



Standard Specification for Specification for Grade 94 Unleaded Aviation Gasoline Certification and Test Fuel¹

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1. Scope*

1.1 This specification covers formulating specifications for purchases of aviation gasoline under contract and is intended primarily for use by purchasing agencies.

1.2 This specification defines a specific type of aviation gasoline that contains no lead. 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 This specification, unless otherwise provided, prescribes the required properties of unleaded aviation gasoline at the time and place of delivery.

1.4 The current purpose for the fuel specified herein is for certification and testing of an engine and engine components.

1.5 The UL94 standard is to be used for engine calibration and FAA certification.

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

2. Referenced Documents

2.1 *ASTM Standards*:²

[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 \(Reid Method\)](#)

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of Test for Knock Characteristics of Motor Fuels Below 100 Octane Number by the Motor Method; Replaced by D 2700 \(Withdrawn 1969\)](#)³

[D614 Method of Test for Knock Characteristics of Aviation Fuels by the Aviation Method; Replaced by D 2700 \(Withdrawn 1970\)](#)³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

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of Test for Knock Characteristics of Motor Fuels Above 100 Octane Number by the Motor Method; Replaced by D 2700 \(Withdrawn 1968\)](#)³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

[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](#)

[D2699 Test Method for Research Octane Number of Spark-Ignition Engine Fuel](#)

[D2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel](#)

[D3237 Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy](#)

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 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.

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

[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](#)
[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 in Gasoline by X-Ray Spectroscopy](#)
[D5191 Test Method for Vapor Pressure of Petroleum Products \(Mini Method\)](#)
[D6227 Specification for Unleaded Aviation Gasoline Containing a Non-hydrocarbon Component](#)
[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 possessing specific properties suitable for fueling 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. Classification

4.1 One grade of unleaded aviation gasoline is provided, known as:
Grade UL94

NOTE 1—The above grade is based on its octane number as measured by Test Method [D2700](#) motor method.

5. Materials and Manufacture

5.1 Unleaded aviation gasoline, except as otherwise specified in this specification, shall consist of blends of refined hydrocarbons derived from crude petroleum, natural gasoline, or blends, thereof, with synthetic hydrocarbons or aromatic hydrocarbons, or both.

5.2 *Additives*—These may be added to each grade of unleaded aviation gasoline in the amount and of the composition specified in the following list of approved materials.⁴ The quantities and types shall be declared by the manufacturer. Additives added after the point of manufacture shall also be declared.

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

5.2.1.1 2, 6-ditertiary butyl-4-methylphenol.

5.2.1.2 2, 4-dimethyl-6-tertiary butylphenol.

5.2.1.3 2, 6-ditertiary butylphenol.

5.2.1.4 ~~75 %~~ 75 % minimum 2, 6-ditertiary butylphenol plus 25 % maximum mixed *tertiary* and *tritertiary* butylphenols.

5.2.1.5 ~~75 %~~ 75 % minimum di- and tri-isopropyl phenols plus 25 % maximum di- and tri-*tertiary* butylphenols.

5.2.1.6 ~~72 %~~ 72 % minimum 2,4-dimethyl-6-tertiary butylphenol plus ~~28 %~~ 28 % maximum monomethyl and dimethyl *tertiary* butylphenols.

5.2.1.7 N,N'-di-isopropyl-para-phenylenediamine.

5.2.1.8 N,N'-di-secondary-butyl-para-phenylenediamine.

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

5.2.2.1 *Isopropyl Alcohol (IPA, propan-2-ol)*, in accordance with the requirements of Specification [D4171](#) (Type II). This may be used in concentrations recommended by the aircraft manufacturer when required by the aircraft owner/operator.

⁴ Supporting data (guidelines for the approval or disapproval of additives) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1125.

NOTE 2—Addition of isopropyl alcohol (IPA) may reduce knock ratings below minimum specification values in a similar manner to Specification **D910** Leaded Aviation Gasoline (see **X1.2.3**).⁵

5.2.2.2 *Di-Ethylene Glycol Monomethyl Ether (Di-EGME)*, conforming to the requirements of Specification **D4171** (Type III), may be used in concentrations of ~~0-10.10 volume %~~ to ~~0.15 volume %~~ **0.15 volume %** when required by the aircraft owner/operator.

5.2.2.3 Test Method **D5006** may be used to determine the concentration of Di-EGME in aviation fuels.

5.2.3 *Electrical Conductivity Additive*—Stadis 450⁶ in concentrations up to ~~33 mg/L~~ **1.0 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 ~~55 mg/L~~ **1.0 mg/L** of Stadis 450.⁶

5.2.4 *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 = 24.0 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

6. Detailed Requirements

6.1 The unleaded aviation gasoline shall conform to the requirements prescribed in **Table 1**.

6.2 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.

