whichever items or codes apply to the particular situation or specification being reported.

X3.4.2.4 *Items 230 and 231*—For those contracts or instances that require reporting in units of API Gravity, Item 231A reports of API Gravity using Test Method D 1298 and Item 230A reports density by the same method, either as an alternate or concurrent measurement. Item 230B reports density by using Test Method D 4052, which only provides for density as currently written.

X3.4.2.5 *Item 310 and 311, Viscosity* —For aviation turbine fuels, viscosity is measured at –20°C; therefore, the value for item 311 will always be *–20* . If the test is performed at some other temperature, use item number 311 to report this temperature.

X3.4.2.6 *Items 601 - 603, JFTOT*—Select the temperature at which the JFTOT was performed. The letter suffix refers to one temperature. Items 601 - 603, as appropriate, refer to the data for that specific test temperature. If results for runs at different temperatures are reported, then use the data with the appropriate suffix consistent for the temperature. In this manner, results for JFTOT at 245°C and 275°C, for example, can be kept separate and reported simultaneously on the same report. For colors that match the Color Standards, report the color code number. If the color falls somewhere between two colors, report an L for *less than* followed by the higher code number of the two between which the color falls. If there are only abnormal or peacock deposits as defined in Test Method D 3241, report an A or P, respectively. If there are both peacock and abnormal deposits, report both an A and P. If the darkest deposit on a tube matches a color code number but there is also an abnormal or peacock deposit, report the code number followed by an A or P, respectively. If the darkest deposit on a tube falls between two color code numbers and there are also abnormal or peacock deposits, or both, record the color as L, followed by the higher of the two code numbers, followed by A, P, or AP, as applicable.

X3.4.2.7 *Items 800, 810, 820, 830, and 840*—Enter the manufacturer's brand name in the square provided. If there is insufficient room in the square provided, indicate by entering asterisks and provide the information on brand name in the REMARKS section.