INTERNATIONAL

**Designation: ~~D7719 – 14a~~ D7719 – 14b**

# Standard Specification for High-Octane Unleaded Fuel[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-octane (MON) unleaded fuel under contract and is intended solely for use by purchasing agencies.[2]

1.2 This specification defines a specific type of high-octane (MON) unleaded 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 This specification, unless otherwise provided, prescribes the required properties of unleaded fuel at the time and place of delivery.

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

1.5 *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 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
D1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
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
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

[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~~D02.J0.02 on ~~Aviation~~ 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**

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)
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 *aviation gasoline fuel, n*—fuel possessing specific properties suitable for operating aircraft powered by reciprocating spark-ignition engines.

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

3.1.3 *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.

3.1.4 *high-octane, adj*—possessing a Motor octane number (MON) greater than 100.

## 4. General

4.1 This specification, unless otherwise provided, prescribes the required properties of a binary aviation fuel at the time and place of delivery.



## 5. Classification

5.1 One grade of high-octane unleaded fuel is provided, known as UL102.

## 6. Materials and Manufacture

6.1 High-octane unleaded fuel, except as otherwise specified in this specification, shall consist of blends of refined reformate 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.



**TABLE 1 Detailed Requirements for High-Octane Unleaded Fuel**

| Octane Ratings | | Grade UL102 | ASTM Test Method |
|---|---|---|---|
| Knock value, Motor Octane Number | min | 102.2 | D2700 |
| Density at 15 °C, kg/m$^3$ | min | 790 | D1298 or D4052 |
| | max | 825 | |
| 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 |
| Vapor pressure, 37.8 °C, kPa | min | 38.0 | D323 orD5191 |
| | max | 49.0 | |
| Freezing point, °C | max | -58 | D2386 |
| Sulfur, mass % | max | 0.05 | D1266 or D2622 |
| Net heat of combustion, MJ/kg | min | 41.5 | D4809 |
| Corrosion, copper strip, 2 h at 100 °C | max | No. 1 | D130 |
| Oxidation stability (5 h aging) | | | D873 |
| Potential gum, mg/100 mL | max | 6 | |
| Water reaction | | | D1094 |
| Volume change, mL | max | ±2 | |
| Electrical conductivity, pS/m | max | 450 | D2624 |
| Tetraethyl Lead, g Pb/L | max | 0.013 | D3237 or D5059 |
| Total Aromatics, vol % | min | 70 | D1319 or D6733 |

6.2 *Additives*—These can be added to each grade of high-octane unleaded aviation 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.

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.

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.

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 high-octane unleaded 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 high-octane unleaded 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 high-octane unleaded 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 high-octane unleaded fuel.

## 11. Test Methods

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

11.1.1 *Knock Value (Lean Rating)*—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 Methods D1319 or D6733.



## 12. Keywords

12.1 aviation fuel; binary; high-octane; unleaded

## ~~APPENDIX~~APPENDIXES

**(Nonmandatory Information)**



## X1. BINARY FUEL COMPOSITION

### X1.1 Introduction

X1.1.1 A new high-octane unleaded fuel 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 binary fuel exhibits a higher volumetric energy density (net heat of combustion times density) which is of great performance interest, although not explicitly stated in Table 1. 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 fuel 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%~~84 % mesitylene ~~16%~~16 % isopentane

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

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

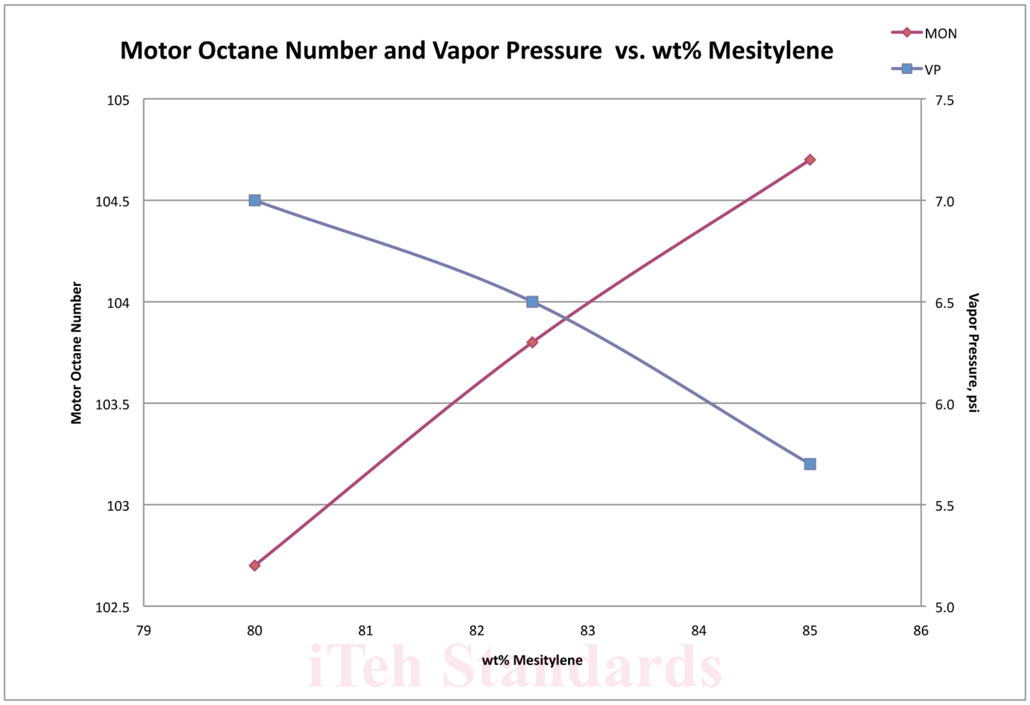


**FIG. X1.1 Motor Octane Number and Vapor Pressure versus % Mesitylene**

## 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 permitted 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. Depending on octane grade, the addition of IPA additive can increase or decrease the MON rating.

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.[4,5,6].

[4] 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.

[5] See pp. 30–31 of RR:D02-1768.

[6] See pp. 53–66 of RR:D02-1768.