Designation: D7566 – 10a

An American National Standard

Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons[1]

This standard is issued under the fixed designation D7566; 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 manufacture of aviation turbine fuel that consists of conventional and synthetic blending components.

1.2 This specification applies only at the point of batch origination. Aviation turbine fuel manufactured, certified and released to all the requirements of this specification, meets the requirements of Specification D1655 and shall be regarded as Specification D1655 turbine fuel. Once released to this specification (D7566) the requirements of this specification are no longer applicable: any recertification shall be done to D1655. Field blending of synthesized paraffinic kerosine (SPK) with D1655 fuel (which may on the whole or in part have originated as D7566 fuel) shall be considered batch origination in which case all of the requirements of this specification (D7566) apply, however the fuel shall be regarded as D1655 turbine fuel after certification and release.

1.3 This specification defines specific types of aviation turbine fuel that contain synthesized hydrocarbons for civil use in the operation and certification of aircraft and describes fuels found satisfactory for the operation of aircraft and engines. The specification is intended to be used as a standard in describing the quality of aviation turbine fuels and synthetic blending components at the place of manufacture but can be used to describe the quality of aviation turbine fuels for contractual transfer at all points in the distribution system.

1.4 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.

1.5 While aviation turbine fuels defined by this specification can be used in applications other than aviation turbine engines, requirements for such other applications have not been considered in the development of this specification.

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

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

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
D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D129 Test Method for Sulfur in Petroleum Products (General Bomb Method)
D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
D156 Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)
D240 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter
D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)
D381 Test Method for Gum Content in Fuels by Jet Evaporation
D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
D1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.J0.06 on Emerging Turbine 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* volume information, refer to the standard's Document Summary page on the ASTM website.

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

D1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
D1322 Test Method for Smoke Point of Kerosine and Aviation Turbine Fuel
D1405 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D1655 Specification for Aviation Turbine Fuels
D1740 Test Method for Luminometer Numbers of Aviation Turbine Fuels[3]
D1840 Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry
D2276 Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling
D2386 Test Method for Freezing Point of Aviation Fuels
D2425 Test Method for Hydrocarbon Types in Middle Distillates by Mass Spectrometry
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)
D3240 Test Method for Undissolved Water In Aviation Turbine Fuels
D3241 Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels
D3242 Test Method for Acidity in Aviation Turbine Fuel
D3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D3343 Test Method for Estimation of Hydrogen Content of Aviation Fuels
D3701 Test Method for Hydrogen Content of Aviation Turbine Fuels by Low Resolution Nuclear Magnetic Resonance Spectrometry
D3828 Test Methods for Flash Point by Small Scale Closed Cup Tester
D3948 Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer
D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4171 Specification for Fuel System Icing Inhibitors
D4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
D4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
D4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D4629 Test Method for Trace Nitrogen in Liquid Petroleum Hydrocarbons by Syringe/Inlet Oxidative Combustion and Chemiluminescence Detection
D4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
D4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
D4952 Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)
D4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)
D5001 Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)
D5006 Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
D5190 Test Method for Vapor Pressure of Petroleum Products (Automatic Method)
D5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)
D5291 Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants
D5452 Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D5972 Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)
D6045 Test Method for Color of Petroleum Products by the Automatic Tristimulus Method
D6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
D6379 Test Method for Determination of Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates—High Performance Liquid Chromatography Method with Refractive Index Detection
D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
D7153 Test Method for Freezing Point of Aviation Fuels (Automatic Laser Method)
D7154 Test Method for Freezing Point of Aviation Fuels (Automatic Fiber Optical Method)
D7359 Test Method for Total Fluorine, Chlorine and Sulfur in Aromatic Hydrocarbons and Their Mixtures by Oxidative Pyrohydrolytic Combustion followed by Ion Chromatography Detection (Combustion Ion Chromatography-CIC)
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

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

2.2 *Energy Institute Standards:*[4]

IP 225 Copper Content of Aviation Turbine Fuel

IP 227 Silver Corrosion of Aviation Turbine Fuel

IP 540 Determination of the Existent Gum Content of Aviation Turbine Fuel—Jet Evaporation Method

