Designation: ~~D910 – 16a~~ D910 – 17

An American National Standard

Standard Specification for Leaded Aviation Gasolines[1]

This standard is issued under the fixed designation D910; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

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

1.2 This specification defines specific types of aviation gasolines for civil use. 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 values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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
D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
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of Test for Knock Characteristics of Motor Fuels Below 100 Octane Number by the Motor Method; Replaced by D 2700 (Withdrawn 1969)[3]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D614 Method of Test for Knock Characteristics of Aviation Fuels by the Aviation Method; Replaced by D 2700 (Withdrawn 1970)[3]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
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
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
D2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel

[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
D3341 Test Method for Lead in Gasoline—Iodine Monochloride Method
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)
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 *aviation gasoline, n*—gasoline possessing specific properties suitable for fueling aircraft powered by reciprocating spark ignition engines.

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.

3.2 *Abbreviations:*

3.2.1 *LL*—low lead

3.2.2 *VLL*—very low lead

4. General

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

5. Classification

5.1 Four grades of leaded aviation gasoline are provided, known as:

~~Grade 80~~
Grade 91
Grade 100
Grade 100LL
Grade 100VLL

NOTE 1—The above grade names are based on their octane/performance numbers as measured by the now obsolete Test Method D614 (Discontinued 1970). A table for converting octane/performance numbers obtained by Test Method D2700 motor method into aviation ratings was last published in Specification D910–94 in the 1995 *Annual Book of ASTM Standards*, Vol 05.01.

5.2 Grades 100, 100LL, and 100VLL represent aviation gasolines identical in minimum antiknock quality but differing in maximum lead content and color. The color identifies the difference for engines that have a low tolerance to lead.

NOTE 2—Listing of, and requirements for, Avgas Grades 91/98, ~~108/135~~108/135, and 115/145 appeared in the 1967 version of this specification. U.S. Military Specification MIL-G-5572F, dated January 24, 1978 (withdrawn March 22, 1988), also covers grade 115/145 aviation gasoline, and is available as a research report.[4] Listing of, and requirements for, Avgas Grade 80 appeared in the 2016 version of this specification.

5.3 Although the grade designations show only a single octane rating for each grade, they shall meet a minimum lean mixture motor rating and a minimum rich mixture supercharge rating (see X1.2.2).

6. Materials and Manufacture

6.1 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.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1255.

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

6.2.1 *Tetraethyl Lead,* shall be added in the form of an antiknock mixture containing not less than 61 mass percent of tetraethyl lead and sufficient ethylene dibromide to provide two bromine atoms per atom of lead. The balance shall contain no added ingredients other than kerosine, an approved oxidation inhibitor, and blue dye, as specified herein. The maximum concentration limit for each grade of gasoline is specified in Table 1.

6.2.1.1 If mutually agreed upon by the fuel producer and additive vendor, tetraethyl lead antiknock mixture may be diluted with 20 mass percent of a mixed aromatic solvent having a minimum flash point of 60 °C according to Test Methods D93 when the product is to be handled in cold climates. The TEL content of the dilute product is reduced to 49 mass percent, so that the amount of antiknock additive must be adjusted to achieve the necessary lead level. The dilute product still delivers two bromine atoms per atom of lead.

6.2.2 *Dyes*—The maximum concentration limits in each grade of gasoline are specified in Table 1.

6.2.2.1 The only blue dye that shall be present in the finished gasoline shall be essentially 1,4-dialkylaminoanthraquinone.

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

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

6.3 *Additives*—These may be added to each grade of aviation gasoline in the amount and of the composition specified in the following list of approved materials.[5] The quantities and types shall be declared by the manufacturer. Additives added after the point of manufacture shall also be declared.

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

6.3.1.1 2,6-ditertiary butyl-4-methylphenol.

6.3.1.2 2,4-dimethyl-6-tertiary butylphenol.

6.3.1.3 2,6-ditertiary butylphenol.

6.3.1.4 75 % minimum 2,6-ditertiary butylphenol plus 25 % maximum mixed *tertiary* and *tritertiary* butylphenols.

6.3.1.5 75 % minimum di- and tri-isopropyl phenols plus 25 % maximum di- and tri-*tertiary* butylphenols.

6.3.1.6 72 % minimum 2,4-dimethyl-6-tertiary butylphenol plus 28 % maximum monomethyl and dimethyl *tertiary* butylphenols.

