Standard Specification for 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 (\(\epsilon\)) indicates an editorial change since the last revision or reapproval.

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

1. Scope\(^2\)

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.

2. Referenced Documents

2.1 ASTM Standards:\(^3\)

- D86 Test Method for Distillation of Petroleum Products 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\(^3\)
- 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\(^3\)
- 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 (Specific Gravity), 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\(^3\)
- 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
- 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

\(^1\) This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.30.02 on Aviation Gasoline.


\(^2\) 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.

\(^3\) Withdrawn. 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.*
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 Five grades of leaded aviation gasoline are provided, known as:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 80</td>
<td></td>
</tr>
<tr>
<td>Grade 91</td>
<td></td>
</tr>
<tr>
<td>Grade 100</td>
<td></td>
</tr>
<tr>
<td>Grade 100LL</td>
<td></td>
</tr>
<tr>
<td>Grade 100VLL</td>
<td></td>
</tr>
</tbody>
</table>

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.


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.

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 % 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 % 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 %, 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-diallylaminanthraquinone.

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-benzenedioli 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.

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

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. 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.

6.4 Tetraethyl Lead Antiknock Additives—Mandatory. Shall be added in the form of an antiknock mixture containing not less than 61 mass % 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.

6.4.1 If mutually agreed upon by the fuel producer and additive vendor, tetraethyl lead antiknock mixture may be diluted with 20 mass % 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 %, 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.

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6.4.3.1 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.

6.4.3.1.1 2,6-ditertiary butyl-4-methylphenol.
6.4.3.1.2 2,4-dimethyl-6-tertiary butylphenol.
6.4.3.1.3 2,6-ditertiary butylphenol.

4 Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1255.
TABLE 1 Detailed Requirements for Aviation Gasolines

<table>
<thead>
<tr>
<th></th>
<th>Grade 80</th>
<th>Grade 91</th>
<th>Grade 100VLL</th>
<th>Grade 100LL</th>
<th>Grade 100</th>
<th>ASTM Test Method</th>
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<tr>
<td><strong>Octane Ratings</strong></td>
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<td><strong>Knock value, lean mixture</strong></td>
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<td>Motor Octane Number</td>
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<td>99.6</td>
<td>99.6</td>
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<tr>
<td>Aviation Lean Rating</td>
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<td>91.0</td>
<td>100.0</td>
<td>100.0</td>
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<td>D2700</td>
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<td></td>
<td>max 130.0</td>
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<td>130.0</td>
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<td><strong>Tetraethyl lead, mL</strong></td>
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<td>TEL/L</td>
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<td>Pb/mL</td>
<td>max 0.14</td>
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<td><strong>Color</strong></td>
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<td>Blue dye, mg/L</td>
<td>max 0.2</td>
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<tr>
<td>Yellow dye, mg/L</td>
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<td>none</td>
<td>none</td>
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<td>Red dye, mg/L</td>
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<td>2.7</td>
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<tr>
<td>Orange dye, mg/L</td>
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<td>none</td>
<td>none</td>
<td>none</td>
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<tr>
<td><strong>Requirements for All Grades</strong></td>
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<tr>
<td><strong>Density at 15°C, kg/m³</strong></td>
<td>Report</td>
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<td>D1298 or D4052</td>
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<td><strong>Distillation</strong></td>
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<td>D86</td>
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<td>Initial boiling point, °C</td>
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<td>Fuel Evaporated</td>
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<td>10 volume % at °C</td>
<td>max 75</td>
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<tr>
<td>40 volume % at °C</td>
<td>min 75</td>
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<td>50 volume % at °C</td>
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<td>90 volume % at °C</td>
<td>max 135</td>
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<tr>
<td>Final boiling point, °C</td>
<td>max 170</td>
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<tr>
<td>Sum of 10 % + 50 % evaporated temperatures, °C</td>
<td>min 135</td>
<td></td>
<td></td>
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<tr>
<td>Recovery volume %</td>
<td>min 97</td>
<td></td>
<td></td>
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<tr>
<td>Residue volume %</td>
<td>max 1.5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Loss volume %</td>
<td>max 1.5</td>
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</tr>
<tr>
<td>Vapor pressure, 38°C, kPa</td>
<td>max 38.0</td>
<td></td>
<td></td>
<td></td>
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<td>D323 or D5190</td>
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<tr>
<td>Freezing point, °C</td>
<td>max −58°F</td>
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<td></td>
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<td>D2386</td>
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<td>Sulfur, mass %</td>
<td>max 0.05</td>
<td></td>
<td></td>
<td></td>
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<td>D1266 or D2622</td>
</tr>
<tr>
<td>Net heat of combustion, MJ/kg</td>
<td>min 43.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D4529 or D3338</td>
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<td>Corrosion, copper strip, 2 h at 100°C</td>
<td>max No. 1</td>
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<td>D130</td>
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<tr>
<td>Oxidation stability (5 h aging)</td>
<td>max 6</td>
<td></td>
<td></td>
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<td>D873</td>
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<tr>
<td>Potential gum, mg/100 mL</td>
<td>max 6</td>
<td></td>
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<td>Lead precipitate, mg/100 mL</td>
<td>max 3</td>
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<td>Water reaction</td>
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<td>D1094</td>
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<tr>
<td>Volume change, mL</td>
<td>max ±2</td>
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<td>Electrical conductivity, pS/m</td>
<td>max 450</td>
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<td>D2624</td>
</tr>
</tbody>
</table>