2.3 *ANSI Standard:*[5]

ANSI 863 Report of Test Results

2.4 *Other Standard:*[6]

Defence Standard 91-91 Turbine Fuel, Aviation Kerosine Type, Jet A-1

2.5 *IATA Guidance:*[7]

9680–02 IATA Guidance Material on Microbiological Contamination in Aircraft Fuel Tanks

2.6 *UOP Test Methods:*[8]

UOP 389 Trace Metals in Oils by Wet Ash/ICP-AES

2.7 *U.S. Department of Defense Specifications:*[9]

MIL-PRF-25017 Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble

QDS-25017 Qualified Data Set for MIL-PRF-25017 (Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble)

3. General

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

4. Terminology

4.1 *Definitions:*

4.1.1 *conventional hydrocarbons*, *n*—hydrocarbons derived from the following conventional sources: crude oil, natural gas liquid condensates, heavy oil, shale oil, and oil sands.

4.2 *Definitions of Terms Specific to This Standard:*

4.2.1 *batch origination*, *n*—location at which fuel is certified as D7566.

4.2.2 *conventional blending component*, *n*—blending streams derived from conventional hydrocarbons.

4.2.3 *synthesized hydrocarbons*, *n*—hydrocarbons derived from alternative sources such as coal, natural gas, biomass, and hydrogenated fats and oils by processes such as gasification, Fischer-Tropsch synthesis, and hydroprocessing.

4.2.4 *synthetic blending component*, *n*—synthesized hydrocarbons that meet the requirements of Annex A1.

5. Classification

5.1 Two grades of aviation turbine fuels are provided, as follows:

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

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

6. Materials and Manufacture

6.1 Aviation turbine fuel, except as otherwise defined in this specification, shall consist of the following blends of components or fuels:

6.1.1 Conventional blending components or Jet A or Jet A-1 fuel certified to Specification D1655; with up to 50 % by volume of the synthetic blending component defined in Annex A1.

6.2 Fuels used in certified engines and aircraft are ultimately approved by the certifying authority subsequent to formal submission of evidence to the authority as part of the type certification program for that aircraft and engine model. Additives to be used as supplements to an approved fuel must also be similarly approved on an individual basis (see X1.2.4).

6.3 *Additives*—May be added to each type of aviation turbine fuel in the amount and of the composition specified in Table 2 or the following list of approved material:[10]

6.3.1 Other additives are permitted under 6.2 and 8.1. These include fuel performance enhancing additives and fuel handling and maintenance additives as found under Table 2. The quantities and types shall be declared by the fuel supplier and agreed to by the purchaser. Only additives approved by the aircraft and engine certifying authorities are permitted in the fuel on which an aircraft is operated.

6.3.1.1 Biocidal additives are available for controlled usage. Where such an additive is used in the fuel, the approval status of the additive and associated conditions shall be checked for the specific aircraft and engines to be operated.

6.3.1.2 *Fuel System Icing Inhibitor*:

(1) Diethylene Glycol Monomethyl Ether (DiEGME), conforming to the requirements of Specification D4171, Type III, may be used in concentrations of 0.10 to 0.15 volume %.

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

6.4 Guidance material is presented in Appendix X3 concerning the need to control processing additives in jet fuel production.

7. Detailed Requirements

7.1 The aviation turbine fuel shall conform to the requirements prescribed in Table 1 Part 1 and Table 1 Part 2 unless otherwise noted in Annex A1.

7.2 The additional requirements of Part 2 of Table 1 apply only for each batch of fuel intentionally containing a synthetic blending component. The additional requirements of Part 2 of Table 1 are not mandated if conventionally-derived jet fuel is mixed with the residue of a D7566 semi-synthetic aviation turbine fuel in refinery equipment from a previous batch of certified final blended product, for example in a tank heel.

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

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[6] Available from Defence Equipment and Support, UK Defence Standardization, Kentigern House, 65 Brown Street, Glasgow, G2 8EX (http://www.dstan.mod.uk).

