This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D7566 – 17

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 U.S. 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, as follows:

1.2.1 Aviation turbine fuel manufactured, certified, and released to all the requirements of Table 1 of this specification (D7566), meets the requirements of Specification D1655 and shall be regarded as Specification D1655 turbine fuel. Duplicate testing is not necessary; the same data may be used for both D7566 and D1655 compliance. Once the fuel is released to this specification (D7566) the unique requirements of this specification are no longer applicable: any recertification shall be done in accordance with Table 1 of Specification D1655.

1.2.2 Field blending of synthesized paraffinic kerosine (SPK) blendstocks, as described in Annex A1 (FT SPK), Annex A2 (HEFA SPK), Annex A3 (SIP), synthesized paraffinic kerosine plus aromatics (SPK/A) as described in Annex A4, or Annex A5 (ATJ) 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 Table 1 of this specification (D7566) apply and shall be evaluated. Short form conformance test programs commonly used to ensure transportation quality are not sufficient. The fuel shall be regarded as D1655 turbine fuel after certification and release as described in 1.2.1.

1.2.3 Once a fuel is redesignated as D1655 aviation turbine fuel, it can be handled in the same fashion as the equivalent refined D1655 aviation turbine fuel.

1.3 This specification defines the minimum property requirements for aviation turbine fuel that contain synthesized hydrocarbons and lists acceptable additives for use in civil operated engines and aircrafts. Specification D7566 is directed at civil applications, and maintained as such, but may be adopted for military, government, or other specialized uses.

1.4 This specification can be used as a standard in describing the quality of aviation turbine fuel from production to the aircraft. However, this specification does not define the quality assurance testing and procedures necessary to ensure that fuel in the distribution system continues to comply with this specification after batch certification. Such procedures are defined elsewhere, for example in ICAO 9977, EI/JIG Standard 1530, JIG 1, JIG 2, API 1543, API 1595, and ATA-103.

1.5 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.

1.6 While aviation turbine fuels defined by Table 1 of 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.

1.7 Synthetic blending components, synthetic fuels, and blends of synthetic fuels with conventional petroleum-derived fuels in this specification have been evaluated and approved in accordance with the principles established in Practice D4054.

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

1.9 *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.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.J0.06 on Emerging Turbine Fuels.

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

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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 and Liquid Fuels at Atmospheric Pressure
D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D129 Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device 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, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
D1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
D1322 Test Method for Smoke Point of Kerosine and Aviation Turbine Fuel
D1405 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D1655 Specification for Aviation Turbine Fuels
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
D2710 Test Method for Bromine Index of Petroleum Hydrocarbons by Electrometric Titration
D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
D2892 Test Method for Distillation of Crude Petroleum (15-Theoretical Plate Column)
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
D4054 Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives
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) (Withdrawn 2012)[3]
D5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)

[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.

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

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
D6866 Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis
D7042 Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
D7111 Test Method for Determination of Trace Elements in Middle Distillate Fuels by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
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)
D7345 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation 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)
D7524 Test Method for Determination of Static Dissipater Additives (SDA) in Aviation Turbine Fuel and Middle Distillate Fuels—High Performance Liquid Chromatograph (HPLC) Method
D7974 Test Method for Determination of Farnesane, Saturated Hydrocarbons, and Hexahydrofarnesol Content of Synthesized Iso-Paraffins (SIP) Fuel for Blending with Jet Fuel by Gas Chromatography
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *Energy Institute Standards:*[4]

EI 1550 Handbook on Equipment Used for the Maintenance and Delivery of Clean Aviation Fuel
EI 1583 Laboratory Tests and Minimum Performance Levels for Aviation Fuel Filter Monitors
EI/JIG 1530 Quality Assurance Requirements for the Manufacture, Storage and Distribution of Aviation Fuels to Airports
IP 12 Determination of Specific Energy
IP 16 Determination of the Freezing Point of Aviation Fuels—Manual Method
IP 30 Detection of Mercaptans, Hydrogen Sulfide, Elemental Sulfur and Peroxides—Doctor Test Method
IP 34 Determination of Flash Point—Pensky-Martens Closed Cup Method
IP 69 Vapour Pressure-Reid Method (St-B-9)
IP 71, Section 1 Petroleum Products—Transparent and Opaque Liquids—Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity
IP 123 Petroleum Products—Determination of Distillation Characteristics at Atmospheric Pressure
IP 154 Petroleum Products—Corrosiveness to Copper—Copper Strip Test
IP 156 Petroleum Products and Related Materials—Determination of Hydrocarbon Types—Fluorescent Indicator Adsorption Method
IP 160 Crude Petroleum and Liquid Petroleum Products—Laboratory Determination of Density—Hydrometer Method
IP 170 Determination of Flash Point—Abel Closed-Cup Method
IP 216 Particulate Contaminant in Aviation Fuel
IP 225 Determination of Copper in Light Petroleum Distillates—Spectrophotometric Method
IP 227 Corrosiveness to Silver of Aviation Turbine Fuels—Silver Strip Method
IP 274 Determination of Electrical Conductivity of Aviation and Distillate Fuels
IP 299 Determination of Bromine Index—Electrometric Titration Method
IP 323 Determination of Thermal Oxidation Stability of Gas Turbine Fuels
IP 336 Petroleum Products—Determination of Sulfur Content—Energy-Dispersive X-ray Fluorescence Spectrometry
IP 342 Petroleum Products—Determination of Thiol (Mercaptan) Sulfur in Light and Middle Distillate Fuels—Potentiometric Method
IP 354 Determination of the Acid Number of Aviation Fuels-Colour-Indicator Titration Method
IP 365 Crude Petroleum and Petroleum Products—Determination of Density—Oscillating U-tube Method
IP 379 Determination of Organically Bound Trace Nitrogen—Oxidative Combustion and Chemiluminescence Method
IP 394 Liquid Petroleum Products—Vapour Pressure—Part 1: Determination of Air Saturated Vapour Pressure (ASVP) and Calculated Dry Vapour Pressure Equivalent (DVPE)
IP 406 Petroleum Products—Determination of Boiling Range Distribution by Gas Chromatography

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

IP 423 Determination of Particulate Contaminant in Aviation Turbine Fuels by Laboratory Filtration
IP 435 Determination of the Freezing Point of Aviation Turbine Fuels by the Automatic Phase Transition Method
IP 436 Determination of Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates—High Performance Liquid Chromatography Method with Refractive Index Detection
IP 438 Determination of Water—Coulometric Karl Fischer Titration Method
IP 475 Petroleum Liquids—Manual Sampling
IP 523 Determination of Flash Point—Rapid Equilibrium Closed Cup Method
IP 524 Determination of Flash/No Flash—Rapid Equilibrium Closed Cup Method
IP 528 Determination for the Freezing Point of Aviation Turbine Fuels—Automatic Fibre Optic Method
IP 529 Determination of the Freezing Point of Aviation Fuels—Automatic Laser Method
IP 540 Determination of the Existent Gum Content of Aviation Turbine Fuel—Jet Evaporation Method
IP 585 Determination of Fatty Acid Methyl Esters (FAME), Derived from Bio-diesel Fuel, in Aviation Turbine Fuel—GC-MS with Selective Ion Monitoring/Scan Detection Method
IP 590 Determination of Fatty Acid Methyl Esters (FAME) in Aviation Turbine Fuel—HPLC Evaporative Light Scattering Detector Method
IP 598 Petroleum Products—Determination of the Smoke Point of Kerosine, Manual and Automated Method

2.3 *ANSI Standard:*[5]

ANSI 863 Report of Test Results

2.4 *API Standards:*[6]

API 1543 Documentation, Monitoring and Laboratory Testing of Aviation Fuel During Shipment from Refinery to Airport
API 1595 Design, Construction, Operation, Maintenance, and Inspection of Aviation Pre-Airfield Storage Terminals[6]

2.5 *Joint Inspection Group Standards:*[7]

JIG 1 Aviation Fuel Quality Control & Operating Standards for Into-Plane Fuelling Services
JIG 2 Aviation Fuel Quality Control & Operating Standards for Airport Depots & Hydrants[7]

2.6 *IATA Guidance:*[8]

9680–04 IATA Guidance Material on Microbiological Contamination in Aircraft Fuel Tanks

2.7 *UOP Test Methods:*[9]

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

2.8 *U.S. Department of Defense Specifications:*[10]

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

2.9 *Other Standards:*

ATA-103 Standard for Jet Fuel Quality Control at Airports[11]
Defence Standard 91-91 Turbine Fuel, Aviation Kerosine Type, Jet A-1[12]
ICAO 9977 Manual on Civil Aviation Jet Fuel Supply[13]
AFRL-RQ-WP-TR-2013-0271 Determination of the Minimum Use Level of Fuel System Icing Inhibitor (FSII) in JP-8 that will Provide Adequate Icing Inhibition and Biostatic Protection for Air Force Aircraft[14]

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 *alcohol-to-jet synthetic paraffinic kerosene (ATJ-SPK), n*—an SPK produced starting from alcohol and processed through the following steps: dehydration, oligomerization, hydrogenation, and fractionation (Annex A5).

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

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

4.2.4 *hydroprocessed, adj*—conventional chemical processing 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.

4.2.5 *identified incidental materials, n*—chemicals and compositions that have defined upper content limits in an aviation fuel specification but are not approved additives.

4.2.6 *metrological method, n*—tube deposit rating methods employing an optical-based deposit thickness measurement and mapping technique described in the D3241 annexes.

[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 American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, http://www.api.org.
[7] Available from Joint Inspection Group (JIG), http://www.jigonline.com.
[8] 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'Aeroport, PO Box 416, 1215 Geneva, 15 Airport, Switzerland. www.iata.org.
[9] Available from ASTM International, www.astm.org, or contact ASTM Customer Service at service@astm.org.
[10] Available from the Standardization Document Order Desk, 700 Robbins, Avenue, Building 4D, Philadelphia PA 19111-5094 (http://assist.daps.dla.mil).
[11] Available from Air Transport Association of America, Inc. (ATA) d/b/a Airlines for America, 1301 Pennsylvania Ave. NW, Suite 1100, Washington, D.C. 20004, http://www.airlines.org.
[12] Available from Defence Equipment and Support, UK Defence Standardization, Kentigern House, 65 Brown Street, Glasgow, G2 8EX (http://www.dstan.mod.uk).
[13] Available from International Civil Aviation Organization (ICAO), 999 University St., Montreal, Quebec H3C 5H7, Canada, http://www.icao.int.
[14] Available from Defense Technical Information Center (DTIC), 8725 John J. Kingman Rd., Ft. Belvoir, VA 22060-6218, http://www.dtic.mil/dtic, accession number ADA595127.

4.2.7 *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.

4.2.8 *synthetic blending component, n*—synthesized hydrocarbons that meet the requirements of Annex A1, Annex A2, or Annex A3.

