Designation: D7566 – 09

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 Once released to this specification (D7566) the requirements of this specification are no longer applicable: any recertification shall be done to D1655.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)

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

[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.

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
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 (JFTOT Procedure)
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 and Relative Density 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
D4305 Test Method for Filter Flow of Aviation Fuels at Low Temperatures
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
D5901 Test Method for Freezing Point of Aviation Fuels (Automated Optical Method)
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

[3] Withdrawn.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

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

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 *UOP Test Methods:*[7]
UOP 389 Trace Metals in Oils by Wet Ash/ICP-AES

2.6 *U.S. Department of Defense Specifications:*[8]
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 delivery.

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

4.2.2 *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.

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

5. Classification

5.1 Two types 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:[9]

6.3.1 Other additives are permitted under 6.2 and 8.1. These include fuel system icing inhibitor, other antioxidants, inhibitors, and special purpose additives. The quantities and types shall 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.

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 X2 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.

7.3 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1, Table A1.1, and

[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 ASTM International, www.astm.org, or contact ASTM Customer Service at service@astm.org.
[8] Available from the Standardization Document Order Desk, 700 Robbins, Avenue, Building 4D, Philadelphia PA 19111-5094 (http://assist.daps.dla.mil).
[9] Supporting data (Guidelines for Approval or Disapproval of Additives) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1125.

TABLE 1 Detailed Requirements of Aviation Turbine Fuels 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			
JFTOT (2.5 h at control temperature)			
Temperature, °C	Min	260	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.

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]	
Corrosion Inhibitor/Lubricity Improvers[J]	
One of the following:	
Apollo PRI-19	23 mg/L max
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 = 1×10^{-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] More information concerning minimum treat rates of corrosion inhibitor/lubricity improver additives is contained in X1.10.2.

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. 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 X3.

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[10]) 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 D02-1572.[10] 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.

11.1.12 *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

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

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).[11] 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[10]) 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 D02-1572.[10] 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.

[11] 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		HSPK	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
JFTOT (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 at the point of manufacture.
[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		HSPK	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, mass %	Max	0.0015	D2622
Metals			
(Al, Ca, Co, Cr, Cu, Fe, K, 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.[12] Additional information on aviation turbine fuel and its properties is found in ASTM's MNL 37, Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing[13] and the Handbook of Aviation Fuel Properties.[14]

X1.2 Significance and Use

X1.2.1 Specification 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, JFTOT, replaced Method of Test D1660, known as the ASTM Coker, for the determination of oxidative thermal stability. (See CRC Report 450, dated 1969 and revised in 1972. See also Bert and Painter's SAE paper 730385.[15]). Today, a single pass/fail run

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

[13] 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.

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

[15] Bert, J. A., and Painter, L., "A New Fuel Thermal Stability Test (A Summary of Coordinating Research Council Activity)," SAE Paper 730385, Society of Automotive Engineers, Warrendale, PA, 1973.

TABLE X1.1 Performance Characteristics of Aviation Turbine Fuels

Performance Characteristics	Test Method	Sections
Engine fuel system deposits and coke	Thermal stability	X1.3
Combustion properties	Smoke point	X1.4.2.1
	Aromatics	X1.4.2.2
	Percent naphthalenes	X1.4.2.3
Fuel metering and aircraft range	Density	X1.5.1
	Net heat of combustion	X1.5.2
Fuel atomization	Distillation	X1.6.1
	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

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 Annex A1. Consequently, a JFTOT 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.[16]

X1.4.2.1 *Smoke Point*—This method provides an indication of the relative smoke-producing properties of jet fuels and is related to the hydrocarbon-type composition of such fuels. Generally, the more highly aromatic the jet fuel, the more smoky the flame. A high smoke point indicates a fuel of low smoke-producing tendency.

X1.4.2.2 *Aromatics*—The combustion of highly aromatic jet fuels generally results in smoke and carbon or soot deposition, and it is therefore desirable to limit the total aromatic content as well as the naphthalenes in jet fuels. 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.

X1.5.2 *Net Heat of Combustion*—The design of aircraft and engines is based on the convertibility of heat into mechanical energy. The net heat of combustion provides a knowledge of the amount of energy obtainable from a given fuel for the performance of useful work; in this instance, power. Aircraft design and operation are dependent upon the availability of a certain predetermined minimum amount of energy as heat. Consequently, a reduction in heat energy below this minimum is accompanied by an increase in fuel consumption with corresponding loss of range. Therefore, a minimum net heat of combustion requirement is incorporated in this specification. The determination of net heat of combustion is time consuming and difficult to conduct accurately. This led to the development and use of the aniline point and density relationship to estimate the heat of combustion of the fuel. This relationship is used along with the sulfur content of the fuel to obtain the net heat of combustion by Test Method D4529 for the purposes of this specification. An alternative calculation, Test Method D3338, is based on correlations of aromatics content, gravity, volatility, and sulfur content. This method may be preferred at refineries where all these values are normally obtained and the necessity to obtain the aniline point is avoided. The direct measurement method, Test Method D4809, is normally used only as a referee method in cases of dispute.

