Designation: D8434 – 21

Standard Specification for Unleaded Aviation Gasoline Test Fuel Containing Organometallic Additive[1]

This standard is issued under the fixed designation D8434; 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 an unleaded aviation gasoline test fuel under contract and is intended solely for use by purchasing agencies for testing purposes.

1.2 This specification defines a specific type of aviation gasoline for use as an aviation spark-ignition engine test fuel. It does not include all gasolines 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 unleaded aviation gasoline test fuel defined by this specification does exhibit similar octane performance to those leaded fuels with which the existing aircraft and ground-based fuel handling equipment have been designed to operate.

1.4 Issuance of this specification does not constitute approval to operate certificated aircraft with this test 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 a certification program.

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

1.6 This specification, unless otherwise provided, prescribes the required properties of unleaded aviation gasoline test fuel at the time and place of delivery.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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)

D357 Method of Test for Knock Characteristics of Motor Fuels Below 100 Octane Number by the Motor Method; Replaced by D 2700 (Withdrawn 1969)[3]

D381 Test Method for Gum Content in Fuels by Jet Evaporation

D614 Method of Test for Knock Characteristics of Aviation Fuels by the Aviation Method; Replaced by D 2700 (Withdrawn 1970)[3]

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

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D1948 Method of Test for Knock Characteristics of Motor Fuels Above 100 Octane Number by the Motor Method; Replaced by D 2700 (Withdrawn 1968)[3]

D2386 Test Method for Freezing Point of Aviation Fuels

D2392 Test Method for Color of Dyed Aviation Gasolines

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

[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 Aviation Piston Engine Fuels.

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

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

D2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel
D3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
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
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
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
D5006 Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
D5059 Test Methods for Lead and Manganese in Gasoline by X-Ray Fluorescence Spectroscopy
D5191 Test Method for Vapor Pressure of Petroleum Products and Liquid Fuels (Mini Method)
D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. Terminology

3.1 *Definitions:*

3.1.1 *unleaded aviation gasoline, n*—gasoline intended for use in aircraft powered by reciprocating spark ignition engines, where lead is not intentionally added for the purpose of enhancing octane performance.

3.1.1.1 *Discussion*—Principal properties include volatility limits, stability, detonation-free performance in the engine for which it is intended, and suitability for low temperature performance.

4. General

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

5. Classification

5.1 One grade of unleaded aviation gasoline test fuel is provided, known as 100M.

6. Materials and Manufacture

6.1 100M[4] unleaded aviation gasoline test fuel, except as otherwise specified in this specification, shall consist of blends of refined hydrocarbons derived from crude petroleum, natural gasoline, biomass or blends thereof, with synthetic hydrocarbons or aromatic hydrocarbons, or both.

6.2 *Additives—Mandatory*, shall be added in the amount and of the composition specified in the following list of approved materials.

6.2.1 *AvGuard UL*[5] Additive Package shall be added in the form of a multifunctional mixture containing not less than 28 % by mass of methylcyclopentadienyl manganese tricarbonyl (MMT®), sufficient phosphorous based scavenger chemistry to provide a stoichiometric ratio of Mn:P from 1:0.1 to 1:10, and oxidation inhibitor in the amount of 1 mg per 12.5 mg Mn/L in the finished fuel. The balance contains no ingredients other than carrier solvent. The maximum manganese concentration limit is specified in Table 1.[6]

6.3 *Additives* may be added to the fuel in the amount and of the composition specified in the following list of approved materials.[7] The quantities and types shall be declared by the manufacturer. Additives added after the point of manufacture shall also be declared.

6.3.1 *Oxidation Inhibitor* 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 liter 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.

6.3.2 *Fuel System Icing Inhibitor (FSII)*—One of the following may be used.

6.3.2.1 *Isopropyl Alcohol (IPA, propan-2-ol),* in accordance with the requirements of Specification D4171 (Type II). May

[4] The following fuel, as described in Table 1 and RR:D02-2026, was used to develop this specification. A test protocol to establish equivalence of high octane unleaded aviation gasoline is on file at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-2026. Contact ASTM Customer Service at service@astm.org.

[5] AvGuard UL is a trademark of Afton Chemical Corporation, 500 Spring Street, Richmond, VA 23219, and was used in the development of this fuel specification. This is not an endorsement or certification by ASTM International.

