Designation: D7719 – 16a

An American National Standard

Standard Specification for High Aromatic Content Unleaded Hydrocarbon Aviation Gasoline[1]

This standard is issued under the fixed designation D7719; 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.

1. Scope*

1.1 This specification covers formulating specifications for purchases of a high aromatic content unleaded hydrocarbon aviation gasoline under contract and is intended solely for use by purchasing agencies.[2]

1.2 This specification defines a specific type of high aromatic content unleaded hydrocarbon aviation gasoline (hereafter also referred to as "D7719 fuel") for use as an aviation spark-ignition fuel. It does not include all fuels satisfactory for reciprocating aviation engines. Certain equipment or conditions of use may permit a wider, or require a narrower, range of characteristics than is shown by this specification.

1.3 The D7719 fuel defined by this specification does not exhibit identical performance to those leaded fuels for which the existing aircraft and ground-based fuel handling equipment have been designed to operate on. Therefore, the suitability of this fuel for use on any specific aircraft, aircraft engine, or ground-based fuel handling equipment should be evaluated before use on that equipment.

1.4 Issuance of this specification does not constitute approval to operate certificated aircraft with this fuel. 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 certification program for that aircraft and engine model.

1.5 This specification, unless otherwise provided, prescribes the required properties of unleaded fuel at the time and place of delivery.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D86 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure
D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)
D873 Test Method for Oxidation Stability of Aviation Fuels (Potential Residue Method)
D909 Test Method for Supercharge Rating of Spark-Ignition Aviation Gasoline
D910 Specification for Leaded Aviation Gasolines
D1094 Test Method for Water Reaction of Aviation Fuels
D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
D2386 Test Method for Freezing Point of Aviation Fuels
D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
D2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
D2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel
D3237 Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy
D3606 Test Method for Determination of Benzene and Toluene in Finished Motor and Aviation Gasoline by Gas Chromatography

[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.J0.02 on Spark and Compression Ignition Aviation Engine Fuels.

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[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1721.

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

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

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4171 Specification for Fuel System Icing Inhibitors
D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
D4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
D4814 Specification for Automotive Spark-Ignition Engine Fuel
D4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
D5006 Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
D5059 Test Methods for Lead in Gasoline by X-Ray Spectroscopy
D5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)
D5580 Test Method for Determination of Benzene, Toluene, Ethylbenzene, *p/m*-Xylene, *o*-Xylene, C_9 and Heavier Aromatics, and Total Aromatics in Finished Gasoline by Gas Chromatography
D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
D6733 Test Method for Determination of Individual Components in Spark Ignition Engine Fuels by 50-Metre Capillary High Resolution Gas Chromatography
D7826 Guide for Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. Terminology

3.1 *Definitions:*

3.1.1 *binary, adj*—characterized by, or consisting of, two components.

3.1.2 *biomass, n*—biological material including any material other than fossil fuels which is or was a living organism or component or product of a living organism.

3.1.3 *non-hydrocarbon, n*—compound or compounds composed of carbon, hydrogen, and other elements such as oxygen, nitrogen, sulfur, and phosphorus.

3.1.4 *unleaded hydrocarbon aviation gasoline, n*—gasoline intended for use in aircraft powered by reciprocating spark-ignition engines, where lead and lead-containing compounds are not intentionally added for the purpose of enhancing octane performance and which excludes non-hydrocarbons, except for additives approved in this specification.

4. General

4.1 This specification, unless otherwise provided, prescribes the required properties of a high aromatic content unleaded hydrocarbon aviation gasoline at the time and place of delivery.

5. Classification

5.1 One grade of high aromatic content unleaded hydrocarbon aviation gasoline is provided, known as UL102.

6. Materials and Manufacture

6.1 D7719 fuel, except as otherwise specified in this specification, shall consist of blends of refined hydrocarbons. The sources for these hydrocarbons include biomass, natural gas, or crude petroleum.

6.1.1 See Appendix X1 for one particular composition that meets the parameters of Table 1.

6.2 *Additives*—These can be added to each grade of D7719 fuel in the amount, and of the composition, specified in the following list of approved materials:

6.2.1 *Dyes*—The total maximum concentration of dye in the fuel is 6.0 mg/L. (See X1.1.1 and X2.2.7.)

6.2.1.1 The only blue dye present in the finished fuel shall be essentially 1,4-dialkylaminoanthraquinone.

6.2.1.2 The only yellow dyes in the finished fuel shall be essentially p-diethylaminoazobenzene (Color Index No. 11021) or 1,3-benzenediol 2,4-bis [(alkylphenyl)azo-].