X1.6 Fuel Atomization

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

X1.6.1.1 Test Method D86 is the referee method for measuring distillation properties; Test Method D2887 is approved as an alternate method. Test Method D86 and Test Method D2887 do not give the same numerical results. Test Method D2887 always starts at a lower temperature and ends at a higher temperature than Test Method D86 because D2887 gives true boiling point distribution (equivalent to D2892), as opposed to D86 which is a low efficiency distillation. To avoid confusion, it is required that Test Method D2887 results be reported as estimated D86 results by applying the correlation in Appendix X5 of Test Method D2887. Caution should be used

[16] 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: D02-1258.

when using distillation properties to estimate other fuel properties. A correlation equation giving a quantitative estimate of a fuel property based on Test Method D86 data should not be used with unconverted Test Method D2887 results without validation. Further, Test Method D2887 results converted into a form compatible with Test Method D86 might not be suitable for some property correlations because of the accumulation of errors from each correlation step.

X1.6.2 *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 as the outside temperature decreases. The minimum temperature experienced during a flight depends mostly on the outside air temperature, flight duration, and aircraft speed. For example, long duration flights would require fuel of lower freezing point than would short duration flights.

X1.7.1.1 The manual freezing point method, Test Method D2386, has a long history of providing results sufficient to support safe aviation operations, so it is designated the referee method. As shown by the results in D02-1572,[10] automated methods often provide greater precision in determining freezing point and more sensitivity to cross-product contamination than the manual method, so their use is recommended in certifying and recertifying jet fuel. Recent experience has shown, however, that automated methods sometimes give unreliable freezing points or freezing points significantly warmer than the manual method. In such cases, in the absence of cross-product contamination, the fuel may be certified/recertified by the manual method.

X1.7.1.2 Because of the advantages of automated freezing point methods, many laboratories no longer run the manual freezing point method on a routine basis. It is recommended, when requesting manual freezing point measurements, that requestors ensure that the method is being conducted properly.

NOTE X1.1—Absence of cross-product contamination is intended to set an expectation that the possibility and ramifications of cross-product contamination are considered before the fuel is released, hence this decision should not be made solely on the manual freezing point result.

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 can be corrosive to turbine metal parts.

X1.8.3 *Copper Strip Corrosion*—A requirement that jet fuel pass the copper strip test ensures that the fuel does not contain any aggressive copper species that could 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.

X1.8.5 *Aromatics*—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.

X1.9 Fuel Storage Stability

X1.9.1 *Existent Gum*—Gum is a nonvolatile residue left on evaporation of fuel. Steam or air 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 Lubricity

X1.10.1 Aircraft/engine fuel system components and fuel control units rely on the fuel to lubricate their sliding parts. The effectiveness of a jet fuel as a lubricant in such equipment is referred to as its lubricity. Differences in fuel system component design and materials result in varying degrees of equipment sensitivity to fuel lubricity. Similarly, jet fuels vary in their level of lubricity. In-service problems experienced have ranged in severity from reductions in pump flow to unexpected mechanical failure leading to in-flight engine shutdown.

X1.10.2 The chemical and physical properties of jet fuel cause it to be a relatively poor lubricating material under high temperature and high load conditions. Severe hydroprocessing removes trace components resulting in fuels that tend to have lower lubricity than straight-run or wet-treated fuels. Corrosion inhibitor/lubricity improver additives (see Table 2) are routinely used to improve the lubricity of military fuels and may be used in civil fuels. These additives vary in efficacy and may be depleted by adsorption on tank and pipe surfaces, so treat rates should be set with care. Because of their polar nature, these additives can have adverse effects on fuel filtration systems and on fuel water separation characteristics. For this reason, it is preferable to avoid adding more of these additives than needed. When adequate jet fuel lubricity performance is achieved solely by additive use (without BOCLE testing or commingling with higher lubricity fuels), the additive concentration should be used at no less than its Minimum Effective Concentration (MEC) from the military Qualified Products List (QPL-25017). These levels are:

CI/LI Additive	MEC
Apollo PRI-19	18 g/m^3
HiTEC 580	15 g/m^3
Octel DCI-4A	9 g/m^3
Nalco 5403	12 g/m^3

X1.10.3 Most modern aircraft fuel system components have been designed to operate on low lubricity fuel (Test Method D5001 (BOCLE) wear scar diameter up to 0.85 mm). Other aircraft can have fuel system components that are more sensitive to fuel lubricity. Because low lubricity fuels are commingled with high lubricity fuels in most distribution systems, the resultant fuels no longer have low lubricity. However, problems have occurred when severely hydroprocessed fuel from a single source was the primary supply for sensitive aircraft. Where there are concerns about fuel lubricity, the air frame manufacturer can advise precautionary measures, such as the use of an approved lubricity additive to enhance the lubricity of the fuel.