[7] Available from International Air Transport Association (IATA), Head Office, 800 Place Victoria, PO Box 113, Montreal H4Z 1M1, Quebec, Canada. Executive Office, 33 Route de l'Aéroport, PO Box 416, Beneva, 15 Airport, Swizerland. www.iataonline.com.

[8] Available from ASTM International, www.astm.org, or contact ASTM Customer Service at service@astm.org.

[9] Available from the Standardization Document Order Desk, 700 Robbins, Avenue, Building 4D, Philadelphia PA 19111-5094 (http://assist.daps.dla.mil).

[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: RR:D02-1125.

TABLE 1 Detailed Requirements of Aviation Turbine Fuels Containing Synthesized Hydrocarbons[A]

Part 1—Basic Requirements

Property		Jet A or Jet A-1	ASTM Test Method[B]
COMPOSITION			
Acidity, total mg KOH/g	Max	0.10	D3242
Aromatics: One of the following requirements shall be met:			
1. Aromatics, vol %	Max	25	D1319
2. Aromatics, vol %	Max	26.5	D6379
Sulfur, mercaptan,[C] mass %	Max	0.003	D3227
Sulfur, total mass %	Max	0.30	D1266, D2622, D4294, or D5453
VOLATILITY			
Distillation			D2887[D] or D86[E]
Distillation temperature, °C:			
10 % recovered, temperature (T10)	Max	205	
50 % recovered, temperature (T50)		report	
90 % recovered, temperature (T90)		report	
Final boiling point, temperature	Max	300	
Distillation residue, %	Max	1.5	
Distillation loss, %	Max	1.5	
Flash point, °C	Min	38[F]	D56 or D3828[G]
Density at 15°C, kg/m^3		775 to 840	D1298 or D4052
FLUIDITY			
Freezing point, °C	Max	–40 Jet A[H] –47 Jet A-1[H]	D5972, D7153, D7154, or D2386
Viscosity –20°C, mm^2/s[I]	Max	8.0	D445
COMBUSTION			
Net heat of combustion, MJ/kg	Min	42.8[J]	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
CORROSION			
Copper strip, 2 h at 100°C	Max	No. 1	D130
THERMAL STABILITY			
2.5 h at control temperature of 260°C, min			D3241
Filter pressure drop, mm Hg	Max	25[K]	
Tube deposits less than		3[L] No peacock or abnormal color deposits	
CONTAMINANTS			
Existent gum, mg/100 mL	Max	7	D381, IP 540
Microseparometer,[M] Rating			D3948
Without electrical conductivity additive	Min	85	
With electrical conductivity additive	Min	70	
ADDITIVES		See 6.3	
Electrical conductivity, pS/m		[N]	D2624

[A] For compliance of test results against the requirements of Table 1, see 7.3.
[B] The test methods indicated in this table are referred to in Section 11.
[C] The mercaptan sulfur determination may be waived if the fuel is considered sweet by the doctor test described in Test Method D4952.
[D] Distillation property criteria are specified in D86 scale units. D2887 results shall be converted to estimated D86 results by application of the correlation in Appendix X5 of D2887 for comparison with the specified property criteria. Distillation residue and loss limits provide control of the distillation process during the D86 test method and do not apply to D2887. Distillation residue and loss shall be reported as "not applicable" (N/A) when reporting D2887 results.
[E] D86 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.
[F] A higher minimum flash point specification may be agreed upon between purchaser and supplier.
[G] Results obtained by Test Methods D3828 can be up to 2°C lower than those obtained by Test Method D56, which is the preferred method. In case of dispute, Test Method D56 will apply.
[H] Other freezing points may be agreed upon between supplier and purchaser.
[I] 1 mm^2/s = 1 cSt.
[J] For all grades use either Eq 1 or Table 1 in Test Method D4529 or Eq 2 in Test Method D3338. Test Method D4809 may be used as an alternative. In case of dispute, Test Method D4809 shall be used.
[K] Preferred SI units are 3.3 kPa, max.
[L] Tube deposit ratings shall always be reported by the Visual Method.
[M] At point of manufacture.
[N] If electrical conductivity additive is used, the conductivity shall not exceed 600 pS/m at the point of use of the fuel. When electrical conductivity additive is specified by the purchaser, the conductivity shall be 50 to 600 pS/m under the conditions at point of delivery. (1 pS/m = 1 × 10^{-12} $\Omega^{-1}m^{-1}$)