[6] Supporting data pending ASTM balloting and acceptance of Research Report RR:D02-2026. AvGuard UL™ is an essential component in this unleaded aviation fuel to deliver the octane levels required for proper engine performance. The integrity of D8434 fuel requires that the unleaded fuel additive package meet the specifications of D8434 Table 1 and give equivalent RR:D02-2026 results to the fuel used in the development of this fuel specification.

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1125. Contact ASTM Customer Service at service@astm.org.

TABLE 1 Detailed Requirements for 100M Unleaded Aviation Gasoline Test Fuel[A]

Property		Grade 100M	ASTM Test Method[B]
COMBUSTION			
Net heat of combustion, MJ/kg[C]	Min	43.5	D4529, D3338, or D4809
Octane Rating			
Knock value, lean mixture Motor Octane Number	Min	99.6	D2700
Knock value, rich mixture Performance Number[D]		Report	D909
COMPOSITION			
Mn, g/L	Min	0.076	D5059
	Max	0.125	
Pb, g/L	Max	0.013	D5059
Sulfur, mass %	Max	0.05	D2622, D4294, or D5453
VOLATILITY			
Vapor pressure, 38 °C, kPa	Min	38.0	D323 or D5191[E]
	Max	49.0	
Density @ 15 °C, kg/m^3		Report	D1298 or D4052
Distillation, °C			D86
Initial boiling point, °C		Report	
Fuel Evaporated			
10 % by volume at °C	Max	75	
40 % by volume at °C	Min	75	
50 % by volume at °C	Max	105	
90 % by volume at °C	Max	135	
Final boiling point, °C	Max	170	
Sum of 10 % + 50 % evaporated, °C	Min	135	
Recovery volume %	Min	97	
Residue volume %	Max	1.5	
Loss volume %	Max	1.5	
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,H]	Max	6	D873
Potential gum, mg/100 mL			
Manganese precipitate, mg/100 mL	Max	3	D873
Water reaction	Max	±2	D1094
Volume change, mL			
ADDITIVES			
Electrical conductivity, pS/m	Max	600[I]	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] Use either Eq 1 or Table 1 in Test Method D4529 or Eq 2 in Test Method D3338. Test Method D4809 may be used as an alternative. In case of dispute, Test Method D4809 shall be used.
[D] Knock values shall be reported to the nearest 0.1 octane/performance number.
[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 and the visible manganese precipitate shall not exceed 4 mg/100 mL. In such fuel the permissible antioxidant shall not exceed 24 mg/L.
[H] Test Method D381 existent gum test can provide a means of detecting quality deterioration or contamination, or both, with heavier products following distribution from refinery to airport. Refer to X1.8.1.
[I] 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 600 pS/m. The supplier shall report the amount of additive added.

be used in concentrations recommended by the aircraft manufacturer when required by the aircraft owner/operator.

NOTE 1—Addition of isopropyl alcohol (IPA) may reduce knock ratings below minimum specification values (see X1.3.5).[8]

6.3.2.2 *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 % by volume when required by the aircraft owner/operator.

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

[8] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1526. Contact ASTM Customer Service at service@astm.org.

6.3.3 *Electrical Conductivity Additive*—AvGuard SDA[9] or Stadis 450[10] in concentrations up to 3 mg/L is permitted. When loss of fuel conductivity necessitates retreatment with electrical conductivity additive, further addition is permissible up to a maximum cumulative level of 5 mg/L of AvGuard SDA™ or Stadis 450.

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

DCI-4A	MAC = 24 g/m^3
DCI-6A	MAC = 15 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
PRI-19	MAC = 22.5 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 100M unleaded aviation gasoline 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 shall 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 100M unleaded aviation gasoline 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 Several 100M unleaded aviation gasoline 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 100M unleaded aviation gasoline.

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

11.1.2 *Knock Value (Lean Rating)*—Test Method D2700.

11.1.3 *Knock Value (Rich Rating)*—Test Method D909.

11.1.4 *Manganese*—Test Method D5059.

11.1.5 *Lead*—Test Method D5059.

11.1.6 *Sulfur*—Test Methods D2622, D4294, or D5453.

11.1.7 *Vapor Pressure*—Test Methods D323 or D5191.

11.1.8 *Density*—Test Methods D1298 or D4052.

11.1.9 *Distillation*—Test Method D86.

11.1.10 *Freezing Point*—Test Method D2386.

