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An American National Standard

Standard Specification for Aviation Certification Turbine Fuel[1]

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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 in the certification of aircraft. The specification can be used as a standard in describing the quality of this aviation fuel from the refinery to the aircraft.

1.3 This specification does not include the fuels that are commonly used in aviation turbine engines. Those are listed in Specification D1655.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D56 Test Method for Flash Point by Tag Closed Cup Tester

D86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure

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

D381 Test Method for Gum Content in Fuels by Jet Evaporation

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

D1094 Test Method for Water Reaction of Aviation Fuels

D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)

D1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption

D1322 Test Method for Smoke Point of Kerosine and Aviation Turbine Fuel

D1655 Specification for Aviation Turbine Fuels

D1840 Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry

D2386 Test Method for Freezing Point of Aviation Fuels

D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry

D2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels

D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography

D3227 Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method)

D3241 Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels (JFTOT Procedure)

D3242 Test Method for Acidity in Aviation Turbine Fuel

D3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels

D3828 Test Methods for Flash Point by Small Scale Closed Cup Tester

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4171 Specification for Fuel System Icing Inhibitors

D4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry

D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination

D4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels

D4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)

D4952 Test Method for Qualitative Analysis for Active

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

Sulfur Species in Fuels and Solvents (Doctor Test)
D5001 Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)
D5006 Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
D5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)
D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D5972 Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)
D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. General

3.1 This specification, unless otherwise provided, prescribes the required properties of aviation certification 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 C-1*—A relatively wide boiling range volatile distillate.

5. Materials and Manufacture

5.1 Aviation turbine fuel, except as otherwise specified in this specification, shall consist of blends of refined hydrocarbons derived from conventional sources including crude oil, natural gas liquid condensates, heavy oil, shale oil, and oil sands. The use of jet fuel blends, containing components from other sources, is only permitted on a specific, individual basis (see Annex A1 on fuels from non-conventional sources in Specification D1655).

5.1.1 Fuels used in 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 Specification D1655).

5.2 *Additives*—May be added to this aviation turbine fuel in the amount and of the composition specified in the following list of approved material:[3]

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 % maximum 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 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[4] 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)[5] may be added to the fuel in amounts not to exceed 1 mg/kg.

5.2.5 Other additives are permitted. These include fuel system icing inhibitor and special purpose additives such as biocides. 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 D4171, Type III, may be used in concentrations of 0.10 to 0.15 volume %.

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

5.3 Guidance material is presented in Appendix X3 of Specification D1655 concerning the need to control processing additives in jet fuel production.

6. Detailed Requirements

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

6.2 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1. No allowance shall be made for the precision of the test methods. To determine conformance to the specification requirement, a test result may be rounded to the same number of significant figures

[3] Supporting data (Guidelines for Approval or Disapproval of Additives) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report D02-1125.

[4] Stadis 450 is a registered trademark marketed by Innospec Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EY, UK.

[5] 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 Certification Turbine Fuel[A]

Property		Jet C-1	ASTM Test Method[B]
Acidity, total mg KOH/g	max	0.10	D3242
Aromatics, vol %	min/max	8 to 25	D1319
Sulfur, mercaptan[C], weight %	max	0.003	D3227
Sulfur, total weight %	max	0.30	D1266, D2622, D4294 or D5453
Distillation temperature, °C (°F):			
Initial boiling point, temperature	min/max	70/100 (158/212)	D2887, D86[D]
5 % recovered, temperature	min/max	80/110 (176/230)	D2887, D86[D]
10 % recovered, temperature	min/max	90/120 (194/248)	D2887, D86[D]
20 % recovered, temperature	min/max	105/140 (221/284)	D2887, D86[D]
50 % recovered, temperature	min/max	150/195 (302/383)	D2887, D86[D]
90 % recovered, temperature	min/max	215/255 (419/491)	D2887, D86[D]
Final boiling point, temperature	min/max	240/290 (464/554)	D2887, D86[D]
Flash Point, °C (°F)	report		D56, D3828
Density at 15°C, kg/m^3		750 to 840	D1298, D4052
Vapor pressure[E]			
at 25°C, kPa (psi)	report	3.0 (0.44) to 5.5 (0.80)	D5191[F]
at 38°C, kPa (psi)	report	5.6 (0.8) to 8.2 (1.2)	D5191[F]
at 50°C, kPa (psi)	min/max	10.0 (1.45) to 12.5 (1.82)	D5191[F]
at 100°C, kPa (psi)	report	56 (8.1) to 60 (8.7)	D5191[F]
Freezing point, °C	max	-35	D2386, D5972[G]
Viscosity at -20°C, mm^2/s[H]	max	8.0	D445
Net heat of combustion, MJ/kg	min	42.8[I]	D4529, D3338, or D4809
One of the following requirements shall be met:			
(1) Smoke point, mm, or	min	25	D1322
(2) Smoke point, mm, and	min	18	D1322
Naphthalenes, vol, %	max	3.0	D1840
Copper strip, 2 h at 100°C	max	No. 1	D130
Thermal stability:			
Filter pressure drop, mm Hg	max	25[J]	D3241[K]
Tube deposit less than		3	D3241
Existent gum, mg/100 mL	max	7	D381
Water reaction:			
Interface rating	max	1b	D1094
Lubricity[L] – BOCLE WSD, mm	max	0.85	D5001[L]
Additives:			see 5.2
Electrical conductivity, pS/m	required	50 to 450	D2624
Other	optional		