6.2.1.3 The only red dye present in the finished fuel shall be essentially alkyl derivatives of azobenzene-4-azo-2-naphthol.

6.2.1.4 The only orange dye present in the finished fuel shall be essentially benzene-azo-2-napthol (Color Index No. 12055).

6.2.2 *Other Additives*—These may be added in the amount and of the composition specified in the following list of approved materials. The quantities and types shall be declared by the manufacturer. Additives added after the point of manufacture shall also be declared.

6.2.2.1 *Antioxidants*—The following oxidation inhibitors may be added to the fuel separately, or in combination, in total concentration not to exceed 12 mg of inhibitor (not including weight of solvent) per litre of fuel.

(1) 2,6-ditertiary butyl-4-methylphenol.

(2) 2,4-dimethyl-6-tertiary butylphenol.

(3) 2,6-ditertiary butylphenol.

(4) 75 % minimum 2,6-ditertiary butylphenol plus 25 % maximum mixed tertiary and tritertiary butylphenols.

(5) 75 % minimum di- and tri-isopropyl phenols plus 25 % maximum di- and tri-tertiary butylphenols.

(6) 72 % minimum 2,4-dimethyl-6-tertiary butylphenol plus 28 % maximum monomethyl and dimethyl tertiary butylphenols.

(7) N,N’-di-isopropyl-para-phenylenediamine.

(8) N,N’-di-secondary-butyl-para-phenylenediamine.

TABLE 1 Detailed Requirements for High Aromatic Content Unleaded Hydrocarbon Aviation Gasoline[A]

Property		Grade UL102	ASTM Test Method[B]
COMBUSTION			
Octane Rating Knock value, Motor Octane Number[C]	min	102.2	D2700
Net heat of combustion, MJ/kg	min	41.5	D4809
COMPOSITION			
Sulfur, mass %	max	0.05	D1266 or D2622
Tetraethyl Lead, g Pb/L	max	0.013	D3237 or D5059
Total Aromatics, % (*m/m*)	min	70	D6733
Benzene, % (*m/m*)	max	0.1	D3606[D] or D5580
Requirements for All Grades			
VOLATILITY			
Vapor pressure, 37.8 °C, kPa	min max	38.0 49.0	D323 or D5191[E]
Density at 15 °C, kg/m^3	min max	790 825	D1298 or D4052
Distillation			D86
Initial boiling point, °C		Report	D86
Fuel Evaporated			D86
10 volume % at °C	max	75	D86
40 volume % at °C	min	75	D86
50 volume % at °C	max	165	D86
90 volume % at °C	max	165	D86
Final boiling point, °C	max	180	D86
Sum of 10 % + 50 % evaporated temperatures, °C	min	135	D86
Recovery, volume %	min	97	D86
Residue, volume %	max	1.5	D86
Loss, volume %	max	1.5	D86
FLUIDITY			
Freezing point, °C	max	–58[F]	D2386
CORROSION			
Copper strip, 2 h at 100 °C	max	No. 1	D130
CONTAMINANTS			
Oxidation stability (5 h aging)[G] Potential gum, mg/100 mL	max	6	D873
Water reaction Volume change, mL	max	±2	D1094
OTHER			
Electrical conductivity, pS/m	max	450[H]	D2624

[A] For compliance of test results against the requirements of Table 1, see 7.2.
[B] The test methods indicated in this table are referred to in Section 11.
[C] Knock ratings shall be reported to the nearest 0.1 octane number.
[D] In case of dispute, Test Method D3606 shall be used as the referee method.
[E] Test Method D5191 shall be the referee vapor pressure method.
[F] If no crystals have appeared on cooling to –58 °C, the freezing point may be reported as less than –58 °C.
[G] If mutually agreed upon between the purchaser and the supplier, a 16 h aging gum requirement may be specified instead of the 5 h aging gum test; in such case the gum content shall not exceed 10 mg ⁄100 mL. In such fuel the permissible antioxidant shall not exceed 24 mg ⁄L.
[H] Applies only when an electrical conductivity additive is used; when a customer specifies fuel containing conductivity additive, the following conductivity limits shall apply under the condition at point of use:
Minimum 50 pS ⁄m
Maximum 450 pS ⁄m.
The supplier shall report the amount of additive added.

6.2.2.2 *Fuel System Icing Inhibitor (FSII)*—One of the following materials may be used:

(1) Isopropyl Alcohol (IPA, propan-2-ol), in accordance with the requirements of Specification D4171 (Type II). May be used in concentrations recommended by the aircraft manufacturer when required by the aircraft owner/operator.