TABLE 1 Detailed Requirements of Aviation Turbine Fuels Containing Synthesized Hydrocarbons[A] *(continued)*

Part 2—Extended Requirements

Property		Jet A or Jet A-1	ASTM Test Method[B]
COMPOSITION			
Aromatics: One of the following requirements shall be met:			
1. Aromatics, vol %	Min[O,Q]	8	D1319
2. Aromatics, vol %	Min[O,Q]	8.4	D6379
Distillation			D2887[D] or D86[E]
T50-T10, °C	Min[P,Q]	15	
T90-T10, °C	Min[P,Q]	40	
Lubricity,[M] mm	Max	0.85	D5001

[O] Minimum aromatics contents are based on current experience with the approved synthetic fuels and those levels were established from what is typical for refined jet fuel. Research is ongoing on the actual need for aromatics.
[P] These distillation slope limits are based on current experience with the approved synthetic fuels and these values were established from what is typical for refined jet fuel. Research is ongoing on the actual requirements for distillation slope.
[Q] The minimum aromatics and distillation slope criteria only apply to aviation turbine fuels containing synthesized hydrocarbons produced to this specification and are not applicable to conventional aviation turbine fuels produced to Specification D1655. Some batches of aviation turbine fuels produced to Specification D1655 may not meet the minimum aromatics and distillation slope criteria specified in Table 1 of this specification.

7.3 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1, Table A1.1, and Table A1.2. 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, Table A1.1, and Table A1.2 using Practice E29. Where multiple determinations are made, the average result, rounded in accordance with Practice E29, shall be used.

8. Workmanship, Finish and Appearance

8.1 The aviation turbine fuel specified in this specification shall be visually free of undissolved water, sediment, and suspended matter. The odor of the fuel shall not be nauseating or irritating. If the fuel has an odor similar to that of "rotten egg," please refer to X1.12.5 for further discussion. No substance of known dangerous toxicity under usual conditions of handling and use shall be present, except as permitted in this specification.

9. Sampling

9.1 Because of the importance of proper sampling procedures in establishing fuel quality, use the appropriate procedures in Practice D4057 to obtain a representative sample from the batch of fuel for specification compliance testing. This requirement is met by producing fuel as a discrete batch then testing it for specification compliance. This requirement is not satisfied by averaging online analysis results.

9.2 A number of jet fuel properties, including thermal stability, water separation, electrical conductivity, and others, are very sensitive to trace contamination, which can originate from sample containers. For recommended sample containers, refer to Practice D4306.

10. Report

10.1 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.

10.2 A suggested form for reporting inspection data on aviation turbine fuels is given in Appendix X4.

11. Test Methods

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

11.1.1 *Density*—Test Method D1298 or D4052.

11.1.2 *Distillation*—Test Method D86. For Jet A and Jet A-1, Test Method D2887 may be used as an alternate. Results from Test Method D2887 shall be reported as estimated D86 results by application of the correlation in Appendix X5 of D2887. In case of dispute, Test Method D86 shall be the referee method (see X1.6.1.1).

11.1.3 *Flash Point*—Test Method D56 or D3828.

11.1.4 *Freezing Point*—Test Method D5972, D7153, D7154, or D2386. Any of these test methods may be used to certify and recertify jet fuel. However, Test Method D2386 is the referee method. An interlaboratory study (RR: D02–1572[11]) that evaluated the ability of freezing point methods to detect jet fuel contamination by diesel fuel determined that Test Methods D5972 and D7153 provided significantly more consistent detection of freeze point changes caused by contamination than Test Methods D2386 and D7154. It is recommended to certify and recertify jet fuel using either Test Method D5972 or Test Method D7153, or both, on the basis of the reproducibility and cross-contamination detection reported in RR:D02-1572.[11] The cause of freezing point results outside specification limits by automated methods should be investigated, but such results do not disqualify the fuel from aviation use if the results from the referee method (Test Method D2386) are within the specification limit.