*For compliance of test results against the requirements of Table 1, see 7.2.
*A The test methods indicated in this table are referred to in Section 11.
*B Both Motor Octane Number (MON) and Aviation Lean Mixture values shall be reported.
*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 D5191 shall be the referee vapor pressure method.
*G If no crystals have appeared on cooling to −58°C, the freezing point may be reported as less than −58°C.
*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.
*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.
6.1.4 75 % minimum 2,6-diteritary butylphenol plus 25 % maximum mixed tertiary and triteritary butylphenols.
6.1.5 75 % minimum di- and tri-isopropyl phenols plus 25 % maximum di- and tri-tertiary butylphenols.
6.1.6 72 % minimum 2,4-dimethyl-6-tertiary butylphenol plus 28 % maximum monomethyl and dimethyl tertiary butylphenols.
6.1.7 N,N′-di-isopropyl-para-phenylenediamine.
6.1.8 N,N'-di-secondary-butyl-para-phenylenediamine.
6.2 Fuel System Icing Inhibitor (FSII)—One of the following may be used.
6.2.1 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 Table 1).

6.2.2 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 % when required by the aircraft owner/operator.

6.2.3 Test Method D5006 can be used to determine the concentration of Di-EGME in aviation fuels.
6.3 Electrical Conductivity Additive—Stadis 4507 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.
6.4 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.

<table>
<thead>
<tr>
<th>Additive</th>
<th>MAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCI-4A</td>
<td>22.5 g/m³</td>
</tr>
<tr>
<td>DCI-6A</td>
<td>9.0 g/m³</td>
</tr>
<tr>
<td>HITELG 580</td>
<td>22.5 g/m³</td>
</tr>
<tr>
<td>NALCO 5403</td>
<td>22.5 g/m³</td>
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<tr>
<td>NALCO 5406</td>
<td>11.0 g/m³</td>
</tr>
<tr>
<td>PRI-19</td>
<td>22.5 g/m³</td>
</tr>
<tr>
<td>UNICOR J</td>
<td>22.5 g/m³</td>
</tr>
<tr>
<td>SPEC-AID 8Q22</td>
<td>24.0 g/m³</td>
</tr>
<tr>
<td>TOLAD 351</td>
<td>24.0 g/m³</td>
</tr>
<tr>
<td>TOLAD 4410</td>
<td>22.5 g/m³</td>
</tr>
</tbody>
</table>

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, D5190, 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.
11.1.14 Electrical Conductivity—Test Methods D2624.

12. Keywords

12.1 Avgas; aviation gasoline; gasoline
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 five 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 tetraethyllead added to isoctane (2,2,4-trimethylpentane). Octane number is defined arbitrarily as the percentage of isoctane in that blend of isoctane and n-heptane that the gasoline matches in knock characteristics when compared by the procedure specified. The quantities of tetraethyllead added to isoctane 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 isoctane, operating at equal knocking intensity. The lean mixture rating together with the rich mixture rating can be used as a guide to the amount of knock-limited power that may be obtained in a full-scale engine under cruise (lean) and take-off (rich) conditions.

X1.2.4 It has been observed that when isopropyl alcohol (IPA) is added to a Grade 100, Grade 100LL, or Grade 100VLL aviation gasoline as a fuel system icing inhibitor, the antiknock rating of the fuel can be reduced. Since isopropyl alcohol is normally added in the field at the point of use, the operator is cautioned that performance numbers on the alcohol-fuel blend may not meet specification minimums. Typical performance number reductions with addition of one volume % IPA has been 0.5 motor octane number on the lean rating and 3.0 to 3.5 performance number on the rich rating. Thus a Grade 100, 100LL, or 100VLL aviation gasoline rated in the knock test engines at the point of manufacture to be 99.5/130 octane/performance number might, with the addition of one volume % alcohol, be about 99/127 octane/performance number. At three volume %, the reductions are about 1.5 octane, operating at equal knock-limited power that may be obtained in a full-scale engine under cruise (lean) and take-off (rich) conditions.