(2) Di-Ethylene Glycol Monomethyl Ether (Di-EGME), conforming to the requirements of Specification D4171 (Type III). May be used in concentrations of 0.10 to 0.15 volume % when required by the aircraft owner/operator.

(3) Test Method D5006 can be used to determine the concentration of Di-EGME in aviation fuels.

NOTE 1—Addition of isopropyl alcohol (IPA) may reduce knock ratings below minimum specification values. See X2.2.3.

6.2.2.3 *Electrical Conductivity Additive*—Stadis 450 in concentrations up to 3 mg/L is permitted. When loss of fuel conductivity necessitates retreatment with electrical conductivity additive, further addition is permissible

6.2.2.4 *Corrosion Inhibitor Additive*—The following corrosion inhibitors may be added to the fuel in concentrations not to exceed the maximum allowable concentration (MAC) listed for each additive.

DCI-4A MAC = 24.0 g/m^3
DCI-6A MAC = 15.0 g/m^3
HITEC 580 MAC = 22.5 g/m^3
NALCO 5403 MAC = 22.5 g/m^3
NALCO 5405 MAC = 11.0 g/m^3
UNICOR J MAC = 22.5 g/m^3
SPEC-AID 8Q22 MAC = 24.0 g/m^3
TOLAD 351 MAC = 24.0 g/m^3
TOLAD 4410 MAC = 22.5 g/m^3

7. Detailed Requirements

7.1 The D7719 fuel shall conform to the requirements prescribed in Table 1.

7.2 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1. No allowance shall be made for the precision of the test methods. To determine the conformance to the specification requirement, a test result may be rounded to the same number of significant figures as in Table 1 using Practice E29. Where multiple determinations are made, the average result, rounded according to Practice E29, shall be used.

8. Workmanship, Finish, and Appearance

8.1 The D7719 fuel specified in this specification shall be free from undissolved water, sediment, and suspended matter. No substances 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 Practice D4177.

9.1.1 Although automatic sampling following Practice D4177 may be useful in certain situations, initial manufacturer/supplier specification compliance testing shall be performed on a sample taken following procedures in Practice D4057.

9.2 A number of D7719 fuel properties, including copper corrosion, electrical conductivity, and others are very sensitive to trace contamination which can originate from sample containers. For recommended sample containers, refer to Practice D4306.

10. Reports

10.1 The type and number of reports to ensure conformance with the requirements of this specification shall be mutually agreed to by the purchaser and the supplier of the D7719 fuel.

11. Test Methods

11.1 The requirements enumerated in this specification shall be determined in accordance with the following ASTM test methods:[4]

11.1.1 *Knock Value (Motor Octane Number)*—Test Method D2700.
11.1.2 *Tetraethyl Lead*—Test Methods D3237 or D5059.
11.1.3 *Density*—Test Methods D1298 or D4052.
11.1.4 *Distillation*—Test Method D86.
11.1.5 *Freezing Point*—Test Method D2386.
11.1.6 *Vapor Pressure*—Test Methods D323 or D5191.
11.1.7 *Net Heat of Combustion*—Test Method D4809.
11.1.8 *Sulfur*—Test Methods D1266 or D2622.
11.1.9 *Corrosion (Copper Strip)*—Test Method D130, 2 h test at 100°C in bomb.
11.1.10 *Potential Gum and Visible Lead Precipitate*—Test Method D873 except that wherever the letter X occurs (referring to oxidation time) insert the number 5, designating the number of hours prescribed in this specification.
11.1.11 *Water Reaction*—Test Method D1094.
11.1.12 *Electrical Conductivity*—Test Method D2624.
11.1.13 *Aromatic Content*—Test Method D6733.
11.1.14 *Benzene Content*—Test Methods D3606 or D5580.

12. Keywords

12.1 aviation gasoline; binary; hydrocarbon; unleaded

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1808. Contact ASTM Customer Service at service@astm.org.

APPENDIXES

(Nonmandatory Information)

X1. HIGH AROMATIC CONTENT BINARY UNLEADED HYDROCARBON AVIATION GASOLINE COMPOSITION

X1.1 Introduction

X1.1.1 A new high aromatic content unleaded hydrocarbon aviation gasoline has been developed for reciprocating aircraft engines. The two essential performance parameters of MON and VP are inversely related with respect to composition and thus can uniquely define a composition range of the two components. The values for VP and MON in Table 1 reflect the limiting values of the two components. The distillation parameters reflect the binary compositional effects. This is an unleaded fuel, so the limit of TEL in Table 1 is the same as is used in Specification D4814 for mogas and is meant to mitigate unintentional contamination by TEL. Lastly, references to dyes remain in the specification so that test groups may use them as necessary. This specification covers a high-octane unleaded hydrocarbon aviation gasoline developed for existing spark-ignition aircraft engines.