11.1.5 *Viscosity*—Test Method D445.

11.1.6 *Net Heat of Combustion*—Test Method D4529, D3338, or D4809.

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

11.1.8 *Total Acidity*—Test Method D3242.

11.1.9 *Sulfur*—Test Method D1266, D2622, D4294, or D5453.

11.1.10 *Mercaptan Sulfur*—Test Method D3227.

11.1.11 *Microseparometer*—Test Method D3948.

[11] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: RR:D02-1572.

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 D4171)	0.15 vol % max
Fuel Handling and Maintenance Additives	
Electrical Conductivity Improver[F]	
Stadis 450[G]	
On initial blending	3 mg/L max
After field reblending, cumulative concentration	5 mg/L max
If the additive concentration is unknown at time of retreatment, additional concentration is restricted to 2 mg/L max	
Leak Detection Additive	1 mg/kg max
Tracer A (LDTA-A)[H]	
Biocidal Additives[E,I,J]	
Biobor JF	
Kathon FP1.5	
Corrosion Inhibitor/Lubricity Improvers[K]	
One of the following:	
HiTEC 580	23 mg/L max
Octel DCI-4A	23 mg/L max
Nalco 5403	23 mg/L max

[A] The active ingredient of the additive must meet the composition specified.
[B] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02:1125.
[C] Active ingredient (not including weight of solvent).
[D] If copper contamination is suspected, initial treatment may exceed 2.0 mg/L but cumulative total must be below 5.7 mg/L.
[E] Quantity must be declared by the fuel supplier and agreed to by the purchaser.
[F] If electrical conductivity improver is used, the conductivity shall not exceed 600 pS/m at the point of use of the fuel. When electrical conductivity additive is specified by the purchaser, the conductivity shall be 50 to 600 pS/m under the conditions at point of delivery. (1 pS/m = $1 \times 10^{-12}\ \Omega^{-1}m^{-1}$)
[G] Stadis 450 is a registered trademark marketed by Innospec Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EY, UK.
[H] Tracer A (LDTA-A) is a registered trademark of Tracer Research Corp., 3755 N. Business Center Dr., Tucson, AZ 85705.
[I] Biocidal additives are available for controlled usage. Where such an additive is used in the fuel, the approval status of the additive and associated conditions must be checked for the specific aircraft and engines to be operated.
[J] Refer to the Aircraft Maintenance Manual (AMM) to determine if either biocide is approved for use and for their appropriate use and dosage.
[K] More information concerning minimum treat rates of corrosion inhibitor/lubricity improver additives is contained in X1.10.2.

11.1.12 *Existent Gum*—Test Method D381 or IP 540. Test Method D381, using steam jet operating conditions, shall be the referee test method.

11.1.13 *Thermal Stability*—Test Method D3241.

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

11.1.15 *Smoke Point*—Test Method D1322.

11.1.16 *Naphthalene Content*—Test Method D1840.

11.1.17 *Electrical Conductivity*—Test Method D2624.

12. Keywords

12.1 aviation turbine fuel; avtur; Jet A; Jet A-1; jet fuel; synthesized hydrocarbons; synthesized paraffinic kerosene; synthetic blending component; turbine fuel

ANNEX

(Mandatory Information)

A1. HYDROPROCESSED SYNTHESIZED PARAFFINIC KEROSINE

A1.1 Scope

A1.1.1 This annex defines hydroprocessed synthesized paraffinic kerosene (SPK) for use as a synthetic blending component in aviation turbine fuels for use in civil aircraft and engines. The specifications in this annex can be used for contractual exchange of synthetic blending components.

A1.1.2 The synthetic blending components defined in this annex are not satisfactory for aviation turbine engines unless blended with conventional fuel or conventional blending components in accordance with the limitations described in 6.1.1.

A1.1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

A1.2 General

A1.2.1 All requirements of the main body of this specification apply except as detailed in this annex.