4.2.9 *synthesized iso-paraffins (SIP), n*—synthetic blending component that is comprised essentially of iso-paraffins.

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

4.2.10.1 *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.

4.2.11 *synthesized paraffinic kerosine plus aromatics (SPK/A), n*—synthetic blending component that is comprised of synthesized paraffinic kerosine (SPK) to which synthesized aromatics have been added.

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.

6.1.2 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 A2.

NOTE 1—The ability to add 50 % of Annex A1 or Annex A2 blending components (SPK) to Jet A or Jet A-1 is also limited by the physical properties of the fuel with which it is being blended. Practice has shown that density, or aromatic content, or both, of the refined fuel often limit the amount of SPK that can be added to the final blend to less than 50 %.

6.1.3 Conventional blending components or Jet A or Jet A-1 fuel certified to Specification D1655; with up to 10 % by volume of the synthetic blending component defined in Annex A3.

NOTE 2—The ability to add 10 % of Annex A3 blending components (SIP) to Jet A or Jet A-1 may also be limited by the physical properties of the fuel with which it is being blended. It is possible in extreme cases that viscosity of the refined fuel may limit the amount of SIP that can be added to the final blend to less than 10 %.

6.1.4 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 A4.

NOTE 3—The ability to add 50 % of Annex A4 blending components (SPK/A) to Jet A or Jet A-1 may also be limited by the physical properties of the fuel with which it is being blended. The density, or aromatic content, or both, of the refined fuel may limit the amount of SPK/A that can be added to the final blend to less than 50 %.

6.1.5 Conventional blending components or Jet A or Jet A-1 fuel certified to Specification D1655; with up to 30 % by volume of the synthetic blending component defined in Annex A5.

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*—Only additives approved by the aviation industry (including the aircraft certifying authority) are permitted in the fuel on which an aircraft is operated. The additives approved for use in D7566 jet fuel are shown in Table 1 and Table 2 and may be used within the concentration limits shown in the tables subject to any restrictions described in the table footnotes. [15]

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

6.5 From the point of manufacture to the point of blending to meet this specification, the synthetic blending component shall be handled and transported in the same manner as finished jet fuel in order to maintain product integrity. Appropriate management of change measures shall be used at manufacturing locations, distribution, and storage to maintain product integrity (see Appendix X3).

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 7.2, Annex A1, Annex A2, Annex A3, Annex A4, or Annex A5, whichever is applicable.

7.2 The fluidity requirement of Part 2 of Table 1 only applies to each batch of fuel containing the synthesized iso-paraffins (SIP) blending component as defined in Annex A3 and blended in accordance with 6.1.3. This requirement does not apply to fuel containing Annex A1, Annex A2, Annex A4, or Annex A5 synthesized components and blended in accordance with 6.1.1, 6.1.2, or 6.1.4.

7.3 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

[15] 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	Test Method[B]
COMPOSITION			
Acidity, total mg KOH/g	Max	0.10	D3242/IP 354
Aromatics: One of the following requirements shall be met:			
1. Aromatics, volume percent	Max	25	D1319 or IP 156
2. Aromatics, volume percent	Max	26.5	D6379/IP 436
Sulfur, mercaptan,[C] mass percent	Max	0.003	D3227/IP 342
Sulfur, total mass percent	Max	0.30	D1266, D2622, D4294, D5453, or IP 336
VOLATILITY			
Distillation			D2887/IP 406[D] or D86[E] or IP 123[E] D7345[F]
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, percent	Max	1.5	
Distillation loss, percent	Max	1.5	
Flash point, °C	Min	38[G]	D56 or D3828[H] , IP 170[H] or IP 523[H]
Density at 15 °C, kg/m^3		775 to 840	D1298/IP 160 or D4052 or IP 365
FLUIDITY			
Freezing point, °C	Max	–40 Jet A[I]	D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16
		–47 Jet A-1[I]	
Viscosity –20 °C, mm^2/s[J]	Max	8.0	D445/IP 71, Section 1, D7042[K]
COMBUSTION			
Net heat of combustion, MJ/kg	Min	42.8[L]	D4529, D3338, D4809 or IP 12
One of the following requirements shall be met:			
(1) Smoke point, mm, or	Min	25.0	D1322/IP 598
(2) Smoke point, mm, and	Min	18.0	D1322/IP 598
Naphthalenes, volume, percent	Max	3.0	D1840
CORROSION			
Copper strip, 2 h at 100 °C	Max	No. 1	D130/IP 154
THERMAL STABILITY			
2.5 h at control temperature of 260 °C, min			D3241[M] /IP 323[M]
Filter pressure drop, mm Hg	Max	25	
Tube rating: One of the following requirements shall be met:[N]			
(1) Annex A1 VTR, VTR Color Code	Less than	3 No peacock or abnormal color deposits	
(2) Annex A2 ITR or Annex A3 ETR, nm avg over area of 2.5 mm^2	Max	85	
CONTAMINANTS			
Existent gum, mg/100 mL	Max	7	D381, IP 540
Microseparometer,[O] Rating			D3948
Without electrical conductivity additive	Min	85	
With electrical conductivity additive	Min	70	
ADDITIVES		See 6.3[P]	
Electrical conductivity, pS/m			D2624/IP 274

Part 2—Extended Requirements

Property		Jet A or Jet A-1	Test Method[B]
COMPOSITION			
Aromatics: One of the following requirements shall be met:			
1. Aromatics, volume percent	Min[Q,R]	8	D1319 or IP 156
2. Aromatics, volume percent	Min[Q,R]	8.4	D6379/IP 436
VOLATILITY			
Distillation			D2887/IP 406[D] , D86[E] or IP 123[E]
T50-T10, °C	Min[R,S]	15	
T90-T10, °C	Min[R,S]	40	
LUBRICITY			
Lubricity,[P,O] mm	Max	0.85	D5001
FLUIDITY[T]			
Viscosity –40 °C, mm^2/s	Max	12	D445[U] /, Section 1[U]

[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 or IP 30.
[D] Distillation property criteria are specified in D86 or IP 123 scale units. D2887/IP 406 results shall be converted to estimated D86 or IP 123 results by application of the correlation in Appendix X5 of D2887 or Annex G of IP 406 for comparison with the specified property criteria. Distillation residue and loss limits provide control of the distillation process during the D86 and IP 123 test methods and do not apply to D2887/IP 406. Distillation residue and loss shall be reported as "not applicable" (N/A) when reporting D2887/IP 406 results.
[E] D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.
[F] Results from Test Method D7345 shall be the bias-corrected.
[G] A higher minimum flash point specification may be agreed upon between purchaser and supplier.
[H] Results obtained by other test methods 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.
[I] Other freezing points may be agreed upon between supplier and purchaser.
[J] 1 mm^2/s = 1 cSt.
[K] Test Method D7042 results shall be converted to bias-corrected kinematic viscosity results by the application of the correction described in Test Method D7042, section 15.4.4.
[L] For all grades use either Eq 1 or Table 1 in Test Method D4529 or Eq 2 in Test Method D3338 or IP 12. Test Method D4809 may be used as an alternative. In case of dispute, Test Method D4809 shall be used.
[M] D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes (test coupons) meet the requirements of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM). A test protocol to demonstrate equivalence of heater tubes from other suppliers is on file at ASTM International Headquarters and can be obtained by requesting Research Report RR:D02-1550. Heater tubes and filter kits, manufactured by the OEM (PAC, 8824 Fallbrook Drive, Houston, TX 77064) were used in the development of the D3241/IP 323 test method. Heater tube and filter kits, manufactured by Falex (Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585) were demonstrated to give equivalent results (see D3241 for research report references). These historical facts should not be construed as an endorsement or certification by ASTM International.
[N] Tube deposit ratings shall be measured by D3241 Annex A2 ITR or Annex A3 ETR, when available. If the Annex A2 ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.
[O] At point of manufacture.
[P] 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 pS/m to 600 pS/m under the conditions at point of delivery. (1 pS/m = 1×10^{-12} $\Omega^{-1}m^{-1}$)
[Q] 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.
[R] 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.
[S] 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.
[T] The fluidity requirement applies only to jet fuel containing synthesized iso-paraffins specified in Annex A3 and blended in accordance with 6.1.3. It does not apply to jet fuel containing Annex A1, Annex A2, or Annex A4 synthesized components blended in accordance with 6.1.1, 6.1.2, or 6.1.4.
[U] D445 or IP 71, Section 1 allows measuring the viscosity at –40 °C, however the precision values were determined down to –20 °C. Data correlating test results at –40 °C for D445 and other related ASTM test methods is provided in Research Report RR:D02-1776, Evaluation of Synthesized Iso-Paraffins produced from Hydroprocessed Fermented Sugars (SIP Fuels), prepared by TOTAL New Energies, Amyris, Inc. and the United States Air Force Research Laboratory (AFRL), Final Version, February 2014. A revision to Test Method D445 to specify measurement precision at –40 °C is in process.

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.

7.4 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1, Tables A1.1 and A1.2, Tables A2.1 and A2.2, Tables A3.1 and A3.2, and Tables A4.1 and A4.2. 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, Tables A1.1 and A1.2, Tables A2.1 and A2.2, Tables A3.1 and A3.2, and Tables A4.1 and A4.2 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 or IP 475 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.

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, F, G, H]	0.07 % by volume min[I]
Diethylene Glycol Monomethyl Ether (see Specification D4171 Type III)	0.15 % by volume max
Fuel Handling and Maintenance Additives	
Electrical Conductivity Improver[J]	
One of the following:	
AvGuard[K] SDA[L]	
On initial blending	3 mg/L max
After field reblending, cumulative concentration	5 mg/L max
Stadis 450[L, M]	
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)[N]	
Biocidal Additives[E,O,P]	
Biobor JF[Q]	
Kathon FP1.5[R]	
Corrosion Inhibitor/Lubricity Improvers[S]	
One of the following:	
HiTEC 580	23 mg/L max
Innospec 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] The quantity shall be declared by the fuel supplier and agreed to by the purchaser.
[F] DiEGME content can by analyzed by Test Method D5006.
[G] DiEGME is not suitable for use in systems that will later use EI 1583 filter monitors, which are commonly used at the point of aircraft fueling. Additional guidance is provided in EI 1550 Chapter 9.
[H] Some aircraft require higher levels than 0.07 % by volume.
[I] The lower FSII concentration limit allowable in Jet Fuel is based on research by the US Air Force as documented in report AFRL-RQ-WP-TR-2013-0271. Some engines and aircraft as certificated require higher minimum concentrations of icing inhibitor than the lower limit in this Jet Fuel specification. When fueling an aircraft, the fuel should be additized to the concentration levels specified in the appropriate engine and aircraft manual.
[J] 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 pS/m to 600 pS/m under the conditions at point of delivery. (1 pS/m = 1×10^{-12} $\Omega^{-1}m^{-1}$)
[K] AvGuard is a trademark of Afton Chemical Corporation, 500 Spring Street Richmond, VA 23219. Supporting documentation for this additive is found in RR:D02-1861.
[L] Electrical conductivity improver content can be analyzed by Test Method D7524.
[M] Stadis 450 is a registered trademark marketed by Innospec Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EY, UK.
[N] Tracer A (LDTA-A) is a registered trademark of Tracer Research Corp., 3755 N. Business Center Dr., Tucson, AZ 85705.
[O] 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.
[P] Refer to the Aircraft Maintenance Manual (AMM) to determine if either biocide is approved for use and for their appropriate use and dosage.
[Q] Biobor JF is a registered trademark of Hammonds Technical Services, Inc., 910 Rankin Rd., Houston, TX 77073.
[R] KATHON is a trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow, 2030 Dow Center, Midland, MI 48674. HiTEC 580 is a trademark of Afton Chemical Corp., 500 Spring St., Richmond, VA 23219. Innospec DCI-4A is available from Innospec Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EY, UK.
[S] More information concerning minimum treat rates of corrosion inhibitor/lubricity improver additives is contained in X1.10.2.