X1.10.4 Test Method D5001 (BOCLE) is a test for assessing fuel lubricity where lower lubricity fuels give larger BOCLE wear scar diameters. BOCLE is used for in-service trouble shooting, lubricity additive evaluation, and in the monitoring of low lubricity test fluid during endurance testing of equipment. However, because the BOCLE may not accurately model all types of wear that cause in-service problems, other methods may be developed to better simulate the type of wear most commonly found in the field.

X1.10.5 Regulations are requiring increased production and distribution of ultralow sulfur diesel fuel (15 mg/kg (15 ppm by mass) maximum sulfur content). Diesel fuels are desulfurized to these low levels by severe hydroprocessing, sometimes resulting in very low lubricity fuels. Jet fuel lubricity may be impacted by the increased use of low sulfur diesel fuel, because batches of jet fuel may be made to these ultralow sulfur levels to maintain efficient production and distribution.

X1.10.6 A lubricity requirement is specified for aviation turbine fuel containing synthesized hydrocarbons because it is recognized that these fuels are typically relatively pure hydrocarbons without the polar acids that enhance lubricity.

X1.11 Fuel Handling

X1.11.1 *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.

X1.11.2 *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 600 pS/m. Studies have shown that when fuels treated with conductivity additive are commingled with non-additized fuel resulting in a low conductivity fuel, that fuel blend does not exhibit unusual static behavior. For more information on this subject, see Guide D4865.

X1.12 Fuel Cleanliness and Contamination

X1.12.1 *Introduction*:

X1.12.1.1 Unlike most other fuel properties, fuel cleanliness is dynamic; constantly changing during transportation and distribution. Jet fuel should be maintained in as clean a condition as possible right up to and in airport storage to ensure that possible failures of individual filtration components will not result in an unsafe condition. Airport control of cleanliness should be such as to ensure that only fuel relatively absent of free water and solid particulates is delivered into aircraft.

X1.12.1.2 The cleanliness of aviation turbine fuel is an essential performance requirement. Cleanliness requires the relative absence of free water and solid particulates. Water or dirt contamination, or both, in fuel onboard an aircraft represents a threat to flight safety and can cause long–term problems in areas such as wear, corrosion, and plugging of filters and other narrow tolerance parts.

X1.12.1.3 The cleanliness of aviation turbine fuel is protected in part by allowing time for dirt and water to settle during fuel distribution and by the routine use of effective filtration that removes both dirt and water. Generally the fuel handling system filters the fuel several times between manufacture and use with the final filtration occurring as the fuel is loaded onto an aircraft.

X1.12.2 *Undissolved Water*—The test method for undissolved water provides a quantitative means for measuring the amount of undissolved or free water in flowing fuel streams without exposing the sample to the atmosphere or to a sample container. It also provides a means for checking the performance of fuel filter-separators. Test Method D3240 describes this test method.

X1.12.3 *Free Water and Particulate Contamination in Distillate Fuels (Clear and Bright Pass/Fail Procedures)*—The procedures in Test Method D4176 provide rapid but nonquantitative methods for detecting contamination in a distillate fuel. Other following methods permit quantitative determinations.

X1.12.4 *Particulate Matter*—The presence of adventitious solid particulate contaminants such as dirt and rust may be detected by filtration of the jet fuel through membrane filters under prescribed conditions. Test Methods D2276 and D5452 describe a suitable technique.

X1.12.4.1 *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 D2276 describes a suitable technique.

X1.12.5 *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.

X1.12.5.1 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.

X1.13 Surfactants

X1.13.1 A key element in preventing contamination is to minimize or eliminate surfactants, which can compromise the ability of fuel handling systems to remove dirt and water. For

example, surfactants can reduce the particle size of suspended solid and water droplets, which slows removal by settling. Surfactants can disperse dirt and water so finely that they pass through filters. Surfactants can adsorb on the surfaces of filter/coalescers interfering with water removal. Surfactants can also lift rust from surfaces, thus increasing the solids level in the fuel.

X1.13.2 *Water Separation Characteristics*—The ease of coalescence of water from fuels as influenced by surface active agents (surfactants) is assessed by Test Methods D3948 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.