A1.3 Terminology

A1.3.1 *Definitions of Terms Specific to This Annex*:

A1.3.1.1 *synthesized paraffinic kerosine (SPK), n*—a synthetic blending component that is comprised essentially of iso-paraffins, normal paraffins and cycloparaffins.

Discussion—Trace materials are permitted provided they are components that normally occur in hydroprocessed jet fuel including but not limited to trace organics, nitrogen compounds, water, dissolved air etc.

A1.3.1.2 *hydroprocessed, n*—a conventional chemical process in which hydrogen is reacted with organic compounds in the presence of a catalyst to remove impurities such as oxygen, sulfur, nitrogen, to saturate unsaturated hydrocarbons, or to alter the molecular structure of the hydrocarbon molecules.

A1.4 Materials and Manufacture

A1.4.1 Synthetic blend components shall be comprised of hydroprocessed synthesized paraffinic kerosene.

A1.4.2 The following types of hydroprocessed SPK are acceptable synthetic blending components for aviation turbine fuel:

A1.4.2.1 Fischer-Tropsch hydroprocessed SPK (FT-SPK).[12] FT-SPK blending components shall be wholly derived from synthesis gas via the Fischer-Tropsch (FT) process using Iron or Cobalt catalyst. Subsequent processing of the product shall include hydrotreating, hydrocracking or hydroisomerization and is expected to include, but not be limited to, a combination of other conventional refinery processes such as polymerization, isomerization and fractionation.

A1.5 Detailed Batch Requirements

A1.5.1 Each batch of synthetic blending component shall conform to the requirements prescribed in Table A1.1.

A1.5.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following ASTM test methods.

A1.5.2.1 *Density*—Test Method D1298 or D4052.

A1.5.2.2 *Distillation*—Test Method D2887. Results from Test Method D2887 shall be reported as estimated D86 results by application of the correlation in Appendix X5 of D2887.

A1.5.2.3 *Flash Point*—Test Method D56 or D3828.

A1.5.2.4 *Freezing Point*—Test Method D5972, D7153, D7154, or D2386. Any of these test methods may be used to certify and recertify jet fuel. However, Test Method D2386 is the referee method. An interlaboratory study (RR: D02–1572[11]) that evaluated the ability of freezing point methods to detect jet fuel contamination by diesel fuel determined that Test Methods D5972 and D7153 provided significantly more consistent detection of freeze point changes caused by contamination than Test Methods D2386 and D7154. It is recommended to certify and recertify jet fuel using either Test Method D5972 or Test Method D7153, or both, on the basis of the reproducibility and cross-contamination detection reported in RR:D02-1572.[11] The cause of freezing point results outside specification limits by automated methods should be investigated, but such results do not disqualify the fuel from aviation use if the results from the referee method (Test Method D2386) are within the specification limit.

A1.5.2.5 *Total Acidity*—Test Method D3242.

A1.5.2.6 *Thermal Stability*—Test Method D3241.

A1.6 Other Detailed Requirements

A1.6.1 The hydroprocessed SPK blend component shall meet the requirements of Table A1.2. It is not necessary to analyze each batch of hydroprocessed SPK for compliance with Table A1.2 once it is demonstrated that the process scheme is adequately controlled to support the expectation that these requirements are always met. At a minimum, significant changes in production operations shall be cause for recertifying that these limits continue to be met.

A1.6.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following ASTM test methods.

A1.6.2.1 *Cycloparaffins*—Test Method D2425.

A1.6.2.2 *Aromatics*—Test Method D2425.

A1.6.2.3 *Paraffins*—Test Method D2425.

A1.6.2.4 *Carbon and Hydrogen*—Test Method D5291.

A1.6.2.5 *Nitrogen*—Test Method D4629.

A1.6.2.6 *Water*—Test Method D6304.

[12] Coordinating Research Council (CRC) Report, "Comparative Evaluation of Semi-Synthetic Jet Fuels," September 2008, provides a more detailed description of key compositional and performance criteria for FT-SPK blending components that evolved from the evaluation of representative samples of these blending components.

