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An American National Standard

Standard Specification for Aviation Gasolines[1]

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

1. Scope

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

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.

2. Referenced Documents

2.1 *ASTM Standards:*

D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure[2]

D 93 Test Methods for Flash-Point by Pensky-Martens Closed Cup Tester[2]

D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test[2]

D 156 Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)[2]

D 323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)[2]

D 357 Method of Test for Knock Characteristics of Motor Fuels Below 100 Octane Number by the Motor Method[3]

D 381 Test Method for Gum Content in Fuels by Jet Evaporation[2]

D 614 Method of Test for Knock Characteristics of Aviation Fuels by the Aviation Method[4]

D 873 Test Method for Oxidation Stability of Aviation Fuels (Potential Residue Method)[2]

D 909 Test Method for Knock Characteristics of Aviation Gasolines by the Supercharge Method[5]

D 1094 Test Method for Water Reaction of Aviation Fuels[2]

D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)[2]

D 1298 Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method[2]

D 2386 Test Method for Freezing Point of Aviation Fuels[2]

D 2392 Test Method for Color of Dyed Aviation Gasolines[2]

D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry[2]

D 2624 Test Method for Electrical Conductivity of Aviation and Distillate Fuels[2]

D 2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel[5]

D 3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels[6]

D 3341 Test Method for Lead in Gasoline—Iodine Monochloride Method[6]

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter[6]

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products[6]

D 4171 Specification for Fuel System Icing Inhibitors[6]

D 4306 Practice for Aviation Fuel Sampling Containers for Tests Affected by Trace Contamination[6]

D 4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels[6]

D 4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)[6]

D 4865 Guide for the Generation and Dissipation of Static Electricity in Petroleum Fuel Systems[6]

D 5006 Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels[6]

D 5059 Test Methods for Lead in Gasoline by X-Ray Spectroscopy[6]

D 5190 Test Method for Vapor Pressure of Petroleum Products (Automatic Method)[6]

D 5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)[6]

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.J0 on Aviation Fuels.

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[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] Discontinued 1969. Replaced by D 2700.

[4] Discontinued; see 1970 *Annual Book of ASTM Standards*.

[5] *Annual Book of ASTM Standards*, Vol 05.05.

[6] *Annual Book of ASTM Standards*, Vol 05.02.

D 6469 Guide for Microbial Contamination in Fuels and Fuel Systems[7]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[8]

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.

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 aviation gasoline are provided, known as:

Grade 80
Grade 91
Grade 100
Grade 100LL

NOTE 1—The above grade names are based on their octane/performance numbers as measured by the now obsolete Test Method D 614 Knock Characteristics of Aviation Fuels by the Aviation Method (Discontinued 1970). A table for converting octane/performance numbers obtained by the Test Method D 2700 Motor Method into aviation ratings was last published in Specification D 910–94 in the 1995 *Annual Book of ASTM Standards*, Vol 05.01.

5.2 Grades 100 and 100LL represent two aviation gasolines identical in anti-knock 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 91/96, 108/135 and 115/145 appeared in the 1967 version of this specification. US 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.[9]

5.3 Although the grade designations show only a single octane rating for each grade, each grade must meet a minimum lean mixture motor rating and a minimum rich mixture super-charge 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.

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 m % 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 m % of a mixed aromatic solvent having a minimum flash point of 60°C according to Test Method D 93 when the product is to be handled in cold climates. The TEL content of the dilute product is reduced to 49 m%, 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 which shall be present in the finished gasoline shall be essentially 1,4-dialkylaminoanthraquinone.

6.2.2.2 The only yellow dyes which 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 which shall be present in the finished gasoline shall be essentially alkyl derivatives of azobenzene-4-azo-2-naphthol.

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

6.3 *Additives—Optional*, may be added to each grade of aviation gasoline in the amount and of the composition specified in the following list of approved materials.[10] The quantities and types must be declared by the manufacturer and agreed to by the purchaser.

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 % min 2,6-ditertiary butylphenol plus 25 % max mixed *tertiary* and *tritertiary* butylphenols.

6.3.1.5 75 % min di- and tri-isopropyl phenols plus 25 % max di- and tri-*tertiary* butylphenols.

6.3.1.6 72 % min 2,4-dimethyl-6-tertiary butylphenol plus 28 % max 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.

[7] *Annual Book of ASTM Standards*,Vol 05.04.

[8] *Annual Book of ASTM Standards*, Vol 14.02.

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

[10] 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.