X1.13.2.1 *Water Separation Characteristics at Point of Manufacture*—The presence of surfactants in aviation turbine fuel specified by Specification D7566 is controlled at the point of manufacture by the Test Method D3948 performance requirement listed in Table 1. To determine if surfactant contamination occurs during transportation the fuel should also be tested downstream of the point of manufacture as appropriate.

X1.13.2.2 *Water Separation Characteristics at Points Downstream*—Results of downstream Test Method D3948 testing are not to be used as the sole reason for rejection of fuel, but they can indicate a mandatory need for further diligent investigation or remedial action, or both, such as passing the fuel through a clay adsorption unit to remove surfactants. However, the fuel may be rejected in the absence of satisfactory Test Method D3948 testing results if no documented evidence is presented that a detailed investigation was carried out demonstrating that the fuel was free of excess water and dirt and could be delivered into aircraft in a clean condition.

X1.13.2.3 *Water Separation Assessment*—Because distribution systems can be complex and employ a variety of methods of transporting the fuel, sampling points and methodologies should be established as a result of a technical assessment designed to ensure that fuel cleanliness is maintained throughout the system to the point of delivery into aircraft. Since transport systems vary in their basic nature, for example, a multi-product pipeline versus a dedicated pipeline, and also in their detailed operating conditions, the parties assuming custody of the fuel should evaluate their particular systems and establish suitable testing requirements.

X1.14 Cleanliness at Time of Fuel Custody Transfer at Airport

X1.14.1 Airport fueling is the most critical location for controlling dirt and water cleanliness. Into-airport storage is thus an important point for controlling surfactant contamination so as to protect out-of-storage and into-plane dirt and water filtration.

X1.15 Miscellaneous

X1.15.1 *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.

X1.15.1.1 *Fuel System Icing Inhibitor*, diethylene glycol monomethyl ether approved in 6.3 shall conform to the requirements shown in Specification D4171.

X1.15.2 *Leak Detection Additive*—Addition of leak detection additive, approved in 6.3, should be added to the fuel in accordance with the Tracer Tight[17] methodology.

X1.15.3 *Sample Containers*—A practice for sampling aviation fuel for tests affected by trace contamination can be found in Practice D4306.

X1.15.4 *Color*—While this specification does not have a color requirement, color can be a useful indicator of fuel quality. Normally fuel color ranges from water white (colorless) to a straw/pale yellow. Other fuel colors may be the result of crude oil characteristics or refining processes. Darkening of fuel or a change in fuel color may be the result of product contamination and may be an indicator that the fuel is off-specification, which could render it unfit and not acceptable for aircraft/engine use. Fuel having various shades of color, that is, pink, red, green, blue, or a change in color from the supply source should be investigated to determine the cause of color change to ensure suitability for aircraft/engine use and should be documented prior to final delivery to airport storage.

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

X2. CONTROL OF PROCESSING ADDITIVES

X2.1 Experience has shown that refinery processing additives, such as corrosion inhibitors, might be carried over in trace quantities into aviation fuel during refinery production. In some cases, this has resulted in operational problems in aircraft fuel systems. Moreover, these additives can cause problems at levels which may not be detected by the standard specification testing detailed in Table 1, Table A1.1, and Table A1.2. While the specification (6.2) requires that only approved additives are used, confirming that non-approved additives are absent is difficult, because it is unclear what analytical method to apply, given that:

X2.1.1 The analytical target may be uncertain, since there is a wide range of (often proprietary) materials involved.

X2.1.2 There is no industry-agreed basis for determining the required analysis sensitivity.

X2.1.3 There usually are no available data, relating to processing additive concentration to aircraft system performance, to set no-harm levels (to define analysis sensitivity).

X2.2 It is therefore not practical for this specification to require detailed chemical analysis of each production batch of aviation fuel beyond the requirements listed in Table 1. Instead, each manufacturing location should ensure that procedures are in place to control processing additive use and impact on product performance. One acceptable approach to do this is to implement a management of change procedure that evaluates the impact of processing changes (including process additives) on finished product quality. Other approaches may also be acceptable.

X3. 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, are 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 would need to search each different data sheet for desired information because of the random ordering of results by different reporting laboratories. One objective, therefore, of standard reporting forms is to provide a precise ordering of inspection test data being reported.

X3.1.2 The inspection forms shown in Figs. X3.1-X3.3 incorporate the requirements of the most commonly used international fuel specifications, including Specification D7566, British specification Defence Standard 91-91, 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 D7566, 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 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.

X3.2 Dimensions of Standard Form

X3.2.1 A standard reporting form for aviation turbine fuels containing synthesized hydrocarbons is shown in Fig. X3.1, a standard batch reporting form for a hydroprocessed synthetic paraffinic kerosene blending component is shown in Fig. X3.2, and a standard reporting form for other requirements for a hydroprocessed SPK blending component is shown in Fig. X3.3.