A1.6.2.7 *Sulfur*—Test Methods D5453 or D2622. Either of these test methods can be used to certify and recertify jet fuel. However, Test Method D5453 is the referee method.

A1.6.2.8 *Metals*—Test Method UOP 389.

A1.6.2.9 *Halogens*—Test Method D7359.

TABLE A1.1 Detailed Batch Requirements; Hydroprocessed SPK[A]

Property		Hydroprocessed SPK	ASTM Test Method[B]
COMPOSITION			
Acidity, total mg KOH/g	Max	0.015	D3242
VOLATILITY			
Simulated Distillation			D2887[C]
Distillation temperature, °C:			
10 % recovered, temperature (T10)	Max	205	
50 % recovered, temperature (T50)		report	
90 % recovered, temperature (T90)		report	
Final boiling point, temperature	Max	300	
T90-T10, °C	Min	22	
Flash point, °C	Min	38[D]	D56 or D3828[E]
Density at 15°C, kg/m^3		730 to 770	D1298 or D4052
Freezing point, °C	Max	–40	D5972, D7153, D7154, or D2386
2.5 h at control temperature			
Temperature, °C	Min	325[F]	D3241
Filter pressure drop, mm Hg	Max	25[G]	
Tube deposit rating less than		3[H] No peacock or abnormal color deposits	
ADDITIVES			
Antioxidants, mg/L[I]	Min	17	
	Max	24	

[A] For compliance of test results against the requirements of Table A1.1, see 7.3.

[B] The test methods indicated in this table are referred to in A1.5.2.

[C] Distillation property criteria are specified in D86 scale units. D2887 results shall be converted to estimated D86 results by application of the correlation in Appendix X5 of D2887 for comparison with the specified property criteria. Distillation residue and loss limits provide control of the distillation process during the D86 test method and do not apply to D2887. Distillation residue and loss shall be reported as “not applicable” (N/A) when reporting D2887 results.

[D] A higher or lower minimum flash point specification may be agreed upon between purchaser and supplier. When the agreed flash point is less then 38°C then the product shall not be known as SPK or as kerosene, but may be used as an Annex A1 blending component.

[E] Results obtained by Test Methods D3828 may be up to 2°C lower than those obtained by Test Method D56, which is the preferred method. In case of dispute, Test Method D56 will apply.

[F] Control temperature of 325°C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.

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

[H] Tube deposit ratings shall always be reported by the Visual Method.

[I] Antioxidant shall be added to the bulk product prior to movements or operations that will significantly expose the product to air and in such a way as to ensure adequate mixing. This shall be done as soon as practicable after hydroprocessing or fractionation to prevent peroxidation and gum formation after manufacture. In-line injection and tank blenders are considered acceptable methods for ensuring adequate mixing.

TABLE A1.2 Other Detailed Requirements; Hydroprocessed SPK[A]

Property		Hydroprocessed SPK	ASTM Test Method[B]
Hydrocarbon Composition			
Cycloparaffins, mass %	Max	15[C]	D2425
Aromatics, mass %	Max	0.5	D2425
Paraffins, mass %		report	D2425
Carbon and Hydrogen, mass%	Min	99.5	D5291
Non-hydrocarbon Composition			
Nitrogen, mg/kg	Max	2	D4629
Water, mg/kg	Max	75	D6304
Sulfur, mg/kg	Max	15	D5453
Sulfur, mg/kg	Max	15	D2622
Metals			
(Al, Ca, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Pt, Sn, Sr, Ti, V, Zn), mg/kg	Max	0.1 per metal	UOP 389
Halogens, mg/kg	Max	1	D7359

[A] For compliance of test results against the requirements of Table A1.2, see 7.3.
[B] The test methods indicated in this table are referred to in A1.6.2.
[C] Maximum cycloparaffin composition is based on current experience with the approved synthetic fuels and is within the range of what is typical for refined jet fuel.