7. Workmanship, Finish, and Appearance

7.1 The unleaded aviation gasoline specified in this specification shall be free from undissolved water, sediment, and suspended matter. The odor of the fuel shall not be nauseating or irritating. No substances of known dangerous toxicity under usual conditions of handling and use shall be present.

8. Sampling

8.1 Because of the importance of proper sampling procedures in establishing fuel quality, use the appropriate procedures in Practice **D4057** or Practice **D4177**.

8.1.1 Although automatic sampling following Practice **D4177** may be useful in certain situations, initial refinery specification compliance testing shall be performed on a sample taken following procedures in Practice **D4057**.

8.2 A number of 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**.

9. Reports

9.1 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 unleaded aviation gasoline.

10. Test Methods

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

10.1.1 *Knock Value*—MON (Test Method **D2700**) and RON (Test Method **D2699**).

10.1.2 *Density*—Test Methods **D1298** or **D4052**.

10.1.3 *Distillation*—Test Method **D86**.

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

10.1.5 *Freezing Point*—Test Method **D2386**.

10.1.6 *Sulfur*—Test Method **D2622**.

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

10.1.8 *Corrosion (Copper Strip)*—Test Method **D130**, 2 h test at $\pm 0^\circ\text{C}$ 100 °C in bomb.

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1256.

⁶ Stadis 450 is a registered trademark marketed by Innospec, Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EY, UK.

TABLE 1 Detailed Requirements for Unleaded Aviation Gasoline^A

Octane Ratings		Grade 94	ASTM Test Method ^B
Knock value, Motor Octane Number ^C	min	94.0	D2700
Knock value, Research Octane Number ^C	min	Report	D2699
Identifying Color		colorless	
Density at 15°C, kg/m ³		Report	D1298 or D4052
Density at 15 °C, kg/m ³		Report	D1298 or D4052
Distillation			D86
Initial boiling point, °C		Report	
Fuel Evaporated			
10 volume % at °C	max	75	
40 volume % at °C	min	75	
50 volume % at °C	max	105	
90 volume % at °C	max	135	
Final boiling point, °C	max	170	
Final boiling point, °C	max	190 ^D	D86
Sum of 10 % + 50 % evaporated temperatures, °C	min	135	
Recovery volume %	min	97	
Residue volume %	max	1.5	
Loss volume %	max	1.5	
Vapor pressure, 38°C, kPa	min	38.0	D323 or D5191 ^D
	max	49.0	
Vapor pressure, 38 °C, kPa	min	38.0	D323 or D5191 ^E
	max	49.0	
Freezing point, °C	max	-58 ^E	D2386
Freezing point, °C	max	-58 ^F	D2386
Sulfur, mass %	max	0.05	D2622
Net heat of combustion, MJ/kg ^E	min	43.5	D4529 or D3338
Net heat of combustion, MJ/kg ^G	min	43.5	D4529 or D3338
Corrosion, copper strip, 2 h at 100°C	max	No. 1	D130
Corrosion, copper strip, 2 h at 100 °C	max	No. 1	D130
Oxidation stability(5 h aging) ^G			D873
Oxidation stability(5 h aging) ^H			D873
Potential gum, mg/100 mL	max	6	
Water reaction			D1094
Volume change, mL	max	±2	
Electrical conductivity, pS/m	max	450 ^I	D2624
Electrical conductivity, pS/m	max	450 ^I	D2624
Tetraethyl Lead, g Pb/L	max	0.0130	D3237 or D5059

^A For compliance of test results against the requirements of Table 1, see 6.2.

^B The test methods indicated in this table are referred to in Section 10.

^C Knock ratings shall be reported to the nearest 0.1 octane number.

^D Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1801. Contact ASTM Customer Service at service@astm.org.

^E Test Method D5191 shall be the referee vapor pressure method.

^F If no crystals have appeared on cooling to -58°C, -58 °C, the freezing point may be reported as less than -58°C, -58 °C.

^G For all grades use either Eq 1 or Table 1 in Test Method D4529 or Eq 2 in Test Method D3338. Test Method D4809 may be used as an alternative. In case of dispute, Test Method D4809 shall be used.

^H If mutually agreed upon between the purchaser and the supplier, a 46-h-16 h aging gum requirement may be specified instead of the 5-h-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 24-24 mg / L.

^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 50-50 pS / m.

Maximum 450-450 pS / m.

The supplier shall report the amount of additive added.

10.1.9 *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.

10.1.10 *Water Reaction*—Test Method D1094.

10.1.11 *Electrical Conductivity*—Test Method D2624.

10.1.12 *Lead-Test Methods*—Test Methods D3237 or D5059 (Test Method C).

11. Keywords

11.1 Avgas; aviation gasoline; gasoline; unleaded Avgas; unleaded aviation gasoline