X3.2.2 Earlier versions of these forms were available from ASTM as an adjunct 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.

X3.3 Description of Standard Form 1 (Fig. X3.1)

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.

X3.3.1.8 *Synthetic Content*—List the percentage volume of synthetic blending component contained in the finished fuel.

X3.3.1.9 *Synthetic Type*—List the type of synthetic blending component from those specified in A1.4.2.

D7566 FORM 1

INSPECTION DATA ON AVIATION TURBINE FUEL CONTAINING SYNTHESIZED HYDROCARBONS

(Items in *italics* are referenced in the specification)

MANUFACTURER/SUPPLIER _____
PRODUCT CODE/GRADE _____
SPECIFICATION _____
SAMPLE NUMBER _____
DATE SAMPLED _____
SAMPLING LOCATION _____
BATCH NUMBER _____
QUANTITY LITRES @ 15°C _____
QUANTITY U.S. GALLONS @ 60°F _____
LABORATORY _____

DATE SAMPLED _____
DATE RECEIVED AT LAB _____
CONTRACT NUMBER _____
ORDER NUMBER _____
TANK NUMBER _____
DESTINATION _____
CRUDE SOURCE _____
PROCESSING METHOD _____
SYNTHETIC CONTENT _____
SYNTHETIC TYPE (Annex A1) _____
REMARKS _____

Method			Result
		APPEARANCE	
010	D156	Color (Saybolt)	xxx
020	D6045	Color (Saybolt)	xxx
030	D4176	Visual (“Pass” or “Fail”)	xxxx
		COMPOSITION	
100C	D3242	*Acidity, Total (mg KOH/g)*	*x.xxx*
110	D1319	*Aromatics (vol %)*	*xx.x*
112	D6379	*Aromatics (vol %)*	*xx.x*
115	D1319	Olefins (vol %)	x.x
120	D1840	*Napthalene (vol %)*	*x.xx*
130	D3227	*Sulfur, Mercaptan (mass %)*	*x.xxx*
140	D4952	Doctor Test (P = poss, N = neg)	x
150A	D129	Sulfur, Total (mass %)	x.xx
150B	D1266	*Sulfur, Total (mass %)*	*x.xx*
150D	D2622	*Sulfur, Total (mass %)*	*x.xx*
150E	D3701	Sulfur, Total (ppm)	xxxx
150F	D4294	*Sulfur, Total (mass %)*	*x.xx*
150G	D5453	*Sulfur, Total (ppm)*	*xxxx*
160A	D3343	Hydrogen Content (mass %)	xx.xx
160B	D3701	Hydrogen Content (mass %)	xx.xx
		VOLATILITY	
200A	D86	*Distillation by Auto/Manual (°C)*	*x*
200B	D2887	Distillation by GC (°C)	x
201		Distillation by Initial BP (°C)	xxx.x
202		*Distillation by 10% Rec (°C)*	*xxx.x*
203		Distillation by 20% Rec (°C)	xxx.x
204		*Distillation by 50% Rec (°C)*	*xxx.x*
205		*Distillation by 90% Rec (°C)*	*xxx.x*
206		Distillation by 95% Rec (°C)	xxx.x
211		Distillation by Final BP (°C)	xxx.x
213		Residue (vol %)	x.x
214		Loss (vol %)	x.x
220A	D56	*Flash Point, TAG Closed (°C)*	*xx.x*
220B	D93	Flash Point, PM Closed (°C)	xx.x
220C	D3828	*Flash Point, Setaflash (°C), Meth A*	*xx.x*
220D	D3828	Flash Point, Setaflash (°C), Meth B	xx.x
221	D3828	Flash Point, Setaflash (Flash/No Flash)	x
230A	D1298	*Density @ 15°C (kg/m^3)*	*xxx.x*
230B	D4052	*Density @ 15°C (kg/m^3)*	*xxx.x*
231A	D1298	API Gravity @ 60°F	xx.x
240A	D323	Vapor Pressure, Reid (kPa)	xx.x
240B	D4953	Vapor Pressure, Dry Method (kPa)	xx.x
240C	D5190	Vapor Pressure, Automatic Method (kPa)	xx.x
240D	D5191	Vapor Pressure, Mini Method (kPa)	xx.x
		FLUIDITY	
300A	D2386	*Freezing Point (°C)*	*-xx. xx*
300B	D5901	*Freezing Point (°C)*	*-xx. xx*
300C	D5972	*Freezing Point (°C)*	*-xx. xx*
300D	D4305	*Freezing Point (°C)*	*-xx. xx*
300F	D7154	*Freezing Point (°C)*	*-xx. xx*
310	D445	*Viscosity @ –20°C (mm^2/s)*	*xx.xxx*
311	D445	Viscosity at other temps (mm^2/s)	xx.xxx
312	D445	Temp (°C) of item 311	xxxx