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

NOTE 4—Where IP test methods are referenced in this standard as alternatives to ASTM test methods, the following nomenclature is used. Where test methods are officially jointed, this is denoted as Dxxxx/IP xxx. Where test methods are technically equivalent or related but not officially jointed, this is denoted as Dxxxx or IP xxx.

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

11.1.1 *Density*—Test Method D1298/IP 160 or D4052 or IP 365.

11.1.2 *Distillation*—Test Method D86 or IP 123. For Jet A and Jet A-1, Test Method D2887/IP 406, and Test Method D7345 may be used as alternatives. Results from Test Method D2887/IP 406 shall be reported as estimated D86 or IP 123 results by application of the correlation in Appendix X5 of D2887 or Annex G of IP 406. Results from Test Method D7345 shall be corrected for bias by applying the GRP4 corrections in the D7345 Precision and Bias section. 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, D3828, IP 170 or IP 523.

11.1.4 *Freezing Point*—Test Method D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16. Any of these test methods may be used to certify and recertify jet fuel. However, Test Method D2386/IP 16 is the referee method. An interlaboratory study (RR:D02-1572[16]) that evaluated the ability of freezing point methods to detect jet fuel contamination by diesel fuel determined that Test Methods D5972/IP 435 and D7153/IP 529 provided significantly more consistent detection of freeze point changes caused by contamination than Test Methods D2386/IP 16 and D7154/IP 528. It is recommended to certify and recertify jet fuel using either Test Method D5972/IP 435 or Test Method D7153/IP 529, or both, on the basis of the reproducibility and cross-contamination detection reported in RR:D02-1572.[16] 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/IP 16) are within the specification limit.

11.1.5 *Viscosity*—Test Method D445/IP 71, Section 1 or Test Method D7042. Results from Test Method D7042 shall be reported as bias-corrected kinematic viscosity results by application of the correction in Test Method D7042, subsection 15.4.4, Relative Bias for jet fuel. In case of dispute, Test Method D445 shall be the referee method.

11.1.6 *Net Heat of Combustion*—Test Method D4529, D3338, D4809, or IP 12.

11.1.7 *Corrosion (Copper Strip)*—Test Method D130/IP 154.

11.1.8 *Total Acidity*—Test Method D3242/IP 354.

11.1.9 *Sulfur*—Test Method D1266, D2622, D4294, D5453, or IP 336.

11.1.10 *Mercaptan Sulfur*—Test Method D3227/IP 342.

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/IP 323.

11.1.14 *Aromatics*—Test Method D1319, IP 156 or D6379/IP 436. Test Method D1319 shall be the referee test method.

11.1.15 *Smoke Point*—Test Method D1322/IP 598.

11.1.16 *Naphthalene Content*—Test Method D1840.

11.1.17 *Electrical Conductivity*—Test Method D2624 / IP 274.

12. Keywords

12.1 alcohol-to-jet synthetic paraffinic kerosene; aviation turbine fuel; avtur; Jet A; Jet A-1; jet fuel; synthesized aromatics; synthesized hydrocarbons; synthesized iso-paraffins; synthesized paraffinic kerosine; synthesized paraffinic kerosine plus aromatics; synthetic blending component; turbine fuel

[16] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1572. Contact ASTM Customer Service at service@astm.org.

ANNEXES

(Mandatory Information)

A1. FISCHER-TROPSCH HYDROPROCESSED SYNTHESIZED PARAFFINIC KEROSINE

A1.1 Scope

A1.1.1 This annex defines hydroprocessed synthesized paraffinic kerosine (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 *Fischer-Tropsch hydroprocessed synthesized paraffinic kerosine (FT-SPK), n*—SPK produced from one or more precursors synthesized by Fischer-Tropsch processing.

A1.4 Materials and Manufacture

A1.4.1 FT-SPK synthetic blending components shall be comprised of hydroprocessed synthesized paraffinic kerosine wholly derived from:

A1.4.1.1 Paraffins and olefins derived from synthesis gas via the Fischer-Tropsch (FT) process using Iron or Cobalt catalyst.

A1.4.1.2 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.[17]

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 test methods.

A1.5.2.1 *Density*—Test Method D1298/IP 160, D4052 or IP 365.

A1.5.2.2 *Distillation*—Test Methods D86/IP 123, or D2887/IP 406 or Test Method D7345.

A1.5.2.3 *Flash Point*—Test Method D56, D3828, IP 170 or IP 523.

A1.5.2.4 *Freezing Point*—Test Method D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16. Any of these test methods may be used to certify and recertify jet fuel. However, Test Method D2386/IP 16 is the referee method. An interlaboratory study (RR:D02-1572[16]) that evaluated the ability of freezing point methods to detect jet fuel contamination by diesel fuel determined that Test Methods D5972/IP 435 and D7153/IP 529 provided significantly more consistent detection of freeze point changes caused by contamination than Test Methods D2386/IP 16 and D7154/IP 528. It is recommended to certify and recertify jet fuel using either Test Method D5972/IP 435 or Test Method D7153/IP 529, or both, on the basis of the reproducibility and cross-contamination detection reported in RR:D02-1572.[16] 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/IP 16) are within the specification limit.

A1.5.2.5 *Total Acidity*—Test Method D3242/IP 354.

A1.5.2.6 *Thermal Stability*—Test Method D3241/IP 323.

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 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/IP 379.

A1.6.2.6 *Water*—Test Method D6304 or IP 438.

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 D7111 or UOP 389.

A1.6.2.9 *Halogens*—Test Method D7359.

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

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

Property		FT–SPK	Test Method[B]
COMPOSITION			
Acidity, total mg KOH/g	Max	0.015	D3242/IP 354
VOLATILITY			
Distillation—both of the following requirements shall be met:			
1. Physical Distillation			D86[C] or IP 123[C] or D7345
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	
Distillation residue, percent	Max	1.5	
Distillation loss, percent	Max	1.5	
2. Simulated Distillation			D2887/IP 406
Distillation temperature, °C:			
10 % recovered, temperature (T10)		report	
50 % recovered, temperature (T50)		report	
90 % recovered, temperature (T90)		report	
Final boiling point, temperature		report	
Flash point, °C	Min	38[D]	D56, D3828[E] , IP 170[E] or IP 523[E]
Density at 15 °C, kg/m^3		730 to 770	D1298 / IP 160, D4052 or IP 365
Freezing point, °C	Max	–40	D5972 / IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16
Thermal Stability (2.5 h at control temperature)			
Temperature, °C	Min	325[F]	D3241[G] /IP 323[G]
Filter pressure drop, mm Hg	Max	25	
Tube rating: One of the following requirements shall be met:[H]			
(1) Annex A1 VTR, VTR Color Code	Less than	3 No peacock or abnormal color deposits	
(2) Annex A2 ITR or Annex A3 ETR, nm avg over area of 2.5 mm^2	Max	85	
ADDITIVES			
Antioxidants, mg/L[I]	Min	17	
	Max	24	

[A] For compliance of test results against the requirements of Table A1.1, see 7.4.
[B] The test methods indicated in this table are referred to in A1.5.2.
[C] D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.
[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 kerosine, but may be used as an Annex A1 blending component.
[E] Results obtained by other test methods 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.
[F] Control temperature of 325 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.
[G] D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes (test coupons) meet the requirements of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM). A test protocol to demonstrate equivalence of heater tubes from other suppliers is on file at ASTM International Headquarters and can be obtained by requesting Research Report RR:D02-1550. Heater tubes and filter kits, manufactured by the OEM (PAC, 8824 Fallbrook Drive, Houston, TX 77064) were used in the development of the D3241/IP 323 test method. Heater tube and filter kits, manufactured by Falex (Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585) were demonstrated to give equivalent results (see D3241 for research report references). These historical facts should not be construed as an endorsement or certification by ASTM International.
[H] Tube deposit ratings shall be measured by D3241 Annex A2 ITR or Annex A3 ETR, when available. If the Annex A2 ITR device reports “N/A” for a tube’s volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.
[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; Fischer-Tropsch Hydroprocessed SPK[A]

Property		FT–SPK	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/IP 379
Water, mg/kg	Max	75	D6304 or IP 438
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	D7111 or UOP 389
Halogens, mg/kg	Max	1	D7359

[A] For compliance of test results against the requirements of Table A1.2, see 7.4.
[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.

A2. SYNTHESIZED PARAFFINIC KEROSINE FROM HYDROPROCESSED ESTERS AND FATTY ACIDS

A2.1 Scope

A2.1.1 This annex defines synthesized paraffinic kerosine produced from hydroprocessed esters and fatty acids for use as a synthetic blending component in aviation turbine fuels for use in civil aircraft and engines. The specifications in this annex may be used for contractual exchange of synthetic blending components.

A2.1.2 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 6.1.2.

A2.1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

A2.2 General

A2.2.1 All requirements of the main body of this specification apply except as detailed in this annex.

A2.3 Terminology

A2.3.1 *Definitions of Terms Specific to This Annex:*

A2.3.1.1 *hydroprocessed esters and fatty acids (HEFAs), n*—Mono-, di-, and triglycerides, free fatty acids and fatty acid esters (for example, fatty acid methyl esters) that have been hydroprocessed to remove essentially all oxygen.

A2.4 Materials and Manufacture

A2.4.1 Synthetic blend components shall be comprised of hydroprocessed synthesized paraffinic kerosine wholly derived from:

A2.4.1.1 Paraffins derived from hydrogenation and deoxygenation of fatty acid esters and free fatty acids.

A2.4.1.2 Subsequent processing of the product shall include hydrocracking, or hydroisomerization, or isomerization, or fractionation, or a combination thereof, and may include other conventional refinery processes.[18]

A2.5 Detailed Batch Requirements

A2.5.1 Each batch of HEFA SPK blending component shall conform to the requirements prescribed in Table A2.1.