### TABLE X1.1 Performance Characteristics of Aviation Gasoline

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recommended 1% maximum level. On Grade 80 aviation gasoline, addition of the IPA additive can increase the octane rating.

X1.2.5 Knock Value, Lean Mixture Rating (Test Method D2700)—The specification parameter knock value, lean value mixture lists both “Motor Octane Number” (MON) and “Aviation Lean,” as determined by Test Method D2700. Historically, aviation lean ratings were determined (from 1941 through 1970) by Test Method D614. An extensive comparison of National Exchange Group data from 1947 through 1964 established that motor octave numbers as determined by Test Methods D357 and D1948 could be converted to equivalent Test Method D614 ratings. A table to convert MON to the corresponding aviation lean rating was included in Test Method D2700, which was first issued in 1968 as a revision, consolidation and intended eventual replacement of Test Methods D357 (Withdrawn 1969), D614 (Withdrawn 1970), and D1948 (Withdrawn 1968). Currently “Aviation Lean” ratings are only determinable from the MON conversion table in Test Method D2700. However, the equivalent “Aviation Lean” rating is maintained as a specified parameter in Table 1 to ensure aircraft compliance with historical type certification data sheets.

X1.2.6 Rich Mixture Rating (Supercharge Test Method D909)—This test method uses a laboratory engine that is capable of being operated at varying air-fuel mixtures and through a range of supercharge manifold pressures. The rating of a fuel is determined by comparing its knock-limited power with those for bracketing blends of reference fuels under standard operating conditions. The rating is made at the rich peak of the mixture response curve (about 0.11 fuel-air ratio) of the lower bracketing reference fuel.

X1.2.7 Tetraethyllead—Tetraethyllead offers the most economical means of providing high antiknock value for aviation gasoline. It is added to aviation gasoline in the form of a fluid which, in addition to tetraethyllead, contains an organic halide scavenging agent and an identifying blue dye. The scavenging agent is needed to keep the tetraethyllead combustion products volatile so that they will theoretically be completely discharged from the cylinder. Actually, lead compounds are deposited in the combustion chamber and some find their way into the lubricating oil. The products of combustion of tetraethyllead fluid are also known to be corrosive. Since deposition and corrosive tendencies are undesirable, the quantity of tetraethyllead in aviation gasoline is limited by specification commensurate with economic considerations.

X1.2.8 Dyes—The law provides that all fuels containing tetraethyllead must be dyed to denote the presence of the poisonous component. Colors are also used in aviation fuels to differentiate between grades. Service experience has indicated that only certain dyes and only certain amounts of dye can be tolerated without manifestation of induction system deposition. The names of the approved dyes are specified as well as the maximum quantity of each permissible in each grade.

X1.3 Fuel Metering and Aircraft Range

X1.3.1 Density—Density is a property of a fluid and is of significance in metering flow and in mass-volume relationships for most commercial transactions. It is particularly useful in empirical assessments of heating value when used with other parameters such as aniline point or distillation.

X1.3.2 Net Heat of Combustion—The net heat of combustion provides a knowledge of the amount of energy obtainable from a given fuel for the performance of useful work, in this instance, power. Aircraft design and operation are dependent upon the availability of a certain predetermined minimum amount of energy as heat. Consequently, a reduction in heat energy below this minimum is accompanied by an increase in fuel consumption with corresponding loss of range. Therefore, a minimum net heat of combustion requirement is incorporated in the specification. The determination of net heat of combustion is time consuming and difficult to conduct accurately. This led to the development and use of the aniline point and density relationship to estimate the heat of combustion of the fuel. This relationship is used along with the sulfur content of the fuel to obtain the net heat of combustion for the purposes of this specification. An alternative calculation, Test Method D3338, is based on correlations of aromatics content, density, volatility, and sulfur content. This test method may be preferred at refineries where all these values are normally obtained and the necessity to obtain the aniline point is avoided. The direct measurement method is normally used only as a referee method in cases of dispute.

X1.3.3 No great variation in density or heat of combustion occurs in modern aviation gasolines, since they depend on hydrocarbon composition that is already closely controlled by other specification properties.

X1.4 Carburetion and Fuel Vaporization

X1.4.1 In many spark-ignition aviation engines, the gasoline is metered in liquid form through the carburetor where it is mixed with air and vaporized before entering the supercharger from which the fuel-air mixture enters the cylinder of the engine. In other types of engines, the fuel may be metered directly into the supercharger, the cylinder, or the combustor. The volatility, the tendency to evaporate or change from a liquid to a gaseous state, is an extremely important characteristic of aviation fuel.

X1.4.2 Gasolines that vaporize too readily may boil in fuel lines or carburetors, particularly as altitude increases, and cause vapor lock with resultant stoppage of fuel flow to the engine. Conversely, fuels that do not completely vaporize may cause engine malfunctioning of other sorts. Therefore, a proper balance of the volatility of the various hydrocarbon components is essential to satisfactory performance of the finished fuel.