Method			Result
		COMBUSTION	
400A	D240	Net Heat of Combustion (MJ/kg)	xx.xxx
400B	D1405	Net Heat of Combustion (MJ/kg)	xx.xxx
400C	D3338	*Net Heat of Combustion (MJ/kg)*	*xx.xxx*
400D	D4529	*Net Heat of Combustion (MJ/kg)*	*xx.xxx*
400E	D4809	*Net Heat of Combustion (MJ/kg)*	*xx.xxx*
410	D1740	*Luminometer No.*	*xx*
420	D1322	*Smoke Point (mm)*	*xx.x*
		CORROSION	
500	D130	*Copper Strip*	*xx*
510	IP 227	Silver Strip	x
		STABILITY	
601A	D3241	*JFTOT ΔP (mmHg) @ other temp*	*xx.x*
602A	D3241	*JFTOT Tube Deposit @ other temp*	*xxxx*
603A	D3241	*JFTOT TDR Spun Rating @ other temp*	*xx*
604A		*Temp (°C) of above JFTOT*	*xxxx*
601B	D3241	*JFTOT ΔP (mmHg) @ 260°C*	*xx.x*
602B	D3241	*JFTOT Tube Deposit @ 260°C*	*xxxx*
603B	D3241	*JFTOT TDR Spun Rating @ 260°C*	*xx*
		CONTAMINANTS	
700	IP 225	Copper Content (mg/kg)	x.xx
710	D381	*Existent Gum (mg/100 mL)*	*xxx*
710A	IP 540	*Existent Gum (mg/100 mL)*	*xxx*
720A	D2276	Particulate (mg/L)	x.xx
720B	D5452	Particulate (mg/L)	x.xx
730		Filtration Time (minutes)	xx
740	D1094	*Water Reaction Interference Rating*	*xx*
750	D3948	MSEP (With SDA)	xxx
751	D3948	MSEP (Without SDA)	xxx
		ADDITIVES	
800		Antioxidant (mg/L) [BRAND]	xx.x
810		Metal Deactivator (mg/L) [BRAND]	x.x
820		Static Dissipator Additive (mg/L) [BRAND]	x.x
830A	(D5006)	FSII (vol %) [BRAND]	x.xxx
830B	(FTM5327)	FSII (vol %) [BRAND]	x.xxx
830C	(FTM5340)	FSII (vol %) [BRAND]	x.xxx
840		Corrosion Inhibitor (mg/L) [BRAND]	xx.x
		EXTENDED REQUIREMENTS	
901	D1319	*Aromatics (vol%)*	*x.x*
	D6379		
902	D2887	*Distillation, T50-T10, °C*	*xx*
903	D2887	*Distillation, T90-T10, °C*	*xx*
904	D5001	*Lubricity BOCLE WSD (mm)*	*x.xx*
		OTHER TESTS	
951	D2624	*Conductivity (pS/m)*	*xxxx*
952	D2624	*Conductivity Test Temperature (°C)*	*xxx*

Comments and/or Additional Tests:

_____
_____
_____

Certified By: _____

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

D7566 FORM 2
BATCH INSPECTION DATA ON HYDROPROCESSED SPK BLENDING COMPONENT
(Items in *italics* are referenced in the specification)

MANUFACTURER/SUPPLIER _____
PRODUCT CODE/GRADE _____
SPECIFICATION _____
SAMPLE NUMBER _____
DATE SAMPLED _____
SAMPLING LOCATION _____
BATCH NUMBER _____
QUANTITY LITRES @ 15°C _____
QUANTITY U.S. GALLONS @ 60°F _____
LABORATORY _____

DATE SAMPLED _____
DATE RECEIVED AT LAB _____
CONTRACT NUMBER _____
ORDER NUMBER _____
TANK NUMBER _____
DESTINATION _____
FEEDSTOCK TYPE _____
PROCESSING METHOD _____
REMARKS _____