A2.5.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following test methods.

A2.5.2.1 *Density*—Test Method D1298/IP 160 or D4052 or IP 365.

A2.5.2.2 *Distillation*—Test Methods D86/IP 123, or D2887/IP 406, or Test Method D7345.

A2.5.2.3 *Existent Gum*—Test Method D381 or IP 540. Test Method D381, using steam jet operating conditions, shall be the referee test method.

A2.5.2.4 *Fatty Acid Methyl Ester (FAME)*—Test Method IP 585, IP 590.

A2.5.2.5 *Flash Point*—Test Method D56, D3828, IP 170 or IP 523.

A2.5.2.6 *Freezing Point*—Test Methods D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16. Any of these test methods may be used to certify and recertify jet fuel. However, Test Method D2386/IP 16 is the referee method. An interlaboratory study (RR:D02-1572[16]) that evaluated the ability of freezing point methods to detect jet fuel contamination by diesel fuel determined that Test Methods D5972/IP 435 and

[18] Supporting data, "Evaluation of Bio-Derived Synthetic Paraffinic Kerosines (Bio-SPKs)," prepared by The Boeing Company/UOP/United States Air Force Research Laboratory (AFRL), Version 5.0, May 2010, have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1739. This report provides a more detailed description of the composition and performance of hydroprocessed ester and fatty acid SPK blending components that evolved from the evaluation of representative samples of these blending components.

TABLE A2.1 Detailed Batch Requirements; SPK from Hydroprocessed Esters and Fatty Acids[A]

Property		HEFA–SPK	Test Method[B]
COMPOSITION			
Acidity, total mg KOH/g	Max	0.015	D3242/IP 354
VOLATILITY			
Distillation—both of the following requirements shall be met:			
1. Physical Distillation			D86[C] or IP 123[C] or D7345
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	
Distillation residue, percent	Max	1.5	
Distillation loss, percent	Max	1.5	
2. Simulated Distillation			D2887
Distillation temperature, °C:			
10 % recovered, temperature (T10)		report	
50 % recovered, temperature (T50)		report	
90 % recovered, temperature (T90)		report	
Final boiling point, temperature		report	
Flash point, °C	Min	38[D]	D56, D3828[E], IP 170[E] or IP 523[E]
Density at 15 °C, kg/m^3		730 to 770	D1298/IP 160, D4052 or IP 365
Freezing point, °C	Max	–40	D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16
Existent gum, mg/100 mL	Max	7	D381, IP 540
FAME, ppm	Max	<5	IP 585 or IP 590
Thermal Stability (2.5 h at control temperature)			
Temperature, °C	Min	325[F]	D3241[G] /IP 323[G]
Filter pressure drop, mm Hg	Max	25	
Tube rating: One of the following requirements shall be met:[H]			
(1) Annex A1 VTR,	Less than	3	
VTR Color Code		No peacock or abnormal color deposits	
(2) Annex A2 ITR or Annex A3 ETR, nm avg over area of 2.5 mm^2	Max	85	
ADDITIVES			
Antioxidants, mg/L[I]	Min	17	
	Max	24	

[A] For compliance of test results against the requirements of Table A2.1, see 7.4.
[B] The test methods indicated in this table are referred to in A2.5.2.
[C] D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.
[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 kerosine, but may be used as an Annex A2 blending component.
[E] Results obtained by other test methods 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.
[F] Control temperature of 325 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.
[G] D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes (test coupons) meet the requirements of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM). A test protocol to demonstrate equivalence of heater tubes from other suppliers is on file at ASTM International Headquarters and can be obtained by requesting Research Report RR:D02-1550. Heater tubes and filter kits, manufactured by the OEM (PAC, 8824 Fallbrook Drive, Houston, TX 77064) were used in the development of the D3241/IP 323 test method. Heater tube and filter kits, manufactured by Falex (Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585) were demonstrated to give equivalent results (see D3241 for research report references). These historical facts should not be construed as an endorsement or certification by ASTM International.
[H] Tube deposit ratings shall be measured by D3241 Annex A2 ITR or Annex A3 ETR, when available. If the Annex A2 ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.
[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.

D7153/IP 529 provided significantly more consistent detection of freeze point changes caused by contamination than Test Methods D2386/IP 16 and D7154/IP 528. It is recommended to certify and recertify jet fuel using either Test Method D5972/IP 435 or Test Method D7153/IP 529, or both, on the basis of the reproducibility and cross-contamination detection reported in RR:D02-1572.[16] 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/IP 16) are within the specification limit.

A2.5.2.7 *Total Acidity*—Test Method D3242.

A2.5.2.8 *Thermal Stability*—Test Method D3241.

A2.6 Other Detailed Requirements

A2.6.1 Each batch of HEFA SPK blend component shall meet the requirements of Table A2.2. These requirements are intended to verify the control of processes during the initial production scale-up of these synthetic blend components. It is the ultimate objective of this committee to transition these batch requirements to a management of change requirement once sufficient production experience is gained. Table A2.2 requirements will then be required only when new production facilities or schemes are established, or when significant changes to existing production operations are implemented, such as the introduction of a new feedstock material.

A2.6.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following test methods.

A2.6.2.1 *Cycloparaffins*—Test Method D2425.

A2.6.2.2 *Aromatics*—Test Method D2425.

A2.6.2.3 *Paraffins*—Test Method D2425.

A2.6.2.4 *Carbon and Hydrogen*—Test Method D5291.

A2.6.2.5 *Nitrogen*—Test Method D4629/IP 379.

A2.6.2.6 *Water*—Test Method D6304 or IP 438.

A2.6.2.7 *Sulfur*—Test Methods D5453 or D2622. Test Method D5453 shall be the referee method.

A2.6.2.8 *Metals*—Test Method D7111 or UOP 389.

A2.6.2.9 *Halogens*—Test Method D7359.

TABLE A2.2 Other Detailed Requirements; SPK from Hydroprocessed Esters and Fatty Acids[A]

Property		HEFA–SPK	Test Method[B]
Hydrocarbon Composition			
Cycloparaffins, mass percent	Max	15[C]	D2425
Aromatics, mass percent	Max	0.5	D2425
Paraffins, mass percent		report	D2425
Carbon and Hydrogen, mass percent	Min	99.5	D5291
Non-hydrocarbon Composition			
Nitrogen, mg/kg	Max	2	D4629/IP 379
Water, mg/kg	Max	75	D6304 or IP 438
Sulfur, mg/kg	Max	15	D5453 or 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	D7111 or UOP 389
Halogens, mg/kg	Max	1	D7359

[A] For compliance of test results against the requirements of Table A2.2, see 7.4.
[B] The test methods indicated in this table are referred to in A2.6.2.
[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.

A3. SYNTHESIZED ISO-PARAFFINS FROM HYDROPROCESSED FERMENTED SUGARS

A3.1 Scope

A3.1.1 This annex defines synthesized iso-paraffins (SIP) produced from hydroprocessed fermented sugars for use as a synthetic blending component in aviation turbine fuels for use in civil aircraft and engines. The specifications in this annex may be used for contractual exchange of synthetic blending components.

A3.1.2 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 6.1.3.

A3.1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

A3.2 General

A3.2.1 All requirements of the main body of this specification apply except as detailed in this annex.

A3.3 Terminology

A3.3.1 *Definitions of Terms Specific to This Annex:*

A3.3.1.1 *farnesane, n*—iso-paraffin with chemical formula: C15H32, chemical name: 2,6,10-trimethyldodecane and CAS Registry Number: 3891-98-3.

A3.3.1.2 *farnesene, n*—branched alkene with chemical formula: C15H24 consisting of isomers and containing at least (6E)-7,11-dimethyl-3-methylene-1,6,10-dodecatriene (CAS Registry Number: 18794-84-8) or (E,E)-3,7,11-trimethyl-1,3,6,10-dodecatetraene (CAS Registry Number: 502-61-4).

A3.3.1.3 *hexahydrofarnesol, n*—alkyl alcohol with chemical formula: C15H32O, chemical name: 3,7,11-trimethyl-1-dodecanol and CAS Registry Number: 6750-34-1.

A3.3.1.4 *synthesized iso-paraffins from hydroprocessed fermented sugars, n*—farnesane that is produced by hydroprocessing and fractionation of farnesene derived from fermentation of sugars.

A3.4 Materials and Manufacture

A3.4.1 Synthetic blend components shall be comprised of hydroprocessed synthesized iso-paraffins wholly derived from farnesene produced from fermentable sugars. Subsequent processing of farnesene into iso-paraffins shall include a combination of hydroprocessing and fractionation operations, and may include other conventional refinery processes. In particular, hydroprocessing operations consist of reacting hydrogen with farnesene feedstock and fractionation operations consist of gas/liquid separation and isolation of synthesized iso-paraffins. For example, fractionation typically includes a distillation step.[19]

A3.5 Detailed Batch Requirements

A3.5.1 Each batch of SIP blending component shall conform to the requirements prescribed in Table A3.1.

A3.5.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following test methods:

A3.5.2.1 *Density*—Test Methods D1298/IP 160, D4052 or IP 365.

[19] Supporting data, Evaluation of Synthesized Iso-Paraffins produced from Hydroprocessed Fermented Sugars (SIP Fuels), prepared by TOTAL New Energies, Amyris, Inc. and the United States Air Force Research Laboratory (AFRL), Final Version, February 2014, have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1776. This report provides a more detailed description of the composition and performance of synthesized iso-paraffin blending components that evolved from the evaluation of representative samples of these blending components.