X1.2 Composition

X1.2.1 The origin of the fuel lies in two essential engine performance parameters: Motor Octane Number, and Vapor Pressure. Fig. X1.1 shows the inverse relationship of these two parameters as a function of mesitylene composition.

X1.2.2 These two parameters coupled with the fact that the fuel is a binary composition, fix the effective composition range as follows:

(1) High-Octane Composition: 84 % mesitylene 16 % isopentane

(2) High Limit Reid Composition 79 % mesitylene 21 % isopentane

X1.2.3 These limits are proposed to define the binary fuel's specification composition.

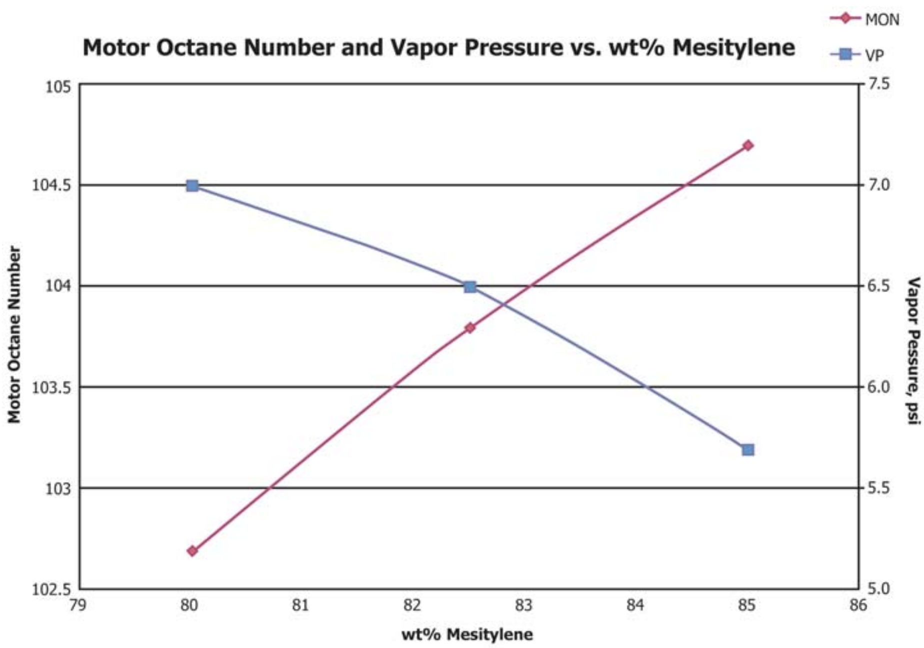

FIG. X1.1 Motor Octane Number and Vapor Pressure versus % Mesitylene

X2. PERFORMANCE CHARACTERISTICS OF HIGH AROMATIC CONTENT UNLEADED HYDROCARBON AVIATION GASOLINE

X2.1 Introduction

X2.1.1 High aromatic content unleaded hydrocarbon aviation gasoline (hereafter referred to as "D7719 fuel") is a mixture of hydrocarbons that result in a narrow range of physical and chemical properties to assure an appropriate amount of power, detonation suppression and volatility for high performance piston-engine aircraft. The engines and aircraft impose a variety of mechanical, physical, and chemical environments. The properties of D7719 fuel (Table 1) are fixed by this specification in order to give satisfactory engine performance over an extremely wide range of conditions for aircraft certified to use this fuel.

X2.1.2 The ASTM requirements summarized in Table 1 are quality limits established on the basis of Guide D7826 guidelines, which include laboratory testing, engine testing, flight testing, toxicology testing, material compatibility testing, ongoing certification testing, and close cooperation of producers of aviation gasoline, manufacturers of aircraft engines, and users of both commodities. The values given define D7719 fuel intended for use in spark-ignition aviation engines and airframes certified to use this fuel.

X2.1.3 This specification includes only one grade of D7719 fuel defined by its antiknock quality. The other requirements prescribe a suite of properties to support production, quality control, and distribution of the fuel.