Method			Result
		APPEARANCE	xxx
1010	D156	Color (Saybolt)	xxx
1020	D6045	Color (Saybolt)	xxx
1030	D4176	Visual (“Pass” or “Fail”)	xxxx
		COMPOSITION	
1100	D3242	Acidity, Total (mgKOH/g)	x.xxx
		VOLATILITY	
1200A	D2887	*Distillation by Auto/Manual (°C)*	*x*
1201		Distillation by Initial BP (°C)	xxx.x
1202		*Distillation by 10% Rec (°C)*	*xxx.x*
1204		*Distillation by 50% Rec (°C)*	*xxx.x*
1205		*Distillation by 90% Rec (°C)*	*xxx.x*
1211		*Distillation by Final BP (°C)*	*xxx.x*
1212		*T90-T10 (°C)*	
1220A	D56	*Flash Point, TAG Closed (°C)*	*xx.x*
1220B	D93	Flash Point, PM Closed (°C)	xx.x
1220C	D3828	*Flash Point, Setaflash (°C), Meth A*	*xx.x*
1220D	D3828	Flash Point, Setaflash (°C), Meth B	xx.x
1221	D3828	Flash Point, Setaflash (Flash/No Flash)	x
1230A	D1298	*Density @ 15°C (kg/m^3)*	*xxx.x*
1230B	D4052	*Density @ 15°C (kg/m^3)*	*xxx.x*
1231A	D1298	API Gravity @ 60°F	xx.x

Method			Result
		FLUIDITY	
1300A	D2386	*Freezing Point (°C)*	*-xx.xx*
1300B	D5901	*Freezing Point (°C)*	*-xx.xx*
1300C	D5972	*Freezing Point (°C)*	*-xx.xx*
1300D	D4305	*Freezing Point (°C)*	*-xx.xx*
1300F	D7154	*Freezing Point (°C)*	*-xx.xx*
1310	D445	*Viscosity @ -20°C (mm^2/s)*	*xx.xxx*
1311	D445	Viscosity at other temps (mm^2/s)	xx.xxx
1312	D445	Temp (°C) of item 1311	xxxx
		STABILITY	
1601A	D3241	*JFTOT ΔP (mmHg) @ other temp*	*xx.x*
1602A	D3241	*JFTOT Tube Deposit @ other temp*	*xxxx*
1603A	D3241	*JFTOT TDR Spun Rating @ other temp*	*xx*
1604A		*Temp (°C) of above JFTOT*	*xxxx*
1601B	D3241	*JFTOT ΔP (mmHg) @ 325°C*	*xx.x*
1602B	D3241	*JFTOT Tube Deposit @ 325°C*	*xxxx*
1603B	D3241	*JFTOT TDR Spun Rating @ 325°C*	*xx*
		ADDITIVES	
1800		*Antioxidant (mg/L) [BRAND]*	*xx.x*

Comments and/or Additional Tests:
_____
_____
_____

Certified By: _____

FIG. X3.2 Standard Form for Reporting Batch Inspection Data on a Hydroprocessed SPK Blending Component

X3.4 Description of Standard Form 2 (Fig. X3.2)

X3.4.1 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 not discussed in X3.3 for Form 1 is provided below:

X3.4.2 *Feedstock Type*—List the raw material source for the blend component. Examples are coal, natural gas, biomass (specify type).

X3.4.3 *Processing Method*—List the synthetic processing technique(s) used to produce the blend component. Examples are Fischer-Tropsch, or Hydroprocessed bio-derived oils. Used in conjunction with the feedstock type, this information can be used to correlate blending component properties with processing technique.

X3.5 Description of Standard Form 3 (Fig. X3.3)

X3.5.1 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 not discussed in X3.3 for Form 1 or X3.4 for Form 2 is provided below:

X3.5.2 *Process Reference*—List a reference for the process used to produce the synthetic blend component.

X3.6 Instructions Applicable to All Forms

X3.6.1 The body of each form provides for entering test results. There are four columns provided for each test.

X3.6.1.1 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:

Form 1	Form 2	Form 3	Fuel Characteristics
10-99	1010-1099		Appearance
100-199	1100-1199	2100-2199	Composition
200-299	1200-1299		Volatility
300-399	1300-1399		Fluidity
400-499			Combustion
500-599			Corrosion
600-699	1600-1699		Stability
700-799			Contaminants
800-899	1800-1899		Additives
900-950			Extended Requirements
951-999	1900-1999		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

D7566 FORM 3
OTHER INSPECTION DATA ON HYDROPROCESSED SPK BLENDING COMPONENT
(Items in *italics* are referenced in the specification)

MANUFACTURER/SUPPLIER _____
PRODUCT CODE/GRADE _____
SPECIFICATION _____
SAMPLE NUMBER _____
DATE SAMPLED _____
SAMPLING LOCATION _____
PROCESS REFERENCE _____
QUANTITY LITRES @ 15°C _____
QUANTITY U.S. GALLONS @ 60°F _____
LABORATORY _____

DATE SAMPLED _____
DATE RECEIVED AT LAB _____
CONTRACT NUMBER _____
ORDER NUMBER _____
TANK NUMBER _____
DESTINATION _____
FEEDSTOCK TYPE_____
PROCESSING METHOD _____
PROCESSING STATUS (NEW/CHANGED) _____
REMARKS _____
_____