11.1.11 *Corrosion (Copper Strip)*—Test Method D130, 2 h test at 100 °C in bomb.

11.1.12 *Potential Gum*—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.

11.1.13 *Water Reaction*—Test Method D1094.

11.1.14 *Electrical Conductivity*—Test Method D2624.

12. Keywords

12.1 aviation gasoline; unleaded aviation gasoline; manganese; MMT®

[9] AvGuard SDA is a trademark of Afton Chemical Corp., 500 Spring Street Richmond, VA 23219. Supporting document for this additive is found in RR:D02-1861. Contact ASTM Customer Service at service@astm.org.

[10] Stadis is a registered trademark marketed by Innospec Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EY, UK.

APPENDIX

(Nonmandatory Information)

X1. PERFORMANCE CHARACTERISTICS OF 100M UNLEADED AVIATION GASOLINE

X1.1 Introduction

X1.1.1 This test specification was developed to identify distillate range refinery products, including refined hydrocarbons derived from crude petroleum, or blends thereof, with synthetic hydrocarbons suitable for high octane unleaded aviation gasoline applications. The requirements of Table 1 are quality limits established based on test development as well as tests performed on airframes and engines specifically designed to use these fuels.

X1.1.2 The performance requirements summarized in Table 1 are quality limits which have as their basis the ASTM Specification D910 limits, which are themselves the result of long-term industry experience and extensive scientific and engineering literature, as well as the cooperation of certain petroleum refiners. The values given are intended to define unleaded aviation gasoline suitable for most types of spark-ignition aviation engines; however, certain equipment or conditions of use may require fuels having other characteristics.

X1.1.3 This test specification includes only one grade of D8434 fuel defined by its antiknock quality. The other requirements either prescribe the proper balance of properties to ensure satisfactory engine performance or limit components of undesirable nature to concentrations so low that they will not have an adverse effect on engine performance.

X1.2 Composition

X1.2.1 The origin of the test fuel lies in balancing the synergistic effects of several components and compounds to achieve, as closely as possible, the performance properties of ASTM Specification D910 Grades 100LL and 100VLL fuels. One example of a potential compositional space permitted by this test specification is as follows:

0 % – 20 % isopentane and/or butane
60 % – 85 % alkylate or alkylate blend
0 % – 20 % aromatics
<1 % AvGuard UL™ additive package

X1.3 Combustion Characteristics (Antiknock Quality and Antiknock Compound Identification)

X1.3.1 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 may cause a detonation or knock, usually inaudible in aircraft engines. This knock, if permitted to continue for more than brief periods, may result in serious loss of power and damage to, or destruction of, the aircraft engine. When aviation gasoline is 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.

X1.3.2 Both the lean mixture rating and the rich mixture rating are determined in standardized laboratory knock test engines that are operated under prescribed conditions. Results are expressed as octane numbers up to 100 and above this point as quantities of tetraethyllead added to *iso*octane (2,2,4-trimethylpentane). Octane number is defined arbitrarily as the percentage of *iso*octane in that blend of *iso*octane and n-heptane that the gasoline matches in knock characteristics when compared by the procedure specified. The quantities of tetraethyllead added to *iso*octane that the gasoline matches in knock characteristics when compared by the procedure specified may be converted to performance numbers by a chart. The performance number is an indication of the relative power obtainable from an engine as compared with operation of the same engine with leaded *iso*octane, operating at equal knocking intensity. The lean mixture rating together with the rich

TABLE X1.1 Performance Characteristics of Unleaded Aviation Gasoline

Performance Characteristics	Test Methods	Sections
Combustion characteristics	Knock value (lean mixture)	X1.3.3
Antiknock quality	Knock value (rich mixture)	X1.3.4
Antiknock compound identification	Isopropyl alcohol	X1.3.5
	Methylcyclopentadienyl manganese tricarbonyl	X1.3.6
Fuel metering	Density	X1.4.1
Aircraft range	Net heat of combustion	X1.4.2
Carburetion and fuel vaporization	Vapor pressure	X1.5.3
	Distillation	X1.5.4
Corrosion of fuel system components	Copper strip corrosion	X1.6.1
	Sulfur content	X1.6.2
Fluidity at low temperatures	Freezing point	X1.7.1
Fuel cleanliness, handling, and storage stability	Existent gum	X1.8.1
	Potential gum	X1.8.2
	Water reaction	X1.8.4
	Visible manganese precipitate	X1.8.8