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

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

NOTE 3—Addition of isopropyl alcohol (IPA) may reduce knock ratings below minimum specification values (see X1.2.4).[6]

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 volume percent 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.

6.3.3 *Electrical Conductivity Additive*—Stadis 450[7] 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 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

[5] 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.

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1526.

[7] Stadis is a registered trademark marketed by Octel America, Inc., Newark, DE 19702.

TABLE 1 Detailed Requirements for Leaded Aviation Gasolines[A]

Property		Grade ~~80~~ 91	Grade 100VLL	Grade 100LL	Grade 100	ASTM Test Method[B]
COMBUSTION						
Net heat of combustion, MJ/kg[C]	min	43.5	43.5	43.5	43.5	D4529 or D3338
Octane Rating						
Knock value, lean mixture[D]						
~~Motor Octane Number~~	~~min~~	~~80.7~~	~~99.6~~	~~99.6~~	~~99.6~~	~~D2700~~
Motor Octane Number	min	90.8	99.6	99.6	99.6	D2700
~~Aviation Lean Rating~~	~~min~~	~~80.0~~	~~100.0~~	~~100.0~~	~~100.0~~	~~D2700~~
Aviation Lean Rating	min	91.0	100.0	100.0	100.0	D2700
Knock value, rich mixture						
~~Octane number~~	~~min~~	~~87~~				~~D909~~
Octane number	min	98				D909
Performance number[E,F]	min		130.0	130.0	130.0	D909
COMPOSITION						
Sulfur, mass percent	max	0.05	0.05	0.05	0.05	D1266 or D2622
Tetraethyl lead[G]						
~~TEL, mL/L~~	~~min~~	~~...~~	~~0.27~~	~~0.27~~	~~0.27~~	~~D3341 or D5059~~
TEL, mL/L	min		0.27	0.27	0.27	D3341 or D5059
	~~max~~	~~0.13~~	~~0.43~~	~~0.53~~	~~1.06~~	
	max	0.53	0.43	0.53	1.06	
~~Pb, g/L~~	~~min~~	~~...~~	~~0.28~~	~~0.28~~	~~0.28~~	
Pb, g/L	min		0.28	0.28	0.28	
	~~max~~	~~0.14~~	~~0.45~~	~~0.56~~	~~1.12~~	
	max	0.56	0.45	0.56	1.12	
~~Color~~		~~red~~	~~blue~~	~~blue~~	~~green~~	~~D2392~~
Color		brown	blue	blue	green	D2392
Dye content[H], mg/L						
~~Blue dye~~	~~max~~	~~0.2~~	~~2.7~~	~~2.7~~	~~2.7~~	
Blue dye	max	3.1	2.7	2.7	2.7	
Yellow dye	max	none	none	none	2.8	
~~Red dye~~	~~max~~	~~2.3~~	~~none~~	~~none~~	~~none~~	
Red dye	max	2.7	none	none	none	
Orange dye	max	6.0	none	none	none	

Requirements for All Grades

Property			ASTM Test Method
VOLATILITY			
Vapor pressure, 38 °C, kPa	min	38.0	D323 or D5191[I]
	max	49.0	
Density at 15 °C, kg/m^3		Report	D1298 or D4052
Distillation, °C			D86
Initial boiling point		Report	
Fuel Evaporated			
10 volume percent at °C	max	75	
40 volume percent at °C	min	75	
50 volume percent at °C	max	105	
90 volume percent at °C	max	135	
Final boiling point	max	170	
Sum of 10 % + 50 % evaporated temperatures	min	135	
Recovery volume percent	min	97	
Residue volume percent	max	1.5	
Loss volume percent	max	1.5	
FLUIDITY			
Freezing point, °C	max	–58[J]	D2386
CORROSION			
Copper strip, 2 h at 100 °C	max	No. 1	D130
CONTAMINANTS			
Oxidation stability, mg/100 mL (5 h aging)[K,L]			D873
Potential gum	max	6	
Lead precipitate	max	3	
Water reaction			D1094
Volume change, mL	max	±2	
OTHER			
Electrical conductivity, pS/m	max	450[M]	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] 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.
[D] Both Motor Octane Number (MON) and Aviation Lean Mixture values shall be reported.
[E] A performance number of 130.0 is equivalent to a knock value determined using *iso*-octane plus 0.34 mL TEL/L.
[F] Knock ratings shall be reported to the nearest 0.1 octane/performance number.