Method			Result
		Hydrocarbon Composition	
2110	D2425	*Cycloparaffins, mass %*	*x.x*
2120	D2425	*Aromatics, mass %*	*x.x*
2130	D2425	*Paraffins, mass %*	*x.xxx*
2150	D5291	Carbon and Hydrogen mass %	x.xx
		Non-hydrocarbon Composition	
2160	D4629	Nitrogen, mg/kg	xxxx
2170	D6304	Water, mg/kg	xx.xx
2180	D5453	Sulfur, mg/kg	xx.xx
	D2622	Mass %	xx.xx
2190	D7359	Halogens, mg/kg	xx.xx

		Metals	
2195A	UOP 389	Al, mg/kg	xxxx
2195B	UOP 389	Ca, mg/kg	xxxx
2195C	UOP 389	Co, mg/kg	xxxx
2195D	UOP 389	Cr, mg/kg	xxxx
2195E	UOP 389	Cu, mg/kg	xxxx
2195F	UOP 389	Fe, mg/kg	xxxx
2195G	UOP 389	K, mg/kg	xxxx
2195H	UOP 389	Mg, mg/kg	xxxx
21951	UOP 389	Mn, mg/kg	xxxx
2195J	UOP 389	Mo, mg/kg	xxxx
2195K	UOP 389	Na, mg/kg	xxxx
2195L	UOP 389	Ni, mg/kg	xxxx
2195M	UOP 389	P, mg/kg	xxxx
2195N	UOP 389	Pb, mg/kg	xxxx
2195O	UOP 389	Sn, mg/kg	xxxx
2195P	UOP 389	V, mg/kg	xxxx
2195Q	UOP 389	Zn, mg/kg	xxxx
2195R	UOP 389	Pt, mg/kg	xxxx
2195S	UOP 389	Pd, mg/kg	xxxx
2195T	UOP 389	Sr, mg/kg	xxxx
2195T	UOP 389	Ti, mg/kg	xxxx

Comments and/or Additional Tests:
_____
_____
_____
Certified By: _____

FIG. X3.3 Standard Form for Reporting Other Inspection Data on a Hydroprocessed SPK Blending Component

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.

X3.6.1.2 The second column lists the applicable ASTM test method designation. Where there is no ASTM test method designation, the applicable IP designation (Institute of Petroleum) is shown.

X3.6.1.3 The third column presents word descriptors for each test.

X3.6.1.4 The fourth column presents diamonds for entering the results of each test with location of the decimal point shown where applicable.

X3.6.2 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.

X3.7 Instructions for Executing Column 4 on All Forms

X3.7.1 *General Instructions*:

X3.7.1.1 Form 1 is intended for use with both naphtha- and kerosine-based aviation fuels with synthesized hydrocarbons and provides choice of test methods. Forms 2 and 3 are intended for blending components comprised of hydroprocessed synthesized paraffinic kerosens. 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.

X3.7.2 *Detailed Instructions*:

X3.7.2.1 *Form 1 Items 10 and 20, Form 2 Items 1010 and 1020, Color (Saybolt)*—Enter either a (+) or a (–) sign in the first square. Example: +15.

X3.7.2.2 *Form 1 Item 30, Form 2 Item 1030, Visual*—According to Test Method D4176, report result as Pass or Fail, using the criteria outlined in the test method.

X3.7.2.3 *Form 1 Item 200, Form 2 Item 1200, 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 are referenced to Test Method D86. When Test Method D2887 is used the results shall be reported as estimated D86 results by application of the correlation in Appendix X5 of D2887. 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.

X3.7.2.4 *Form 1 Items 230 and 231, Form 2 Items 1230 and 1231*—For those contracts or instances that require reporting in units of API Gravity, Item 231A reports of API Gravity using Test Method D1298, and Items 230A and 1230A report density by the same method, either as an alternate or concurrent measurement. Items 230B and 1230B report density by using Test Method D4052, which only provides for density as currently written.

X3.7.2.5 *Form 1 Item 310 and 311, Form 2 Item 1310 and 1311, Viscosity*—For aviation turbine fuels, viscosity is measured at –20°C; therefore, the value for Form 1 item 311 and Form 2 item 1311 will always be –20. If the test is performed at some other temperature, use item number 311 or 1311 to report this temperature.

X3.7.2.6 *Form 1 Items 601 - 603, Form 2 Items 1601–1603, JFTOT*—Select the temperature at which the JFTOT was performed. The letter suffix refers to one temperature. Items 601–603, and items 1601 and 1603 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 Form 1, or 300°C for Form 2, 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 D3241, 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.

X3.7.2.7 *Form 1 Items 800, 810, 820, 830, and 840, Form 2 Item 800*—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.