Designation: ~~D7547 – 14~~ D7547 – 14a

An American National Standard

Standard Specification for Hydrocarbon Unleaded Aviation Gasoline[1]

This standard is issued under the fixed designation D7547; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

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

1.2 ~~This specification defines a specific type of aviation gasoline, containing 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.~~Unleaded aviation gasoline defined by this specification is for use in engines and associated aircraft that are specifically approved by the engine and aircraft manufacturers. This fuel is not considered suitable for use in other engines and associated aircraft that are certified to use only leaded aviation gasolines of the same octane grade.

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

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

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)
D873 Test Method for Oxidation Stability of Aviation Fuels (Potential Residue Method)
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
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
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

[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 J2 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.

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

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 *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 UL 91.

NOTE 1—Grade UL 91 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. 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 % minimum 2,6-ditertiary butylphenol plus 25 % maximum mixed tertiary and tritertiary butylphenols.

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

5.2.1.6 72 % minimum 2,4-dimethyl-6-tertiary butylphenol plus 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). May be used in concentrations recommended by the aircraft manufacturer when required by the aircraft owner/operator.

NOTE 2—Addition of isopropyl alcohol (IPA) can reduce knock ratings below minimum specification values (see X1.2.3).[3]

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~~ 0.10 volume % to 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 450[4] 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.[4]

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 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

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. Report

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.

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 ~~100°C~~100 °C in bomb.

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

[4] Stadis 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 91	ASTM Test Method[B]
Knock value, Motor Octane Number[C]	min	91.0	D2700
Knock value, Research Octane Number[C]	min	96.0	D2699
~~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	
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[D]
	max	49.0	
Freezing point, °C	max	–58[E]	D2386
Sulfur, mass %	max	0.05	D2622
Net heat of combustion, MJ/kg[F]	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
Potential gum, mg/100 mL	max	6	
Water reaction			D1094
Volume change, mL	max	±2	
Electrical conductivity, pS/m	max	450[H]	D2624
Lead Content, g/L (g/U.S. gal)	max	0.013 (0.05)	D3237 or D5059
Tetraethyl Lead, g Pb/L	max	0.0130	D3237 or D5059[I]
Identifying Color		Orange	
Dye Content, mg/L[J]	max	6.0	

[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] Test Method D5191 shall be the referee vapor pressure method.
[E] 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.
[F] 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.
[G] If mutually agreed upon between the purchaser and the supplier, a 16 h aging gum requirement may be specified instead of the 5 h aging gum test; in such case the gum content shall not exceed 10 mg/100 mL. In such fuel the permissible antioxidant shall not exceed 24 mg/L.
[H] 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.
[I] Test Method C.
[J] The maximum dye concentration shown does not include solvent in dyes supplied in liquid form.

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 Content*—Test Method D3237 and D3341.

11. Keywords

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

APPENDIX

(Nonmandatory Information)

X1. PERFORMANCE CHARACTERISTICS OF UNLEADED AVIATION GASOLINE

X1.1 Introduction

X1.1.1 Unleaded 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 unleaded aviation gasoline (Table X1.1) shall 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 unleaded aviation gasoline, manufacturers of aircraft engines, and users of both commodities. The values given are intended to define unleaded aviation gasoline suitable for most types of spark-ignition aviation engines; however, certain equipment or conditions of use may require fuels having other characteristics.

X1.1.3 Specifications covering antiknock quality defines the grade of unleaded 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 unleaded 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 The MON rating is determined in standardized laboratory knock test engines that are operated under prescribed conditions. Results are expressed as octane numbers up to 100. Octane number is defined arbitrarily as the percentage of isooctane in that blend of isooctane and n-heptane that the gasoline matches in knock characteristics when compared by the procedure specified. The MON of the gasoline can be used as a guide to the amount of knock-limited power that may be obtained in a full-scale engine under take-off, climb and cruise conditions.

TABLE X1.1 Performance Characteristics of Unleaded Aviation Gasoline

Performance Characteristics	Test Methods	Sections
Combustion characteristics	knock value (MON)	X1.2
Antiknock quality	isopropyl alcohol	X1.2.3
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	
Fluidity at low temperatures	freezing point	X1.6
Fuel cleanliness, handling, and storage stability	potential gum	X1.7.1
	water reaction	X1.7.3