TABLE A3.1 Detailed Batch Requirements; SIP from Hydroprocessed Fermented Sugars[A]

Property		SIP	Test Method[B]
COMPOSITION			
Acidity Total mg KOH/g	Max	0.015	D3242/IP 354
VOLATILITY			
Physical Distillation			D86[C] or IP 123[C]
Distillation temperature, °C:			
10 % recovered, temperature (T10)	Max	250	
50 % recovered, temperature (T50)		Report	
90 % recovered, temperature (T90)		Report	
Final boiling point, temperature	Max	255	
T90-T10, °C	Max	5	
Distillation residue, percent	Max	1.5	
Distillation loss, percent	Max	1.5	
Flash point, °C	Min	100	D93/IP 34, D3828, or IP 523
Density at 15 °C, kg/m3		765–780	D1298/IP 160, D4052 or IP 365
FLUIDITY			
Freezing point, °C	Max	–60	D2386/IP 16, D5972/IP 435, D7153/IP 529 or D7154/IP 528
CONTAMINANTS			
Existent gum, mg/100 mL	Max	7	D381 or IP 540
Microseparometer, Rating			D3948
Without electrical conductivity additive	Min	85	
THERMAL STABILITY (2.5 h at control temperature)			
Temperature, °C	Min	355[D]	D3241[E] /IP 323[E]
Filter pressure drop, mm Hg	Max	25	
Tube rating: One of the following requirements shall be met:[F]			
(1) Annex A1 VTR, VTR Color Code	Less than	3 No peacock or abnormal color deposits	
(2) Annex A2 ITR or Annex A3 ETR, nm avg over area of 2.5 mm^2	Max	85	
COMBUSTION			
Net Heat of Combustion, MJ/kg	Min	43.5	D3338 or D4809[G]
ADDITIVES			
Antioxidants, mg/LH[H]	Min	17	
	Max	24	

[A] For compliance of test results against the requirements of Table A3.1, see 7.4.
[B] The test methods indicated in this table are referred to in A3.5.2.
[C] D86 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.
[D] Control temperature of 355 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.
[E] D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes (test coupons) meet the requirements of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM). A test protocol to demonstrate equivalence of heater tubes from other suppliers is on file at ASTM International Headquarters and can be obtained by requesting Research Report RR:D02-1550. Heater tubes and filter kits, manufactured by the OEM (PAC, 8824 Fallbrook Drive, Houston, TX 77064) were used in the development of the D3241/IP 323 test method. Heater tube and filter kits, manufactured by Falex (Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585) were demonstrated to give equivalent results (see D3241 for research report references). These historical facts should not be construed as an endorsement or certification by ASTM International.
[F] Tube deposit ratings shall be measured by D3241 Annex A2 ITR or Annex A3 ETR, when available. If the Annex A2 ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.
[G] In case of dispute, Test Method D4809 will apply.
[H] 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 and fractionation to prevent peroxidation and gum formation after manufacture. In-line injection and tank blenders are considered acceptable methods for ensuring adequate mixing.

A3.5.2.2 *Distillation*—Test Method D86 or IP 123.

A3.5.2.3 *Existent Gum*—Test Methods D381 or IP 540. Test Method D381, using steam jet operating conditions, shall be the referee test method.

A3.5.2.4 *Flash Point*—Test Methods D93/IP 34, D3828 or IP 523.

A3.5.2.5 *Freezing Point*—Test Methods D2386/IP 16, D5972/IP 435, D7153/IP 529, or D7154/IP 528. Test Methods D7153 and D7154 are the referee methods to certify and recertify jet fuel because these methods allow to measure freezing point down to –100 °C.

A3.5.2.6 *Microseparameter Number*—Test Method D3948.

A3.5.2.7 *Net Heat of Combustion*—Test Methods D3338 or D4809.

A3.5.2.8 *Total Acidity*—Test Method D3242/IP 354.

A3.5.2.9 *Thermal Stability*—Test Method D3241/IP 323.

A3.6 Other Detailed Requirements

A3.6.1 Each batch of SIP blend component shall meet the requirements of Table A3.2. These requirements are intended to verify the control of processes during the initial production scale-up of these synthetic blend components. It is the ultimate objective of this committee to transition these batch requirements to a management of change requirement once sufficient

TABLE A3.2 Other Detailed Requirements; SIP from Hydroprocessed Fermented Sugars[A]

Property		SIP	Method[B]
Hydrocarbon Composition			
Saturated Hydrocarbons, mass percent	Min	98	D7974
Farnesane[C], mass percent	Min	97	D7974
Hexahydrofarnesol[D], mass percent	Max	1.5[E]	D7974
Olefins, mgBr_2/100 g	Max	300	D2710/IP 299
Aromatics, mass percent	Max	0.5	D2425
Carbon and Hydrogen, mass percent	Min	99.5	D5291
Non-hydrocarbon Composition			
Nitrogen, mg/kg	Max	2	D4629/IP 379
Water, mg/kg	Max	75	D6304 or IP 438
Sulfur, mg/kg	Max	2	D5453 or D2622[F]
Metals (ppm) (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	D7111 or UOP 389
Halogens, mg/kg	Max	1 per halogen	D7359

[A] For compliance of test results against the requirements of Table A3.1, see 7.4.
[B] The test methods indicated in this table are referred to in A3.6.2.
[C] Farnesane is an iso-paraffin with chemical formula: C15H32, chemical name: 2,6,10-trimethyldodecane and CAS Registry Number: 3891-98-3.
[D] Hexahydrofarnesol is an alkyl alcohol with chemical formula: C15H32O, chemical name: 3,7,11-trimethyl-1-dodecanol and CAS Registry Number: 6750-34-1.
[E] The maximum level of hexahydrofarnesol is controlled by a mass percent of hexahydrofarnesol below 1.5 %, which represents a maximum of 0.11 percent by mass of remaining alcohol moieties brought by hexahydrofarnesol in the grade.
[F] Sulfur content can be quantified by Test Method D2622 by certain laboratories with a lower detection limit of 1 mg/kg. In case of dispute, Test Method D5453 will apply.

production experience is gained. Table A3.2 requirements will then be required only when new production facilities or schemes are established, or when significant changes to existing production operations are implemented, such as the introduction of a new feedstock material.

A3.6.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following test methods:

A3.6.2.1 *Saturated Hydrocarbons*—Test Method D7974.

A3.6.2.2 *Farnesane*—Test Method D7974.

A3.6.2.3 *Hexahydrofarnesol*—Test Method D7974.

A3.6.2.4 *Olefins*—Test Method D2710/IP 299.

A3.6.2.5 *Aromatics*—Test Method D2425.

A3.6.2.6 *Carbon and Hydrogen*—Test Method D5291

A3.6.2.7 *Nitrogen*—Test Methods D4629/IP 379.

A3.6.2.8 *Water*—Test Method D6304 or IP 438.

A3.6.2.9 *Sulfur*—Test Methods D5453 or D2622. Test Method D5453 shall be the referee method.

A3.6.2.10 *Metals*—Test Method D7111 or UOP 389.

A3.6.2.11 *Halogens*—Test Method D7359.

A4. SYNTHESIZED KEROSINE WITH AROMATICS DERIVED BY ALKYLATION OF LIGHT AROMATICS FROM NON-PETROLEUM SOURCES

A4.1 Scope

A4.1.1 This annex defines FT Synthesized Paraffinic Kerosine plus Aromatics (SPK/A) 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. The difference between this annex and Annex A1 is that Annex A1 is restricted to materials derived from FT processing having low aromatics content, whereas this annex describes streams where the aromatics content is intentionally increased by alkylation of non-petroleum derived light aromatics (primarily benzene) with Fischer-Tropsch-derived olefins.

A4.1.2 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.

A4.1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

A4.2 General

A4.2.1 All requirements of the main body of this specification apply except as detailed in this annex.

A4.3 Terminology

A4.3.1 *Definitions of Terms Specific to This Annex:*

A4.3.1.1 *Fischer-Tropsch hydroprocessed synthesized paraffinic kerosine plus aromatics (FT-SPK/A), n*—Fischer-Tropsch Synthesized Paraffinic Kerosine plus aromatics, produced by alkylation of nonpetroleum derived light aromatics (primarily benzene).

A4.4 Materials and Manufacture

A4.4.1 SPK/A synthetic blending component shall be comprised of FT SPK as defined in Annex A1 combined with synthesized aromatics from the alkylation of non-petroleum derived light aromatics (primarily benzene). Subsequent processing of the product shall include hydroprocessing, fractionation, and other conventional refinery processes.[20]

A4.5 Detailed Batch Requirements

A4.5.1 Each batch of synthetic blending component shall conform to the requirements prescribed in Table A4.1.

A4.5.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following test methods.

A4.5.2.1 *Density*—Test Method D1298/IP 160, D4052, or IP 365.

A4.5.2.2 *Distillation*—Test Methods D86 or IP 123, and D2887/IP 406.

A4.5.2.3 *Flash Point*—Test Method D56, D3828, IP 170, or IP 523.

A4.5.2.4 *Freezing Point*—Test Method D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16. Any of these test methods may be used to certify and recertify jet fuel. However, Test Method D2386/IP 16 is the referee method. An interlaboratory study (RR:D02-1572[16]) that evaluated the ability of freezing point methods to detect jet fuel contamination by diesel fuel determined that Test Methods D5972/IP 435 and D7153/IP 529 provided significantly more consistent detection of freeze point changes caused by contamination than Test Methods D2386/IP 16 and D7154/IP 528. It is recommended to certify and recertify jet fuel using either Test Method D5972/IP 435 or Test Method D7153/IP 529, or both, on the basis of the reproducibility and cross- contamination detection reported in RR:D02-1572[16]. 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/IP 16) are within the specification limit.

A4.5.2.5 *Total Acidity*—Test Method D3242/IP 354.

A4.5.2.6 *Thermal Stability*—Test Method D3241/IP 323.

A4.5.2.7 *Existent Gum*—Test Method D381.

A4.5.2.8 *MSEP*—Test Method D3948.

A4.5.2.9 *Aromatics*—Test Methods D1319/IP 156 or D6379/IP 436. Test Method D1319 shall be the referee test method.

A4.6 Other Detailed Requirements

A4.6.1 Each batch of FT SPK/A blend component shall meet the requirements of Table A4.2. These requirements are intended to verify the control of processes during the initial production scale-up of these synthetic blend components. It is the ultimate objective of this committee to transition these batch requirements to a management of change requirement once sufficient production experience is gained. Table A4.2 requirements will then be required only when new production facilities or schemes are established, or when significant changes to existing production operations are implemented.

A4.6.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following test methods.

A4.6.2.1 *Cycloparaffins*—Test Method D2425.

A4.6.2.2 *Aromatics*—Test Method D2425.

A4.6.2.3 *Paraffins*—Test Method D2425.

A4.6.2.4 *Carbon and Hydrogen*—Test Method D5291.

A4.6.2.5 *Nitrogen*—Test Method D4629/IP 379.

A4.6.2.6 *Water*—Test Method D6304 or IP 438.

A4.6.2.7 *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.

A4.6.2.8 *Metals*—Test Method UOP 389 or D7111.

A4.6.2.9 *Halogens*—Test Method D7359.

[20] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1810. Contact ASTM Customer Service at service@astm.org.