X1.4.3 Vapor Pressure—The vapor pressure of an aviation gasoline is the measure of the tendency of the more volatile components to evaporate. Experience has shown that fuels having a Reid vapor pressure no higher than 49 kPa will be free of vapor-locking tendencies under most conditions of aircraft usage. A research report is available.

X1.4.4 Distillation—The relative proportions of all the hydrocarbon components of a gasoline are measured in terms

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8 Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1146.
X1.6 Fluidity at Low Temperatures

X1.6.1 A freezing point requirement is specified to preclude solidification of any hydrocarbon components at extremely low temperatures with consequent interference with fuel flow to the engine.

X1.6.2 Fuel System Icing Inhibitor—Isopropyl alcohol (IPA), approved in 6.3.2.1, and diethylene glycol monomethyl ether (Di-EGME), approved in 6.3.2.2, shall be in accordance with the requirements shown in Specification D4171.

X1.7 Fuel Cleanliness, Handling, and Storage Stability

X1.7.1 Existent Gum—Gum is a non-volatile residue left by evaporation of fuel. The amount of gum present is an indication of the condition of the fuel at the time of test only. Large quantities of gum are indicative of contamination of fuel by higher boiling oils or particulate matter and generally reflect poor fuel handling practices.

X1.7.2 Potential Gum—Fuel must be usable after storage for variable periods under a variety of climatic conditions. The potential gum test, which is an accelerated oxidation method, is used to estimate fuel stability in storage and the effectiveness of oxidation inhibitors. If the fuel is to be stored under relatively mild conditions for short periods, an oxidation period of 5 h is generally considered sufficient to indicate if the desired stability has been obtained, whereas a 16-h period is desirable to provide stability assurance for long periods and severe conditions, such as storage in tropical climates.

X1.7.3 Visible Lead Precipitate—The formation of a lead precipitate during the aging period of the potential gum test under the accelerated oxidation conditions used in this determination indicates a potential instability. Since even small amounts of insoluble material may foul the induction system and plug filters, it is necessary to place a limit on the amount of precipitate formed in this determination.

X1.7.4 Permissible Oxidation Inhibitors and Oxidation Inhibitor Content—Antioxidants are used to prevent the formation of gum in fuel during storage. The efficacy of a given inhibitor determined by the apparent oxidation stability of a fuel does not completely establish its suitability for use in an aircraft engine. Oxidation inhibitors have been found to contribute to excessive induction system deposits; therefore, their acceptability for use must ultimately be determined in the full-scale aircraft engine.

X1.7.5 Water Reaction—The water reaction method provides a means of determining the presence of materials readily extractable by water or having a tendency to absorb water. When the fuel consists essentially of hydrocarbon components, there is no measurable change in the volume of the water layer.

X1.7.6 Electrical Conductivity—The generation of static electricity can create problems in the handling of aviation gasolines. Addition of a conductivity improver may be used as
an additional precaution to reduce the amount of static electrical charge present during fuel handling. See Guide D4865 for more information.

X1.7.7 Microbial Contamination—Uncontrolled microbial contamination in fuel systems may cause or contribute to a variety of problems including corrosion, odor, filter plugging, decreased stability, and deterioration of fuel/water separation characteristics. In addition to system component damage, off-specification fuel can result.

X1.7.8 Guide D6469 provides personnel with limited microbiological background and an understanding of the symptoms, occurrence, and consequences of chronic microbial contamination. The guide also suggests means for detection and control. Biocides used in aviation fuels must follow engine and airframe manufacturers’ approval guidelines.

X1.8 Miscellaneous Tests

X1.8.1 Aromatics Content—Low boiling aromatics, which are common constituents of aviation gasolines, are known to affect elastomers to a greater extent than other components in aviation gasoline. Although Specification D910 does not include an explicit maximum aromatic limit, other specification limits effectively restrict the aromatic content of aviation gasolines. Benzene is virtually excluded by the maximum freezing point of $-58^\circ C$, while other aromatics are limited by the minimum heating value and the maximum distillation end point. Thus, the heating value limits toluene to about 24 %. Xylenes have a slightly higher heating value and, therefore, would permit somewhat higher aromatic concentrations; however, their boiling points (above 138°C) limit their inclusion at levels not higher than 10 %. Total aromatic levels above 25 % in aviation gasoline are, therefore, extremely unlikely.

X1.9 General

X1.9.1 Further detailed information on the significance of all test methods relevant to aviation gasoline is provided in Manual MNL 1.9

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**SUMMARY OF CHANGES**

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D910–07a) that may impact the use of this standard.

(I) Included provisions for Grade 100/130VLL (very low lead) aviation gasoline throughout the standard.