[G] Historically, market survey and test engine data have indicated that for ASTM D910 leaded aviation gasolines, tetraethyl lead concentration typically must exceed 0.28 g lead per litre (0.265 mL tetraethyl lead per litre) for Grades 100, 100LL, and 100VLL. Fuels containing substantially less lead may not satisfy the octane requirements of reciprocating spark ignition aviation engines while meeting the lean and rich mixture limits specified in Table 1.
[H] The maximum dye concentrations shown do not include solvent in dyes supplied in liquid form.
[I] Test Method D5191 shall be the referee vapor pressure method.
[J] If no crystals have appeared on cooling to −58 °C, the freezing point may be reported as less than −58 °C.
[K] 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 lead precipitate shall not exceed 4 mg/100 mL. In such fuel the permissible antioxidant shall not exceed 24 mg/L.
[L] 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 X1.7.1.
[M] 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.

7. Detailed Requirements

7.1 The 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 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 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 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 refinery specification compliance testing shall be performed on a sample taken following procedures in Practice D4057.

9.2 A number of 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 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 *Knock Value (Lean Rating)*—Test Method D2700.
11.1.2 *Knock Value (Rich Rating)*—Test Method D909.
11.1.3 *Tetraethyllead*—Test Methods D3341 or D5059.
11.1.4 *Color*—Test Method D2392.
11.1.5 *Density*—Test Methods D1298 or D4052.
11.1.6 *Distillation*—Test Method D86.
11.1.7 *Vapor Pressure*—Test Methods D323 or D5191.
11.1.8 *Freezing Point*—Test Method D2386.
11.1.9 *Sulfur*—Test Methods D1266 or D2622.
11.1.10 *Net Heat of Combustion*—Test Methods D4529 or D3338.
11.1.11 *Corrosion (Copper Strip)*—Test Method D130, 2 h test at 100 °C in bomb.
11.1.12 *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.
11.1.13 *Water Reaction*—Test Method D1094.
11.1.14 *Electrical Conductivity*—Test Methods D2624.

12. Keywords

12.1 Avgas; aviation gasoline; gasoline

APPENDIX

(Nonmandatory Information)

X1. PERFORMANCE CHARACTERISTICS OF AVIATION GASOLINES

X1.1 Introduction

X1.1.1 Aviation gasoline is a complex mixture of relatively volatile hydrocarbons that vary widely in their physical and chemical properties. The engines and aircraft impose a variety of mechanical, physical, and chemical environments. The properties of aviation gasoline (Table X1.1) must be properly balanced to give satisfactory engine performance over an extremely wide range of conditions.

X1.1.2 The ASTM requirements summarized in Table 1 are quality limits established on the basis of the broad experience and close cooperation of producers of aviation gasoline, manufacturers of aircraft engines, and users of both commodities. The values given are intended to define 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 Specifications covering antiknock quality define the grades of aviation gasoline. 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 Combustion Characteristics (Antiknock Quality and Antiknock Compound Identification)

X1.2.1 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 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.

X1.2.2 Aviation gasoline grades are also identified by two numbers separated by a slant line (/). The first number is called the lean mixture rating and the second number is called the rich mixture rating. This specification describes four grades of aviation gasoline as follows: ~~80/87,~~91/98, 100/130, 100/130LL, and 100/130VLL. Numbers below 100 are octane numbers, while numbers above 100 are performance numbers. At 100, octane number and performance number are equal. The suffix LL describes a grade containing lower tetraethyllead than a second grade of identical lean and rich mixture ratings. The suffix VLL designates a grade containing lower tetraethyllead than grade 100/130LL of identical lean and rich mixture ratings.

X1.2.3 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

TABLE X1.1 Performance Characteristics of Aviation Gasoline

Performance Characteristics	Test Methods	Sections
Combustion characteristics	knock value (lean mixture)	X1.2.4
Antiknock quality and antiknock compound identification	knock value (rich mixture)	X1.2.5
	isopropyl alcohol	X1.2.6
	tetraethyllead	X1.2.7
	dyes	X1.2.8
Fuel metering and aircraft range	density	X1.3.1
	net heat of combustion	X1.3.2
Carburetion and fuel vaporization	vapor pressure	X1.4.1
	distillation	X1.4.2
Corrosion of fuel system and engine parts	copper strip corrosion	X1.5.1
	sulfur content	X1.5.2
Fluidity at low temperatures	freezing point	X1.6
Fuel cleanliness, handling, and storage stability	existent gum	X1.7.1
	potential gum	X1.7.2
	visible lead precipitate	X1.7.3
	water reaction	X1.7.5