TABLE A4.1 Detailed Batch Requirements; SPK/A[A]

Property		SPK/A	Test Method[B]
COMPOSITION			
Acidity, total mg KOH/g	Max	0.015	D3242/IP 354
1. Aromatics, vol %	Max	20	D1319/IP 156
2. Aromatics, vol %	Max	21.2	D6379/IP 436
VOLATILITY			
Distillation—both of the following requirements shall be met:			
1. Physical Distillation			D86[C] or IP 123[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	
Distillation residue, percent	Max	1.5	
Distillation loss, percent	Max	1.5	
2. Simulated Distillation			D2887
Distillation temperature, °C:			
10 % recovered, temperature (T10)		report	
50 % recovered, temperature (T50)		report	
90 % recovered, temperature (T90)		report	
Final boiling point, temperature		report	
Flash point, °C	Min	38[D]	D56, D3828[E] , IP 170[E] or IP 523[E]
Density at 15 °C, kg/m^3		755 to 800	D1298/IP 160, D4052 or IP 365
Freezing point, °C	Max	–40	D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16
Thermal Stability (2.5 h at control temperature)			
Temperature, °C	Min	325[F]	D3241[G] /IP 323[G]
Filter pressure drop, mm Hg	Max	25	
Tube rating: One of the following requirements shall be met:[G]			
(1) Annex A1 VTR, VTR Color Code	Less than	3 No peacock or abnormal color deposits	
(2) Annex A2 ITR or Annex A3 ETR, nm avg over area of 2.5 mm^2	Max	85	
CONTAMINANTS			
Existent gum, mg/100 mL	Max	4	D381/IP 540
MSEP	Min	90	D3948
ADDITIVES			
Antioxidants, mg/L[H]	Min	17	
	Max	24	

[A] For compliance of test results against the requirements of Table A4.1, see 7.4.
[B] The test methods indicated in this table are referred to in A4.5.2.
[C] D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.
[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/A or as kerosine, but may be used as an Annex A4 blending component.
[E] Results obtained by other test methods 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.
[F] Control temperature of 325 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.
[G] Tube deposit ratings shall be measured by D3241 Annex A2 ITR or Annex A3 ETR, when available. If the Annex A2 ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.
[H] 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 A4.2 Other Detailed Requirements; SPK/A[A]

Property		SPK/A	Test Method[B]
Hydrocarbon Composition			
Cycloparaffins, mass percent	Max	15[C]	D2425
Aromatics, mass percent	Max	20	D2425
Paraffins, mass percent		report	D2425
Carbon and Hydrogen, mass %	Min	99.5	D5291
Non-hydrocarbon Composition			
Nitrogen, mg/kg	Max	2	D4629/IP 379
Water, mg/kg	Max	75	D6304 or IP 438
Sulfur, mg/kg	Max	15	D5453, 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	D7111 or UOP 389
Halogens, mg/kg	Max	1	D7359

[A] For compliance of test results against the requirements of Table A4.2, see 7.4.
[B] The test methods indicated in this table are referred to in A4.6.2.
[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.

A5. ALCOHOL-TO-JET SYNTHETIC PARAFFINIC KEROSENE (ATJ-SPK)

A5.1 Scope

A5.1.1 This annex defines alcohol-to-jet synthetic paraffinic kerosene (ATJ-SPK) as a synthetic blending component for 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.

A5.1.2 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 6.1.5.

A5.1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

A5.2 General

A5.2.1 All requirements of the main body of this specification apply except as detailed in this annex.

A5.3 Terminology

A5.3.1 *Definitions of Terms Specific to This Annex:*

A5.3.1.1 *alcohol-to-jet synthetic paraffinic kerosene (ATJ-SPK), n*, an SPK produced starting from alcohol and processed through the following steps: dehydration, oligomerization, hydrogenation, and fractionation.

A5.4 Materials and Manufacture

A5.4.1 ATJ-SPK synthetic blending components shall be comprised of hydroprocessed synthesized paraffinic kerosene wholly derived from isobutanol (see Note A5.1) processed through dehydration, oligomerization, hydrogenation, and fractionation.[21]

NOTE A5.1—It is the ultimate objective of this committee to permit use of all C2 to C5 alcohols for production of ATJ-SPK once sufficient test data is available for these other alcohols.

A5.5 Detailed Batch Requirements

A5.5.1 Each batch of synthetic blending component shall conform to the requirements prescribed in Table A5.1.

A5.5.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following test methods.

A5.5.2.1 *Density*—Test Method D1298/IP 160, D4052 or IP 365.

A5.5.2.2 *Distillation*—Test Methods D86 or IP 123, and D2887/IP 406.

A5.5.2.3 *Flash Point*—Test Method D56, D3828, IP 170, or IP 523.

A5.5.2.4 *Freezing Point*—Test Method D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16. Any of these test methods may be used to certify and recertify jet fuel. However, Test Method D2386/IP 16 is the referee method. An interlaboratory study (RR:D02-1572[16]) that evaluated the ability of freezing point methods to detect jet fuel contamination by diesel fuel determined that Test Methods D5972/IP 435 and D7153/IP 529 provided significantly more consistent detection of freeze point changes caused by contamination than Test Methods D2386/IP 16 and D7154/IP 528. It is recommended to certify and recertify jet fuel using either Test Method D5972/IP 435 or Test Method D7153/IP 529, or both, on the basis of the reproducibility and cross-contamination detection reported in RR:D02-1572.[16] 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/IP 16) are within the specification limit.

A5.5.2.5 *Total Acidity*—Test Method D3242/IP 354.

A5.5.2.6 *Thermal Stability*—Test Method D3241/IP 323.

[21] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1828. Contact ASTM Customer Service at service@astm.org.

TABLE A5.1 Detailed Batch Requirements; Alcohol-to-Jet (ATJ-SPK)[A]

Property		ATJ-SPK	Test Method[B]
COMPOSITION			
Acidity, total KOH, mg/g	Max	0.015	D3242/IP 354
VOLATILITY			
Distillation—both of the following requirements shall be met:			
1. Physical Distillation			D86[C] or IP 123[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	21	
Distillation residue, percent	Max	1.5	
Distillation loss, percent	Max	1.5	
Flash point, °C	Min	38[D]	D56, D3828[E], IP 170[E] or IP 523[E]
Density at 15 °C, kg/m^3		730 to 770	D1298/IP 160, D4052 or IP 365
Freezing point, °C	Max	–40	D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16
Thermal Stability (2.5 h at control temperature)			
Temperature, °C	Min	325[F]	D3241[G] /IP 323[G]
Filter pressure drop, mm Hg	Max	25	
Tube rating: One of the following requirements shall be met:[H]			
(*1*) Annex A1 VTR, VTR Color Code	Less than	3 No peacock or abnormal color deposits	
(*2*) Annex A2 ITR or Annex A3 ETR, nm avg over area of 2.5 mm^2	Max	85	
ADDITIVES			
Antioxidants, mg/L[I]	Min	17	
	Max	24	

[A] For compliance of test results against the requirements of Table A5.1, see 7.4.
[B] The test methods indicated in this table are referred to in A5.5.2.
[C] D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.
[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 A5 blending component.
[E] Results obtained by other test methods 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.
[F] Control temperature of 325 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.
[G] D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes (test coupons) meet the requirements of D3241, Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM). A test protocol to demonstrate equivalence of heater tubes from other suppliers is on file at ASTM International Headquarters and can be obtained by requesting Research Report RR:D02-1550. Heater tubes and filter kits, manufactured by the OEM (PAC, 8824 Fallbrook Drive, Houston, TX 77064) were used in the development of the D3241/IP 323 test method. Heater tube and filter kits, manufactured by Falex (Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585) were demonstrated to give equivalent results (see D3241 for research report references).
These historical facts should not be construed as an endorsement or certification by ASTM International
[H] Tube deposit ratings shall be measured by D3241 Annex A2 ITR or Annex A3 ETR, when available. If the Annex A2 ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.
[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.

A5.6 Other Detailed Requirements

A5.6.1 Each batch of ATJ-SPK blend component shall meet the requirements of Table A5.2. These requirements are intended to verify the control of processes during the initial production scale-up of these synthetic blend components. It is the ultimate objective of this committee to transition these batch requirements to a management of change requirement once sufficient production experience is gained. Table A5.2 requirements will then be required only when new production facilities or schemes are established, or when significant changes to existing production operations are implemented, such as the introduction of a new feedstock material.

A5.6.2 *Test Methods*—Determine the requirements enumerated in this annex in accordance with the following test methods.

A5.6.2.1 *Cycloparaffins*—Test Method D2425.

A5.6.2.2 *Aromatics*—Test Method D2425.

A5.6.2.3 *Paraffins*—Test Method D2425.

A5.6.2.4 *Carbon and Hydrogen*—Test Method D5291.

A5.6.2.5 *Nitrogen*—D4629/IP 379.

A5.6.2.6 *Water*—Test Method D6304 or IP 438.

A5.6.2.7 *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.

A5.6.2.8 *Metals*—Test Method D7111 or UOP 389.

A5.6.2.9 *Halogens*—Test Method D7359.

TABLE A5.2 Other Detailed Requirements; Alcohol-to-Jet (ATJ-SPK)[A]

Property		ATJ-SPK	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/IP 379
Water, mg/kg	Max	75	D6304 or IP 438
Sulfur, mg/kg	Max	15	D5453 or 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	D7111 or UOP 389
Halogens, mg/kg	Max	1	D7359

[A] For compliance of test results against the requirements of Table A5.2, see 7.4.
[B] The test methods indicated in this table are referred to in A5.6.2.
[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.[22] 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[23] and the Handbook of Aviation Fuel Properties.[24]

X1.2 Significance and Use

X1.2.1 Requests to modify D7566 to better support applications of military, governmental, or other specialized agencies are considered when the proposed changes do not conflict with or further burden the primary purpose of supporting civil aviation. Conversely, requests to modify D7566 to better support civil aviation cannot be contingent upon the requirements of military, governmental, or other specialized agencies.

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/IP 323 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.[25]). 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

[22] *Manual on Significance of Tests for Petroleum Products*, MNL 1, ASTM International, 2003.
[23] 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.
[24] *Handbook of Aviation Fuel Properties* , Fourth Edition (2014), CRC Report 663, Coordinating Research Council, Alpharetta, GA, 30022.
[25] 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.[26]

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

[26] 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.

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 or IP 12, 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 or IP 123 is the referee method for measuring distillation properties; Test Method D2887/IP 406 and Test Method D7345 are approved as alternative methods. Results from Test Method D7345 shall be corrected for bias by applying the GRP4 corrections in the D7345 Precision and Bias section. Test Method D86 or IP 123, and Test Method D2887/IP 406 do not give the same numerical results. Test Method D2887/IP 406 always starts at a lower temperature and ends at a higher temperature than Test Method D86 or IP 123 because D2887/IP 406 gives true boiling point distribution (equivalent to D2892), as opposed to D86 or IP 123 which are low efficiency distillation. To avoid confusion, it is required that Test Method D2887/IP 406 results be reported as estimated D86 or IP 123 results by applying the correlation in Appendix X5 of Test Method D2887 or Annex G of IP 406. Caution should be used 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 or IP 123 data should not be used with unconverted Test Method D2887/IP 406 results without validation. Further, Test Method D2887/IP 406 results converted into a form compatible with Test Method D86 or IP 123 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/IP 16, 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 RR:D02-1572,[16] 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
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 pS/m 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/IP 216 and D5452/IP 423 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 or Annex B of IP 216 describes a suitable technique.