[A] For compliance of test results against the requirements of Table 1, see 6.2.
[B] The test methods indicated in this table are referred to in Section 10.
[C] The mercaptan sulfur determination may be waived if the fuel is considered sweet by the doctor test described in Test Method D4952.
[D] If Test Method D2887 is used, use correlation procedure (Appendix X5) in Test Method D2887 to convert D2887 temperatures to D86 equivalent temperatures. Both minimums and maximums shall be met.
[E] Absolute vapor pressure is the primary property to be controlled; Cyclohexane and toluene, as cited in 7.2 and 7.7 of Test Method D5191, shall be used as calibrating reagents. 1.0 kPa = 0.145 psi.
[F] Record absolute vapor pressure.
[G] Test Method D5972 may produce a higher (warmer) result than that from Test Method D2386. In case of dispute, Test Method D2386 shall be the referee method.
[H] 1 mm^2/s = 1 cSt.
[I] Use either Eq 1 or Table 1 in Test Method D4529 or Eq 2 in Test Method D3338. Test Method D4809 may be used as an alternative. In case of dispute, Test Method D4809 shall be used.
[J] Preferred SI units are 3.3 kPa, max.
[K] Thermal stability test (JFTOT) shall be conducted for 2.5 h at a control temperature of 260°C. 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. No peacock or abnormal colored tube deposits are permitted.
[L] Lubricity test can be waved with purchaser's agreement.

as in Table 1 using Practice E29. Where multiple determinations are made, the average result, rounded according to Practice E29, shall be used.

6.3 If any additives are used, the aviation turbine fuel shall conform to the Table 2 listed requirements.

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 in this specification.

8. Sampling

8.1 Because of the importance of proper sampling procedures in establishing fuel quality, use the appropriate procedures in Practice D4057.

8.2 A number of jet fuel properties including thermal stability, water separation, electrical conductivity, and others

TABLE 2 Detailed Requirements for Additives in Aviation Turbine Fuels

Fuel Performance Enhancing Additive	Dosage
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 DeactivatorA	
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 D4171)	0.15 vol % max
Fuel Handling and Maintenance Additives	**Dosage**
Electrical Conductivity Improver[F]	
Stadis 450[4]	
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	
Tracer A (LDTA-A)9	1 mg/kg max
Biocide 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 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 the point of delivery. 1 pS/m = 1×10^{-12} $Ohms^{-1}$ m^{-1}.

[G] Biocide 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.

are very sensitive to trace contamination that can originate from sample containers. For recommended sample containers refer to Practice D4306.

9. Report

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

9.2 A suggested form for reporting inspection data on aviation turbine fuel is given in Specification D1655.

10. Test Methods

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

10.1.1 *Density*—Test Method D1298 or D4052. Test Method D4052 shall be the referee test method.

10.1.2 *Distillation*—Test Method D86 or D2887 with the conversion to D86 temperatures given in correlation procedure (Appendix X5) in Test Method D2887.

10.1.3 *Vapor Pressure*—Test Method D5191. Record absolute vapor pressure.

10.1.4 *Flash Point*—Test Method D56 or D3828. Test Method D3828 shall be the referee test method.

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

10.1.6 *Viscosity*—Test Method D445.

10.1.7 *Net Heat of Combustion*—Test Method D4529, D3338, or D4809. Test Method D4809 shall be the referee test method.

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

10.1.9 *Total Acidity*—Test Method D3242.

10.1.10 *Sulfur*—Test Methods D1266, D2622, D4294, or D5453. Test Method D2622 shall be the referee test method.

10.1.11 *Mercaptan Sulfur*—Test Method D3227.

10.1.12 *Water Reaction*—Test Method D1094.

10.1.13 *Existent Gum*—Test Method D381.

10.1.14 *Thermal Stability*—Test Method D3241.

10.1.15 *Aromatics*—Test Method D1319.

10.1.16 *Smoke Point*—Test Method D1322.

10.1.17 *Naphthalene Content*—Test Method D1840.

10.1.18 *Electrical Conductivity*—Test Method D2624.