X2.2 Combustion Characteristics and Antiknock Quality

X2.2.1 The fuel-air mixture in the cylinder of a spark-ignition engine will, under certain conditions, ignite spontaneously in localized areas instead of progressing from the spark. This can cause a detonation or knock, usually inaudible in aircraft engines. This knock, if permitted to continue for more than brief periods, can result in serious loss of power and damage to, or destruction of, the aircraft engine. Should D7719 fuel be used in other types of aviation engines, for example, in certain turbine engines where specifically approved by the engine manufacturers, knock or detonation characteristics may not be critical requirements. Modifications or adjustments to avoid knock or detonation when operating with D7719 fuel on aircraft engines originally designed to operate on other aviation gasolines should consider the impacts that those modifications or adjustments can have on aircraft or engine performance.

X2.2.2 The D7719 fuel grade is rated based upon an ASTM Motor Octane Number (MON) which expressed a knock value based upon a standard laboratory test (Test Method D2700). The MON is a measure of how the fuel behaves when under load (stress). MON testing uses a test engine with a preheated fuel mixture, 900 r/min engine speed, and variable ignition timing to stress the fuel's knock resistance. The MON of the D7719 fuel can be used as a guide to the amount of knock-limiting power that can be obtained in a full-scale engine under take-off, climb and cruise conditions. Leaded aviation gasolines also specify the Test Method D909 Supercharge Rating, but this method is not currently specified in Table 1 for D7719 fuel because it produces an atypical response compared to the leaded reference fuels used in the method. Research is ongoing to determine if an alternative Supercharge Rating method is necessary for D7719 fuel.

X2.2.3 Since isopropyl alcohol (IPA) is normally added in the field at the point of sale as a fuel system icing inhibitor, the operator is cautioned that it can impact octane performance and therefore may not meet specification minimums. It has been observed that when isopropyl alcohol (IPA) is added to an aviation gasoline as a fuel system icing inhibitor, the antiknock rating of the fuel can be reduced.

X2.2.4 *Blends with Other Aviation Gasolines*—It is anticipated that D7719 fuel could potentially be mixed with other, existing aviation gasolines in aircraft fuel tanks. Testing results for a range of blends of D7719 fuel with 100LL aviation gasoline is provided in an ASTM research report and shows some antagonistic octane blending effects. Additional research may be necessary to evaluate the impact of blending on the octane rating of the blended fuel relative to the minimum octane rating of currently available aviation gasolines.[5,6,7].

X2.2.5 The composition of D7719 fuel impacts the maximum exhaust gas temperature level experienced by spark-ignition piston engines. Testing has shown that D7719 fuel causes an increase in average exhaust gas temperature of 22 °C to 39 °C relative to those fuels on which existing aircraft have

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1768. Contact ASTM Customer Service at service@astm.org.

[6] See pp. 30–31 of RR:D02-1768.

[7] See pp. 53–66 of RR:D02-1768.

TABLE X2.1 Performance Characteristics of Unleaded Aviation Gasoline

Performance Characteristics	Test Method	Sections
Combustion characteristics	knock value (MON)	X2.2.2
Antiknock quality	isopropyl alcohol	X2.2.3
Fuel metering and aircraft range	density	X2.3.1
	net heat of combustion	X2.3.2
Carburetion and fuel vaporization	vapor pressure	X2.4.3
	distillation	X2.4.4
Corrosion of fuel system and engine parts	copper strip	X2.5.1
	sulfur	X2.5.2
Fluidity at low temperatures	freezing point	X2.6.1
Fuel cleanliness, handling, and storage stability	potential gum	X2.7.1
	water reaction	X2.7.3

been designed to operate.[5,8] During certification, the resultant durability of aircraft engine combustion components should be investigated before operation of specific engine models with fuel to D7719.

X2.2.6 *Combustion Heaters*—Combustion heaters used at altitude must be individually approved for use.

X2.2.7 *Dyes*—Environmental regulations require that all fuels containing tetraethyllead must be dyed to denote the presence of the lead. D7719 fuel does not contain lead and is not currently dyed. However, a provision for the addition of dyes is available in D7719. For many years spark ignition piston engine aircraft have used Specification D910 aviation gasoline containing dye for grade differentiation. There is the risk that unleaded aviation gasoline can contain a small amount of such dyes as a result of residual material being present in the manufacturing and distribution infrastructure, including airfield and aircraft tanks. To manage this issue, provision has been made for unleaded aviation gasoline specifications to temporarily permit dye at point of manufacture, with the intention to further limit and extend this specification throughout the distribution infrastructure at a later date.