TABLE 1 Detailed Requirements for Aviation Gasolines[A]

		Grade 80	Grade 91	Grade 100LL	Grade 100	ASTM Test Method[B]
Knock value, lean mixture						
Motor Method						D 2700
Octane number	min	80.0	91.0	99.5	99.5	
Knock value, rich mixture						
Supercharge rating						D 909
Octane number	min	87.0	98.0			
Performance number[C,D]	min			130.0	130.0	
Tetraethyl lead, mL TEL/L	max	0.13	0.53	0.53	1.06	D 3341 or D 5059
gPb/L	max	0.14	0.56	0.56	1.12	
Color		red	brown	blue	green	D 2392
Dye content[E]						
Blue dye, mg/L	max	0.2	3.1	2.7	2.7	
Yellow dye, mg/L	max	none	none	none	2.8	
Red dye, mg/L	max	2.3	2.7	none	none	
Orange dye, mg/L	max	none	6.0	none	none	

Requirements for All Grades			
Density at 15°C, kg/m^3		Report	D 1298 or D 4052
Distillation			D 86
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	
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	D 323 or D 5190
	max	49.0	or D 5191[F]
Freezing point, °C	max	−58	D 2386
Sulfur, m %	max	0.05	D 1266 or D 2622
Net heat of combustion, MJ/kg[G]	min	43.5	D 4529 or D 3338
Corrosion, copper strip, 2 h at 100°C	max	No. 1	D 130
Oxidation stability (5 h aging)[H,I]			D 873
Potential gum, mg/100 mL	max	6	
Lead precipitate, mg/100 mL	max	3	
Water reaction			D 1094
Volume change, mL	max	±2	
Electrical conductivity, pS/m	max	450[J]	D 2624

[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] A performance number of 130.0 is equivalent to a knock value determined using *iso*-octane plus 0.34 mL TEL/L.
[D] Knock ratings shall be reported to the nearest 0.1 octane/performance number.
[E] The maximum dye concentrations shown do not include solvent in dyes supplied in liquid form.
[F] Test Method D 5191 shall be the referee vapor pressure method.
[G] For all grades use either Eq 1 or Table 1 in Test Method D 4529 or Eq 2 in Test Method D 3338. Test Method D 4809 may be used as an alternative. In case of dispute, Test Method D 4809 shall be used.
[H] 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.
[I] Test Method D 381 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.
[J] 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.

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

6.3.2.1 *Isopropyl Alcohol (IPA, propan-2-ol)*, conforming to the requirements of Specification D 4171 (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).[11]

6.3.2.2 *Di-Ethylene Glycol Monomethyl Ether (Di-EGME)*, conforming to the requirements of Specification D 4171 (Type III). May be used in concentrations of 0.10 to 0.15 volume %

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

when required by the aircraft owner/operator.

6.3.2.3 Test Method D 5006 can be used to determine the concentration of Di-EGME in aviation fuels.

6.3.3 *Electrical Conductivity Additive*—Stadis 450[12] 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 = 22.5 g/m^3
DCI-6A	MAC = 9.0 g/m^3
HITEC 580	MAC = 22.5 g/m^3
MOBILAD F800	MAC = 22.5 g/m^3
NALCO/EXXON 5403	MAC = 22.5 g/m^3
NALCO/EXXON 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

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 E 29. Where multiple determinations are made, the average result, rounded according to Practice E 29, shall be used.

8. Workmanship, Finish and Appearance

8.1 The aviation gasoline herein specified 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 herein.

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

9. Sampling

9.1 Because of the importance of proper sampling procedures in establishing fuel quality, use the appropriate procedures in Practice D 4057.

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 D 4306.

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 D 2700.

11.1.2 *Knock Value (Rich Rating)*—Test Method D 909.

11.1.3 *Tetraethyllead*—Test Methods D 3341 or D 5059.

11.1.4 *Color*—Test Method D 2392.

11.1.5 *Density*—Test Methods D 1298 or D 4052.

11.1.6 *Distillation*—Test Method D 86.

11.1.7 *Vapor Pressure*—Test Methods D 323, D 5190, or D 5191.

11.1.8 *Freezing Point*—Test Method D 2386.

11.1.9 *Sulfur*—Test Methods D 1266 or D 2622.

11.1.10 *Net Heat of Combustion*—Test Methods D 4529 or D 3338.

11.1.11 *Corrosion (Copper Strip)*—Test Method D 130, 2 h test at 100°C in bomb.

11.1.12 *Potential Gum and Visible Lead Precipitate*—Test Method D 873 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 D 1094.

11.1.14 *Electrical Conductivity*—Test Method D 2624.

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;