10.1.19 *Lubricity*—Test Method D5001.

11. Keywords

11.1 aviation certification turbine fuel; aviation turbine fuel; Jet C-1; jet fuel; kerosine

ANNEX

(Mandatory Information)

A1. PRODUCTION OF THIS FUEL

A1.1 This fuel may be produced from blends of hydrocarbon streams found in a refinery or by blending hydrocarbon components with Jet A/A-1 fuel or other approved jet fuels. Acceptable blending components are petroleum naphtha and petroleum solvents. The blended fuel shall satisfy the requirements in Table 1. A target vapor pressure versus temperature curve is given in Appendix X4. Table 2 lists the requirements if any additives are used.

APPENDIXES

(Nonmandatory Information)

X1. PERFORMANCE CHARACTERISTICS OF AVIATION TURBINE FUELS

X1.1 The performance characteristics of aviation turbine fuels are described in Appendix X1 of Specification D1655. A more detailed discussion of the individual test methods and their significance is found in ASTM Manual No. 1.[6]

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

X2. CLEANLINESS GUIDELINES

X2.1 Jet fuel should be maintained in as clean a condition as possible. Control of cleanliness must be such as to ensure that only clean fuel is delivered into aircraft. For cleanliness guidelines see Specification D1655. For handling guidelines see Manual MNL 5.[7]

X2.2 If this fuel is to be stored for several months, microbial contamination can occur. Storage tanks should be sumped on a regular basis. Drainage from sump drains should be inspected for microbial contamination. Microbial infestations 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.

X2.3 Guide D6469 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.

[7] *Manual on Aviation Fuel Quality Control Procedures*, MNL 5, ASTM International, 2004.

X3. FORM FOR REPORTING INSPECTION DATA ON AVIATION FUELS

X3.1 Many companies and government agencies conduct detailed studies of inspection data on aviation turbine fuels. The standardized inspection form shown in Specification D1655 can be used to report the fuel property test results required in this specification.

X4. TARGET VAPOR PRESSURE CURVE

X4.1 Fuel volatility, vapor pressure and ease of vaporization at different temperatures are important properties of this fuel. A target vapor pressure versus temperature curve is provided to aid producers in formulating this fuel, Fig. X4.1. The associated numerical values are also provided in Table X4.1. Aircraft equipment manufacturers will analyze the absolute vapor pressure of the delivered fuel by Test Method D5191 and produce such a chart to verify that the volatility of the fuel is smooth and uniform over a wide range of temperatures.

TABLE X4.1 Suggested Targets for the Absolute Vapor Pressure versus Temperature

°F	°C	psi	kPa
77	25	0.6	4.1
100	38	1.0	6.9
122	50	1.6	11.0
150	65	2.8	19.3
212	100	8.4	57.9
257	125	16.0	110.0
302	150	30.0	207.0

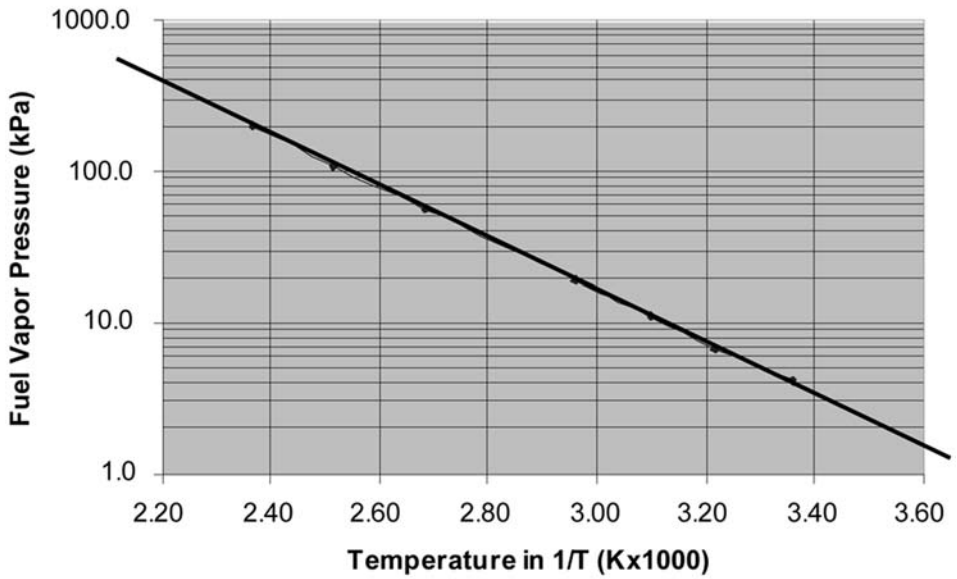

FIG. X4.1 Suggested Targets for the Absolute Vapor Pressure versus Temperature