X2.3 Fuel Metering and Aircraft Range

X2.3.1 *Density*—Density is a property of a fluid and is of significance in metering flow and in mass-volume relationships for most commercial transactions. D7719 fuel typically has a narrow density range of 6.5 lb to 6.7 lb per U.S. gal (0.779 kg/L to 0.803 kg/L), yet due to the higher energy density per gallon may increase flight range up to 15 % per gallon over leaded aviation gasolines. Tests show that the density of 100LL aviation gasoline can vary from 5.5 lb per U.S. gal to as high as 6.2 lb per U.S. gal (0.66 kg/L to 0.74 kg/L). The higher density of D7719 fuel will result in a greater aircraft weight compared to the 100LL aviation gasoline for a full fuel tank, and care should be exercised that operating limitations are not exceeded.

X2.3.2 *Net Heat of Combustion*—The net heat of combustion provides knowledge of the amount of energy obtainable from a given mass of 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 the specification.

X2.3.3 Testing has shown that the net heat of combustion of D7719 fuel influences the amount of available power or range of certain aircraft. Aircraft may therefore require an ignition timing adjustment to attain maximum power and/or revised operating procedures to manage increased range levelsobtainable versus those fuels on which existing aircraft have been designed to operate.[9]

X2.3.3.1 In addition, an ASTM research report exists that recommends that some carbureted engines may require rejetting for optimum operation when using D7719 fuels.[5,10]

X2.4 Fuel Injection, Carburetion, and Fuel Vaporization

X2.4.1 Fuel-injected spark-ignition aviation engines manage the vaporization and combustion of the fuel in an efficient and repeatable fashion. In carbureted spark-ignition aviation engines, the gasoline is metered in liquid form through the carburetor where it is mixed with air and vaporized before entering the cylinder of the engine. In other types of engines, the fuel can be metered directly into the supercharger, the cylinder, or the combustor. The volatility, the tendency to evaporate or change from a liquid to a gaseous state, is an extremely important characteristic of all aviation gasoline, but particularly in the carbureted engines.

X2.4.2 Gasolines that vaporize too readily can boil in fuel lines or carburetors, particularly as altitude increases, and cause vapor lock with resultant stoppage of fuel flow to the engine. Conversely, fuels that do not completely vaporize can cause engine malfunctioning of other sorts. Therefore, a proper balance of the volatility of the various hydrocarbon components is essential to satisfactory performance of the finished fuel. D7719 fuel specifies a distillation range that is different to those leaded fuels on which existing aircraft have been designed to operate. An ASTM research report outlines recommended starting procedures for certain carbureted engines.[5,10] Certain aircraft may require modifications to achieve smooth starting or acceleration characteristics.

X2.4.3 *Vapor Pressure*—The vapor pressure of an aviation gasoline is the measure of the tendency of the more volatile components to evaporate. Experience has shown that fuels having a vapor pressure no higher than 49 kPa will be free of vapor-locking tendencies under most conditions of aircraft usage. A research report is available. [5,11]

X2.4.4 *Distillation*—The relative proportions of all the hydrocarbon components of a gasoline are measured in terms of volatility by the range of distillation temperatures. It should be noted that the distillation properties of D7719 fuels differ from those specified for 100LL aviation gasoline. Differences have been highlighted in the sections below and in the referenced research reports. The method is empirical and useful in comparing fuels, but is not intended to separate or identify quantitatively the individual hydrocarbons present in the fuel.

X2.4.4.1 A maximum value is set on the 10 % evaporated point to ensure ease of starting and a reasonable degree of

[8] See pp. 30, 65 of RR:D02-1768.

[9] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1721. Contact ASTM Customer Service at service@astm.org. See pp. 61–243 of RR:D02-1721.

[10] See pp. 103–104 of RR:D02-1768.

[11] See pp. 23, 24, 45, 46, 70, 106, 129, 136, 150, 160 of RR:D02-1768.

flexibility during the warm-up period. To guard against too high a volatility that might lead to carburetor icing or vapor lock, or both, (also protected against by the vapor pressure test) a minimum value is set for the sum of the 10 % and 50 % evaporated points. D7719 fuel specifies identical criteria for these points as those aviation gasolines on which existing aircraft have been designed to operate.