X1.12.5 *Microbial Contamination*—Uncontrolled microbial contamination in fuel systems can 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. Microorganisms (that is, bacteria, yeast, and mold) that have become established in a fuel system can present the fuel manufacturer, distributer, or user with a unique set of operational and maintenance challenges. Unlike inanimate material such as dirt, rust, or chemicals, microorganisms are living organisms that are ubiquitous in the environment, can reproduce from a single cell into a great number ($>10^9$) of cells, are transported during fuel movement, need only small amounts of water to remain viable and utilize aviation fuel as a food source. Gross evidence of the presence of microbial contamination can both include suspended matter in the fuel or at the fuel water interface or the smell of "rotten egg," which is due to the presence of hydrogen sulfide a typical metabolite of sulfate reducing bacteria. There are a number of semi-quantitative and quantitative techniques available when gross observation proves inconclusive to rule out the presence of microorganisms. These techniques include nutrient/growth media, bioluminescence and immunoassay. As a result of uncontrolled microbial growth, structural components that make up the aviation fuel storage and distribution network such as product pipeline, tankers, storage tanks and airport fueling hydrant systems can experience accelerated forms of corrosion thereby compromising the integrity and operation of the fuel network as well as acting as a conduit to introduce microorganisms into aircraft fuel systems. Once microorganisms have established a presence in an aircraft fuel system a variety of operational and maintenance issues can occur that could affect the safe and economic operation of the aircraft. For example, uncontrolled microbial contamination can lead to the corrosion of metallic structures such as wing tanks; degradation of protective coatings, alloys, and electrical insulation; erratic readings in the Fuel Quantity Indication System (FQIS); blocking of the scavenge systems; and blocking of engine fuel filters. The two biocide additives that are generally approved for use by the airframe and engine manufacturers are Biobor JF and KATHON FP1.5. These biocide additives may be used in aviation fuel only in accordance with local regulations, aircraft engine guidelines and airframe manufacturer guidelines. The ultimate user shall be informed and agree to the presence of biocide additive in their jet fuel supply. Consult with the appropriate Aircraft Maintenance Manual (AMM) for instructions.

X1.12.5.1 Guide D6469 provides individuals with a limited background in microbiology an understanding of the occurrence, symptoms, and consequences of chronic microbial contamination. This guide also suggests means for detection and remediation of microbial contamination in fuels and fuel systems. IATA Guidance Material on Microbiological Contamination in Aircraft Fuel Tanks also provides guidance for determining the potential source, detection and remediation of the potential microbial contamination.

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 (DiEGME) conforming to the requirements shown in Specification D4171, Type III, may be used in concentrations of 0.07 to 0.15 volume percent. Test Method D5006 can be used to determine the concentration of DiEGME in aviation fuels.

X1.15.2 *Leak Detection Additive*—Addition of leak detection additive, approved in 6.3, should be accomplished in accordance with the Tracer Tight[27] 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.

X1.15.5 *Biobased Carbon Content*—This specification does not generate a renewability rating for any product produced as that is a regulatory matter that considers other factors beyond the technical requirements of this specification. However, knowing fossil versus present day carbon content of a synthesized hydrocarbon is a key factor in determining the renewable content. For regulators attempting to make such an assessment, the following information is provided: Radiocarbon (^{14}C) is an isotope of carbon which allows for determination of renewable content. ^{14}C exists in living cells in constant concentration (equilibrium) as a function of ongoing radioactive decay versus metabolic uptake. Once a source of new ^{14}C is removed from the respiratory process, decay induces disequilibrium whereby the ^{14}C concentration eventually reaches zero. As such, identical hydrocarbons derived from fossil fuels, containing essentially no ^{14}C and present day living sources, containing a standard level of ^{14}C, can be differentiated depending upon whether or not ^{14}C is present. Blends can also be identified to proportion based on ^{14}C concentration. Although FTIR, GS-MS or other analysis may identify the hydrocarbon, radiocarbon analysis differentiates the molecule to source. The applicable method for using radiocarbon to determine the biobased content of a hydrocarbon is Test Methods D6866.

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

X2. OTHER DETAILED REQUIREMENTS FOR SYNTHESIZED BLEND COMPONENTS

X2.1 Specifications for conventional aviation fuel primarily rely on the measurement of performance properties to ensure that the fuel is fit for purpose. Compositional analysis generally has not been required due to years of experience with petroleum feedstocks and conventional processing methods.

X2.2 The fuels described in this specification rely on the use of new feedstocks such as coal, natural gas, and biomass, in combination with processing such as Fischer-Tropsch. Industry experience with these feedstocks and processes is not sufficient to ensure that performance property measurements alone adequately describe fuel that is fit for purpose.

X2.3 Consequently, this specification includes Table A1.2, Table A2.2, Table A3.2, Table A4.2, and Table A5.2 to examine the composition of the synthesized blend component to ensure that trace materials are within the ranges evaluated by the task force when determining the compatibility and fit for purpose of that blend component with commercial aviation engines and airframes.

X2.4 It is recognized that the chemical processing schemes employed to produce FT-SPK generally produce consistent products once steady state is established. Therefore, although analysis to Table A1.2 requirements is required at the initiation of production, it is not required to test every batch of hydroprocessed SPK for compliance with the limits of Table A1.2. Ongoing compliance with Table A1.2 limits may be documented by conducting a statistically-based program of periodic testing.

X2.5 Complete certification to Table A1.2 should be conducted as part of the management of change when there is any significant change to the feedstock or processing scheme. Any Table A1.2 compositional items locally determined to be sensitive to process conditions should be monitored during the recovery from process upsets to ensure compliance with this specification.

X2.6 It is also recognized that sufficient production experience with the HEFA-SPK, SIP, SPK/A, and ATJ-SPK processing schemes is not yet available to employ the management of change approach to compliance with Table A2.2, Table A3.2, Table A4.2, and Table A5.2. Therefore, it is required to test every batch of HEFA-SPK, SIP, SPK/A, and ATJ-SPK for compliance with the limits of Table A2.2, Table A3.2, Table A4.2, and Table A5.2.

X3. PRODUCT INTEGRITY MANAGEMENT

X3.1 Jet fuel can come into contact with incidental materials during manufacture and distribution. In a refinery, processing materials might be carried over in trace quantities into aviation fuels and some have been known to cause operational problems in aircraft fuel systems. In distribution, bulk jet fuel is typically handled in non-dedicated systems, such as multi-product pipelines and marine vessels, where contact with incidental materials is unavoidable.

X3.2 *Production Control*—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, Tables A1.1 and A1.2, Tables A2.1 and A2.2, and Tables A3.1 and A3.2. 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:

X3.2.1 The analytical target may be uncertain, since there is a wide range of (often proprietary) materials involved.

X3.2.2 There is no industry-agreed basis for determining the required analysis sensitivity.

X3.2.3 There usually are no available data, relating to processing additive concentration to aircraft system performance, to set no-harm levels (to define analysis sensitivity).

X3.2.4 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, Tables A1.1 and A1.2, Tables A2.1 and A2.2, and Tables A3.1 and A3.2. 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.

X3.3 *Distribution Control*—Although the application of Specification D1655 extends from jet fuel manufacture to the wing tip, Specification D1655 does not define quality assurance testing and handling procedures appropriate for maintaining the quality of the fuel through the distribution system. Standards for such procedures were originally developed and maintained by fuel suppliers/handlers. Recent initiatives in response to field incidents have resulted in the industry publishing ICAO 9977 to provide guidance for jet fuel handling. ICAO 9977 calls out EI/JIG 1530, JIG 1, JIG 2,

API 1543, API 1595, and other standards for producing, handling, and supplying aviation fuels. Any changes in the fuel handling systems should be subject to a formal risk assessment and management of change to ensure product quality is maintained.

X4. FORM FOR REPORTING INSPECTION DATA ON AVIATION TURBINE FUELS

X4.1 Introduction

X4.1.1 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 entry 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.

X4.1.2 The inspection forms shown in Figs. X4.1-X4.3 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).

X4.1.3 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.

X4.1.4 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.

X4.2 Dimensions of Standard Form

X4.2.1 A standard reporting form for aviation turbine fuels containing synthesized hydrocarbons is shown in Fig. X4.1, a standard batch reporting form for a hydroprocessed synthetic paraffinic kerosine blending component is shown in Fig. X4.2, and a standard reporting form for other requirements for a hydroprocessed SPK blending component is shown in Fig. X4.3.

X4.2.2 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.

X4.3 Description of Standard Form 1 (Fig. X4.1)

X4.3.1 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:

X4.3.1.1 *Manufacturer/Supplier*—Agency or activity who has possession of the fuel to be tested.

X4.3.1.2 *Product Code/Grade*—Accepted code for product being tested.

X4.3.1.3 *Sampling Location*—Place where sample was collected, as specific as possible.

X4.3.1.4 *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.

X4.3.1.5 *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.

X4.3.1.6 *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.

X4.3.1.7 *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.

X4.3.1.8 *Synthetic Content*—List the percentage volume of synthetic blending component contained in the finished fuel.

X4.3.1.9 *Synthetic Type*—List the type of synthetic blending component from those specified in Annex A1, Annex A2, or Annex A3.

X4.4 Description of Standard Form 2 (Fig. X4.2)

X4.4.1 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 X4.3 for Form 1 is provided below:

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, Annex A2, or Annex A3) _____
REMARKS _____

	Method		Result
		APPEARANCE	
010	D156	Color (Saybolt)	xxx
020	D6045	Color (Saybolt)	xxx
030	D4176	Visual (“Pass” or “Fail”)	xxxx
		COMPOSITION	
100C	D3242/IP 354	*Acidity, Total (mg KOH/g)*	*x.xxx*
110	D1319 or IP 156	*Aromatics (vol %)*	*xx.x*
112	D6379/IP 436	*Aromatics (vol %)*	*xx.x*
115	D1319 or IP 156	Olefins (vol %)	x.x
120	D1840	*Napthalene (vol %)*	*x.xx*
130	D3227/IP 342	*Sulfur, Mercaptan (mass %)*	*x.xxx*
140	D4952 or IP 30	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 or IP 336	*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 or IP 123	*Distillation by Auto/Manual (°C)*	*x*
200B	D2887/IP 406	Distillation by GC (°C)	x
200C	D7345	Distillation by Micro Distillation Method	
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/IP 34	Flash Point, PM Closed (°C)	xx.x
220C	D3828 or IP 523	*Flash Point, Setaflash (°C), Meth A*	*xx.x*
220D	D3828 or IP 523	Flash Point, Setaflash (°C), Meth B	xx.x
220E	IP 170	Flash Point Abel (°C)	xx.x
221	D3828 or IP 524	Flash Point, Setaflash (Flash/No Flash)	x
230A	D1298/IP 160	*Density @ 15 °C (kg/m^3)*	*xxx.x*
230B	D4052/IP 365	*Density @ 15 °C (kg/m^3)*	*xxx.x*
231A	D1298/IP 160	API Gravity @ 60 °F	xx.x
240A	D323 or IP 69	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 or IP 394	Vapor Pressure, Mini Method (kPa)	xx.x
		FLUIDITY	
300A	D2386/IP 16	*Freezing Point (°C)*	*-xx. xx*
300B		*Freezing Point (°C)*	*-xx. xx*
300C	D5972/IP 435	*Freezing Point (°C)*	*-xx. xx*
300D		*Freezing Point (°C)*	*-xx. xx*
300F	D7154/IP 528	*Freezing Point (°C)*	*-xx. xx*
310A	D445/IP 71, Section 1	*Viscosity @ –20 °C (mm^2/s)*	*xx.xxx*
311A	D445/IP 71, Section 1	Viscosity at other temps (mm^2/s)	xx.xxx
310B	D7042	Viscosity @ –20 °C (mm^2/s)	xx.xxx
311B	D7042	Viscosity at other temps (mm^2/s)	xx.xxx
312	D445/IP 71, Section 1/D7042	Temp (°C) of item 311	xxxx