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] Additional information on aviation turbine fuel and its properties is found in ASTM's MNL 37, Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing[14] and the Handbook of Aviation Fuel Properties.[15]

X1.2 Significance and Use

X1.2.1 Specification D7566 defines two grades of jet fuel for civil use. Limiting values for the two grades of fuel covered are placed on fuel properties believed to be related to the performance of the aircraft and engines in which they are most commonly used.

X1.2.2 The safe and economical operation of aircraft requires fuel that is essentially clean and dry and free of any contamination prior to use. It is possible to measure a number of jet fuel characteristics related to quality.

X1.2.3 The significance of standard tests for fuel properties may be summarized for convenience in terms of the technical relationships with performance characteristics as shown in Table X1.1.

X1.2.4 The acceptability of additives for use is determined by the engine and aircraft type certificate holder and must be approved by his certifying authority. In the United States of America, the certifying authority is the Federal Aviation Administration.

X1.3 Thermal Stability

X1.3.1 Stability to oxidation and polymerization at the operating temperatures encountered in certain jet aircraft is an important performance requirement. The thermal stability measurements are related to the amount of deposits formed in the engine fuel system on heating the fuel in a jet aircraft. Commercial jet fuels should be thermally stable at a fuel temperature as high as 163°C (325°F). Such fuels have been demonstrated to have inherent storage stability.

X1.3.2 In 1973, Test Method D3241 replaced Method of Test D1660, known as the ASTM Coker, for the determination of oxidative thermal stability. (See CRC Report 450, dated 1969 and revised in 1972. See also Bert and Painter's SAE paper 730385.[16]). Today, a single pass/fail run with the tube temperature controlled at 260°C is used to ensure compliance with the specification minimum requirements. For a more complete characterization of a fuel's thermal stability, a breakpoint can be obtained. The breakpoint is the highest tube temperature at which the fuel still passes the specification requirements of tube deposit color and pressure differential. Normally, obtaining a breakpoint requires two or more runs at differing tube temperatures. Breakpoints are therefore not used for quality control, but they serve mostly for research purposes.

X1.3.3 It was determined that additional margin was required for hydroprocessed SPK blend components described in

[13] *Manual on Significance of Tests for Petroleum Products*, MNL 1, ASTM International, 2003.

[14] MNL 37, *Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing*, Eds., Totten, George E., Westbrook, Steven R., and Shah, Rajesh J., ASTM International, W. Conshohocken, PA, 2003.

[15] *Handbook of Aviation Fuel Properties*, Third Edition, CRC Report 635, Coordinating Research Council, Atlanta, GA, 2004.

[16] 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
	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 handling	Flash point	X1.11.1
	Static Electricity	X1.11.2
	Water separation characteristics	X1.13.2
	Free water and particulate contamination	X1.12.3
	Particulate matter	X1.12.4
	Membrane color ratings	X1.12.4.1
	Undissolved water	X1.12.2
Fuel lubricating ability (lubricity)	Fuel lubricity	X1.10
Miscellaneous	Additives	X1.15.1
	Sample containers	X1.15.3

Annex A1. Consequently, a control temperature of 325°C is specified to ensure that these blend components are free of reactive species.

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. Cycloparaffins are the next most desirable hydrocarbons for this use. Although olefins generally have good combustion characteristics, their poor gum stability usually limits their use in aircraft turbine fuels to about 1 % or less. Aromatics generally have the least desirable combustion characteristics for aircraft turbine fuel. In aircraft turbines they tend to burn with a smoky flame and release a greater proportion of their chemical energy as undesirable thermal radiation than the other hydrocarbons. Naphthalenes or bicyclic aromatics produce more soot, smoke, and thermal radiation than monocyclic aromatics and are, therefore, the least desirable hydrocarbon class for aircraft jet fuel use. All of the following measurements are influenced by the hydrocarbon composition of the fuel and, therefore, pertain to combustion quality: smoke point, percent naphthalenes, and percent aromatics.[17]

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. However, recent research in support of fuels containing synthesized hydrocarbons has indicated that a minimum level of aromatics is desirable to ensure that shrinkage of aged elastomer seals and associated fuel leakage is prevented.

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 indicates low heating value per unit volume, and would indicate a reduced flight range for a given volume of fuel.

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