X2.4.4.2 A maximum value is specified for the 50 % evaporated temperature to ensure average volatility sufficient to permit adequate evaporation of the fuel in the engine induction system. Insufficient evaporation can lead to loss of power and/or issues with engine acceleration. D7719 fuel specifies a higher 50 % evaporated temperature than those aviation gasolines on which existing aircraft have been designed to operate. An ASTM research report is available that shows that, for a range of temperatures, the operability of certain piston engines is not impacted by the higher boiling point of 165 °C. Additionally, certain low-compression, lowhorsepower, carbureted engines may require modifications before adequate operation can be assured over a wide range of temperatures.[5,10,12]

X2.4.4.3 A maximum temperature is prescribed for the 90 % evaporated point to prevent too much liquid fuel being delivered to the cylinders, resulting in power loss, to prevent poor distribution to the various cylinders, and to prevent lubricant washing from cylinder walls. Such a condition might lead to excessive leanness in some cylinders with consequent engine roughness, perhaps accompanied by knocking and damage to the engine. Lowered fuel economy and excessive dilution of the lubricating oil can result from too high a 90 % evaporated point. D7719 fuel specifies a higher 90 % evaporated temperature than those aviation gasolines on which existing aircraft have been designed to operate. An ASTM research report is available that shows certain aircraft piston engines operate satisfactorily with the higher boiling point of 165 °C. [5,10,13] It is recommended that testing be performed to evaluate engine lubrication and operability in low ambient temperatures when certifying D7719 fuel for use on specific engine models.

X2.4.4.4 A minimum value is stipulated for the 40 % evaporated temperature in an effort to control the use of low boiling components in relation to higher boiling mesitylene. D7719 fuel specifies identical criteria for this point as those aviation gasolines on which existing aircraft have been designed to operate.

X2.4.4.5 A maximum is placed on the final boiling point (end point) which is used to prevent incorporation of excessively high boiling components in the fuel that can lead to maldistribution, spark plug fouling, power loss, lowered fuel economy, and lubricating oil dilution. D7719 fuel specifies a 10 °C higher final boiling point than those aviation gasolines on which existing aircraft have been designed to operate, which should be considered when certifying.

X2.4.4.6 The stipulation of a minimum recovery and a maximum loss in this specification in conjunction with the vapor pressure requirement is intended to protect against excessive losses by evaporation in storage, handling, and in the aircraft tank. It is also a check on the distillation test technique.

X2.4.4.7 A maximum value is specified for the distillation residue to prevent the inclusion of undesirable high-boiling components, the presence of which can reflect the degree of care with which the product is refined or handled. The amount of residue along with the end point temperature can be used as an indication of contamination with high-boiling materials.

X2.5 Corrosion of Fuel System and Engine Parts

X2.5.1 *Copper Strip*—The requirement that gasoline shall pass the copper strip corrosion test provides assurance that the product will not corrode the metal parts of fuel systems.

X2.5.2 *Sulfur*—Total sulfur content of aviation gasoline is significant because the products of combustion of sulfur can cause corrosive wear of engine parts.

X2.6 Low Temperature Performance

X2.6.1 *Freezing Point*—A freezing point requirement is specified to preclude solidification of any hydrocarbon components at extremely low temperatures with consequent interference with fuel flow to the engine.

X2.6.2 *Fuel System Icing Inhibitor*—Isopropyl alcohol (IPA) and diethyleneglycol monomethyl ether (Di-EGME), both approved in 6.2.2.2, shall be in accordance with the requirements shown in Specification D4171.

X2.7 Fuel Cleanliness, Handling, and Storage Stability

X2.7.1 *Potential Gum*—Fuel shall be usable after storage for variable periods under a variety of climatic conditions. The potential gum test, which is an accelerated oxidation method, is used to estimate fuel stability in storage and the effectiveness of oxidation inhibitors. If the fuel is to be stored under relatively mild conditions for short periods, an oxidation period of 5 h is generally considered sufficient to indicate if the desired stability has been obtained, whereas a 16 h period is desirable to provide stability assurance for long periods and severe conditions, such as storage in tropical climates.

X2.7.2 *Permissible Oxidation Inhibitors and Oxidation Inhibitor Content*—Antioxidants are used to prevent the formation of gum in fuel during storage. The efficacy of a given inhibitor determined by the apparent oxidation stability of a fuel does not completely establish its suitability for use in an aircraft engine. Oxidation inhibitors have been found to contribute to excessive induction system deposits; therefore, their acceptability for use shall ultimately be determined in the full-scale aircraft engine.

X2.7.2.1 The chemical names of approved inhibitors and the maximum quantities permitted are shown in this specification.

X2.7.3 *Water Reaction*—The water reaction method provides a means of determining the presence of materials readily extractable by water or having a tendency to absorb water. When the fuel consists essentially of hydrocarbon components, there is no measurable change in the volume of the water layer.

[12] See pp. 268–304 of RR:D02-1721.

[13] See pp. 244–315 of RR:D02-1768.