	Method		Result
		COMBUSTION	
400A	D240 or IP 12	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*
420	D1322/IP 598	*Smoke Point (mm)*	*xx.x*
		CORROSION	
500	D130/IP 154	*Copper Strip*	*xx*
510	IP 227	Silver Strip	x
		STABILITY	
601A	D3241/IP 323	*Filter ΔP (mmHg) @ other temp*	*xx.x*
602A	D3241/IP 323	*Tube Deposit @ other temp*	*xxxx*
603A	D3241/IP 323	*TDR Spun Rating @ other temp*	*xx*
604A		*Temp (°C) of above*	*xxxx*
601B	D3241/IP 323	*ΔP (mmHg) @ 260 °C*	*xx.x*
602B	D3241/IP 323	*Tube Deposit @ 260 °C*	*xxxx*
603B	D3241/IP 323	*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/IP 216	Particulate (mg/L)	x.xx
720B	D5452/IP 423	Particulate (mg/L)	x.xx
730		Filtration Time (minutes)	xx
740		*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 or IP 156 D6379/ IP 436	*Aromatics (vol %)*	*x.x*
902	D2887 / IP 406	*Distillation, T50-T10, °C*	*xx*
903	D2887/ IP 406	*Distillation, T90-T10, °C*	*xx*
904	D5001	*Lubricity BOCLE WSD (mm)*	*x.xx*
905	D445/IP 71, Section 1	*Viscosity @ –40 °C (mm^2/s)*	*xx.xxx*
		OTHER TESTS	
951	D2624/IP 274	*Conductivity (pS/m)*	*xxxx*
952	D2624/IP 274	*Conductivity Test Temperature (°C)*	*xxx*

Comments and/or Additional Tests:

_____
_____
_____

Certified By: _____

FIG. X4.1 Standard Form for Reporting Inspection Data on Aviation Turbine Fuels Containing Synthesized Hydrocarbons

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

MANUFACTURER/SUPPLIER _____
PRODUCT CODE/GRADE _____
SPECIFICATION _____
ANNEX NUMBER_____
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/IP 354	Acidity, Total (mgKOH/g)	x.xxx
		VOLATILITY	
1200A	D2887/IP 406	*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/IP 34	Flash Point, PM Closed (°C)	xx.x
1220C	D3828 or IP 523	*Flash Point, Setaflash (°C), Meth A*	*xx.x*
1220D	D3828 or IP 523	Flash Point, Setaflash (°C), Meth B	xx.x
1220E	IP 170	Flash Point Abel (°C)	xx.x
1221	D3828 or IP 524	Flash Point, Setaflash (Flash/No Flash)	x
1230A	D1298 or IP 160	*Density @ 15 °C (kg/m^3)*	*xxx.x*
1230B	D4052/IP 365	*Density @ 15 °C (kg/m^3)*	*xxx.x*
1231A	D1298	API Gravity @ 60 °F	xx.x

	Method		Result
		FLUIDITY	
1300A	D2386/IP 16	*Freezing Point (°C)*	*-xx.xx*
1300B		*Freezing Point (°C)*	*-xx.xx*
1300C	D5972/IP 435	*Freezing Point (°C)*	*-xx.xx*
1300D	D7153/IP 529	*Freezing Point (°C)*	*-xx.xx*
1300F	D7154/IP 528	*Freezing Point (°C)*	*-xx.xx*
1310A	D445/IP 71, Section 1	*Viscosity @ –20 °C (mm^2/s)*	*xx.xxx*
1311A	D445/IP 71, Section 1	Viscosity at other temps (mm^2/s)	xx.xxx
1310B	D7042	Viscosity @ –20 °C (mm^2/s)	
1311B	D7042	Viscosity at other temps (mm^2/s)	
1312	D445/IP 71, Section 1/D7042	Temp (°C) of item 1311	xxxx
		CONTAMINANTS	
1400	D381/IP 540	*Existent gum (mg/100 mL)*	xxx
1401	D3948	*MSEP (without SDA)*	xxx
		STABILITY	
1601A	D3241/IP 323	*Filter ΔP (mmHg) @ other temp*	*xx.x*
1602A	D3241/IP 323	*Tube Deposit @ other temp*	*xxxx*
1603A	D3241/IP 323	*TDR Spun Rating @ other temp*	*xx*
1604A		*Temp (°C) of above*	*xxxx*
1601B	D3241/IP 323	*ΔP (mmHg) @ 325 °C*	*xx.x*
1602B	D3241/IP 323	*Tube Deposit @ 325 °C*	*xxxx*
1603B	D3241/IP 323	*TDR Spun Rating @ 325 °C*	*xx*
1601C	D3241/IP 323	*ΔP (mmHg) @ 355 °C*	*xx.x*
1602C	D3241/IP 323	*Tube Deposit @ 355 °C*	*xxxx*
1603C	D3241/IP 323	*TDR Spun Rating @ 355 °C*	*xx*
		COMBUSTION	
1700A	D4809	*Net Heat of Combustion (MJ/kg)*	*xx.xxx*
1700B	D3338	*Net Heat of Combustion (MJ/kg)*	*xx.xxx*
		ADDITIVES	
1800		*Antioxidant (mg/L) [BRAND]*	*xx.x*

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

FIG. X4.2 Standard Form for Reporting Batch Inspection Data on a Synthesized Blending Component

X4.4.2 *Feedstock Type*—List the raw material source for the blend component. Examples are coal, natural gas, biomass (specify type).

X4.4.3 *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.

X4.5 Description of Standard Form 3 (Fig. X4.3)

X4.5.1 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 X4.3 for Form 1 or X4.4 for Form 2 is provided below:

X4.5.2 *Process Reference*—List a reference for the process used to produce the synthetic blend component.

X4.6 Instructions Applicable to All Forms

X4.6.1 The body of each form provides for entering test results. There are four columns provided for each test.

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

MANUFACTURER/SUPPLIER _____
PRODUCT CODE/GRADE _____
SPECIFICATION _____
ANNEX NUMBER_____
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*
2140	D7974	*Saturated Hydrocarbons (mass %)*	*xx*
2141	D7974	*Farnesane (mass %)*	*xx*
2142	D7974	*Hexahydrofarnesol (mass %)*	*xx*
2143	D2710/IP 299	*Olefins (mgBr_2/100 g)*	*xxx*
2150	D5291	Carbon and Hydrogen mass %	x.xx
		Non-hydrocarbon Composition	
2160	D4629/IP 379	Nitrogen, mg/kg	xxxx
2170	D6304/IP 438	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. X4.3 Standard Form for Reporting Other Inspection Data on a Synthesized Blending Component

X4.6.1.1 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 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 D3241/IP 323 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.

X4.6.1.2 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.

X4.6.1.3 The third column presents word descriptors for each test.

X4.6.1.4 The fourth column presents diamonds for entering the results of each test with location of the decimal point shown where applicable.

X4.6.2 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.

X4.7 Instructions for Executing Column 4 on All Forms

X4.7.1 *General Instructions:*

X4.7.1.1 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 kerosines. 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.

X4.7.2 *Detailed Instructions:*

X4.7.2.1 *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.

X4.7.2.2 *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.

X4.7.2.3 *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*, *B*, or *C* for item 200 selects which method is used. All of the subsequent measurements are referenced to Test Method D86 or IP 123. When Test Method D2887/IP 406 is used the results shall be reported as estimated D86 or IP 123 results by application of the correlation in Appendix X5 of D2887 or Annex G of IP 406. Select, using an *x* in the appropriate *A*, *B*, or *C* , which test method is used, and whichever items or codes apply to the particular situation or specification being reported.

X4.7.2.4 *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 alternative or concurrent measurement. Items 230B and 1230B report density by using Test Method D4052 or IP 365, which only provides for density as currently written.

X4.7.2.5 *Form 1 Item 310, 311, and 905, Form 2 Item 1310 and 1311, Viscosity*—For aviation turbine fuels, viscosity is measured at –20 °C and at –40 °C for aviation turbine fuels containing the Annex A3 synthesized blending component; therefore, the value for Form 1 item 311 and Form 2 item 1311 will always be –20, and the value for Form 1 item 907 will always be –40. If the test is performed at some other temperature, use item number 311 or 1311 to report this temperature.

X4.7.2.6 *Form 1 Items 601 - 603, Form 2 Items 1601–1603, D3241*—Select the temperature at which the test 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 test 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/IP 323, 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.

X4.7.2.7 *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.

SUMMARY OF CHANGES

Subcommittee D02.J0.06 has identified the location of selected changes to this standard since the last issue (D7566 – 16b) that may impact the use of this standard. (Approved May 1, 2017.)

(1) Added Test Method D7524 to Referenced Documents.
(2) Revised Table 2.
(3) This revision incorporates previously balloted changes to: Referenced Documents; subsections 11.1.2, A1.5.2.2, A2.5.2.2, X1.6.1.1, X4.7.2.3; and Table 1, Table A1.1, Table A2.1, Fig. X4.1.

Subcommittee D02.J0.06 has identified the location of selected changes to this standard since the last issue (D7566 – 16a) that may impact the use of this standard. (Approved July 1, 2016.)

(1) Revised subsections 1.3, 1.4, and X1.2.1.
(2) Added EI 1550 and EI 1583 to Section 2.
(3) Revised Table 2, adding new footnotes G and H.
(4) Added new subsection A4.5.2.9 and revised Table A4.1.

Subcommittee D02.J0.06 has identified the location of selected changes to this standard since the last issue (D7566 – 16) that may impact the use of this standard. (Approved June 1, 2016.)

(1) Added new term, *metrological method*, and its definition as subsection 4.2.6.

Subcommittee D02.J0.06 has identified the location of selected changes to this standard since the last issue (D7566 – 15c) that may impact the use of this standard. (Approved April 1, 2016.)

(1) Added new Annex A5.
(2) Revised subsection 1.2.2 and Section 4.
(3) Added new subsection 6.1.5.

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