X2.7.4 *Electrical Conductivity*—The generation of static electricity can create problems in the handling of aviation gasolines. Addition of a conductivity improver may be used as an additional precaution to reduce the amount of static electrical charge present during fuel handling. See Guide D4865 for more information.

X2.7.5 *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. However, microbials do not ingest fuel components found in D7719 fuel.

X2.7.5.1 Guide D6469 provides personnel with limited microbiological background and an understanding of the symptoms, occurrence, and consequences of chronic microbial contamination. The guide also suggests means for detection and control. Biocides used in aviation fuels shall follow engine and airframe manufacturers" approval guidelines.

X2.8 Lead Content and Toxins

X2.8.1 *Lead Memory*—Unleaded aviation gasoline when added to an aircraft fuel tank that previously had leaded fuel will scavenge, remove, and combust the leaded components within a short period. Tests show D7719 fuel when placed in a fuel tank that previously held 100LL, had a lead memory of less than 30 min.[5,14]

X2.8.2 *Lead Content*—For many years spark ignition piston engine aircraft have used Specification D910 aviation gasoline containing the octane enhancement additive tetraethyl lead. There is the risk that unleaded aviation gasoline can contain a small amount of this additive as a result of residual material being present in the manufacturing and distribution infrastructure, including airfield and aircraft tanks. To manage this issue, provision has been made for unleaded aviation gasoline specifications to temporarily permit up to 0.013 g of lead/L (0.05 g/U.S. gal) at point of manufacture, with the intention to further limit and extend this specification throughout the distribution infrastructure at a later date.

X2.8.3 *Toxins*—D7719 fuel does not intentionally contain components such as: tetraethyllead, MTBE, aromatic amines, benzene, or other carcinogens. Furthermore, no unintentional trace amounts of these components were found in the fuel used in the creation of the ASTM research reports. The D7719 fuel and its components are not water soluble. Benzene is virtually excluded by the maximum freezing point of −58 °C. A toxicology assessment has been conducted which compares Specification D910 Grade 100LL with D7719 fuel based on U.S. EPA ecological and human health risk assessment guidelines; exhaust emissions toxicology has not been evaluated for either fuel.[5,15]

X2.9 Material Compatibility

X2.9.1 *Material Compatibility*—The physical properties of elastomeric sealing materials and other non-metallic materials utilized in aviation, tend to be impacted by the chemical composition of fuel with which they come into contact. Certain aircraft, engines, and ground-handling components or equipment may require modifications to replace existing elastomeric materials with alternative materials to ensure continued safe operation.

X2.9.1.1 The concentration and type of aromatics can impact the swell of elastomeric sealing materials, specifically Nitrile Rubber, Neoprene and Buna-based materials. Testing of D7719 fuel, as prescribed in Guide D7826, has shown increased elastomer swelling for these three materials when compared with the leaded aviation gasoline that existing aircraft have been designed to operate on and that the existing leaded aviation gasoline ground-based infrastructure has been designed to handle. A complete report of static material compatibility results for non-metals, metals and composites, according to Guide D7826 guidelines, is available in an ASTM research report.[5,16] Additional dynamic testing of non-metallic materials, as well as testing of OEM-specific metallic and non-metallic materials may be conducted prior to certification approval for use of D7719 fuel, if required.

X2.9.1.2 All key operational ground-handling equipment should follow proper aviation industry qualification and quality control procedures, for example, as defined in ASTM International Manual 5 Aviation Fuel Quality Control Procedures.[17] In one such illustration, filter monitors that utilize a super absorbent polymer, such as those compliant with EI-1583, have been found to be impacted by the chemical composition of fuels that pass through these filters and should be evaluated prior to use with D7719 fuel.

[14] See p. 382 of RR:D02-1768.

[15] See Section 8 of RR:D02-1768.

[16] See Section 7 of RR:D02-1768.

[17] See Section A.15 of *Aviation Fuel Quality Control Procedures, ASTM MNL5*—4th, ASTM International, 2009.

SUMMARY OF CHANGES

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D7719 – 16) that may impact the use of this standard. (Approved Dec. 1, 2016.)

(1) Revised subsection X1.1.1.

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D7719 – 15a) that may impact the use of this standard. (Approved June 1, 2016.)

(1) Added new footnote D to Table 1; relabeled subsequent footnotes.

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D7719 – 15) that may impact the use of this standard. (Approved Oct. 1, 2015.)

(1) Revised Table 1.
(2) Revised subsection 11.1.13 and added new subsection 11.1.14.
(3) Added Test Methods D3606 and D5580 to Referenced Documents.
(4) Added new Research Report RR:D02-1808 to footnote 4.