Designation: ~~D6227 – 18~~ D6227 – 18 (Reapproved 2023)

Standard Specification for Unleaded Aviation Gasoline Containing a Non-hydrocarbon Component[1]

This standard is issued under the fixed designation D6227; 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*~~Scope

1.1 This specification covers Grades UL82 and UL87 unleaded aviation gasolines, which are defined by this specification and are only for use in engines and associated aircraft that are specifically approved by the engine and aircraft manufacturers, and certified by the National Certifying Agencies to use these fuels. Components containing hetro-atoms (oxygenates) may be present within the limits specified.

1.2 A fuel may be certified to meet this specification by a producer as Grade UL82 or UL87 aviation gasoline only if blended from component(s) approved for use in these grades of aviation gasoline by the refiner(s) of such components, because only the refiner(s) can attest to the component source and processing, absence of contamination, and the additives used and their concentrations. Consequently, reclassifying of any other product to Grade UL82 or Grade UL87 aviation gasoline does not meet this specification.

1.3 Appendix X1 contains an explanation for the rationale of the specification. Appendix X2 details the reasons for the individual specification requirements.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.5 *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
D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
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of Test for Knock Characteristics of Motor Fuels Below 100 Octane Number by the Motor Method; Replaced by D 2700 (Withdrawn 1969)[3]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
D873 Test Method for Oxidation Stability of Aviation Fuels (Potential Residue Method)

[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 Aviation Piston Engine Fuels.

Current edition approved ~~Oct. 1, 2018~~July 1, 2023. Published ~~October 2018~~July 2023. Originally approved in 1998. Last previous edition approved in ~~2017~~2018 as ~~D6227 – 17~~.D6227 – 18. DOI: ~~10.1520/D6227-18.~~10.1520/D6227-18R23.

[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**

D909 Test Method for Supercharge Rating of Spark-Ignition Aviation Gasoline
D910 Specification for Leaded Aviation Gasolines
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
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
D2699 Test Method for Research Octane Number of Spark-Ignition Engine Fuel
D2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel
D3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
D3231 Test Method for Phosphorus in Gasoline
D3237 Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy
D3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4171 Specification for Fuel System Icing Inhibitors
D4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
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)
D4815 Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C_1 to C_4 Alcohols in Gasoline by Gas Chromatography
D4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)
D5059 Test Methods for Lead and Manganese in Gasoline by X-Ray Fluorescence Spectroscopy
D5191 Test Method for Vapor Pressure of Petroleum Products and Liquid Fuels (Mini Method)
D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D5482 Test Method for Vapor Pressure of Petroleum Products and Liquid Fuels (Mini Method—Atmospheric)
D5599 Test Method for Determination of Oxygenates in Gasoline by Gas Chromatography and Oxygen Selective Flame Ionization Detection
D5845 Test Method for Determination of MTBE, ETBE, TAME, DIPE, Methanol, Ethanol and *tert*-Butanol in Gasoline by Infrared Spectroscopy
D5983 Specification for Methyl Tertiary-Butyl Ether (MTBE) for Blending With Gasolines for Use as Automotive Spark-Ignition Engine Fuel
D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
D7220 Test Method for Sulfur in Automotive, Heating, and Jet Fuels by Monochromatic Energy Dispersive X-ray Fluorescence Spectrometry
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *Military Standard:*[4]
MIL-PRF-25017F Performance Specification for Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble
QPL-25017 Qualified Products List of Products Qualified Under Performance Specification MIL-PRF-25017F

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*—
The principal properties of aviation gasoline include volatility limits, stability, detonation-free performance in the engine for which it is intended, and suitability for low temperature performance.

3.1.2 *non-hydrocarbon, n*—compound or compounds composed of carbon, hydrogen and other elements such as O, N, S, and P.

3.1.3 *oxygenate, n*—an oxygen-containing ashless organic compound, such as an alcohol or ether, which may be used as fuel or fuel supplement.

[4] Available from Standardization Document Order Desk, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111–5094 Attn: NPODS.

4. Grades

4.1 The specification covers two grades of unleaded aviation gasoline designated Grade UL82 and Grade UL87.

5. General

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

6. Material

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 specific aliphatic ethers, synthetic hydrocarbons, or aromatic hydrocarbons. When applicable, methyl *tertiary* -butyl ether (MTBE) shall conform to the requirements of Specification D5983. Types and quantities of trace alcohols shall meet the requirements of Table 1 and 6.2.4.2.

6.2 Only additives approved by this specification are permitted. In addition to identification dyes, corrosion inhibitors, antioxidants, and metal deactivators, fuel system icing inhibitor additives are permitted under 6.2.4. Permitted additives may be added to 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.

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

6.2.1.1 2,6-ditertiary-butyl-phenol.

6.2.1.2 2,6-ditertiary-butyl-4-methyl-phenol.

6.2.1.3 2,4-dimethyl-6-tertiary-butyl-phenol.

6.2.1.4 2,6-ditertiary-butyl-phenol, 75 % minimum.
Tertiary and tritertiary-butyl-phenols, 25 % maximum.

6.2.1.5 2,4-dimethyl-6-tertiary-butyl-phenol, 55 % minimum; 4-methyl-2,6-ditertiary-butyl phenol 15 % minimum; the remainder as a mixture of monomethyl and dimethyl-tertiary-butyl-phenols.

6.2.1.6 2,4-dimethyl-6-tertiary-butyl-phenol, 72 % minimum.
Mixture of tertiary-butyl-methyl-phenols and tertiary-butyl-dimethyl-phenols, 28 % maximum.

6.2.1.7 2,6-ditertiary-butyl-4-methyl-phenol, 35 % minimum.
Mixed methyl, ethyl, and dimethyl tertiary-butyl-phenols, 65 % maximum.

6.2.1.8 2,4-di-tertiary butyl-phenol, 60 % minimum.
Mixed tertiary-butyl-phenol, 40 % maximum.

6.2.1.9 Butylated ethyl-phenols, 55 % minimum.
Butylated methyl and dimethyl-phenols, 45 % maximum.

6.2.1.10 Mixture of a di- and tri-isopropyl-phenols, 75 % minimum.
Mixture of di- and tri-tertiary butyl-phenols, 25 % maximum.

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

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

6.2.1.13 N-secondary butyl, N'-phenyl
ortho-phenylenediamine.

TABLE 1 Requirements for Grades UL82 and UL87 Aviation Gasoline[A]

		Grade UL82	Grade UL87	ASTM Test Method[B]
Octane Ratings				
Knock value, lean mixture, Motor method octane number	min	82.0	87.0	D2700
Knock value, Research method octane number	min	...	95.0	D2699
Color		undyed	undyed	D2392
Dye content[C]				
Blue dye,[D] mg/L	max	none	none	
Red dye,[E] mg/L	max	none	none	
Yellow dye,[F] mg/L	max	none	none	
		Requirements for All Grades		
~~Density at 15°C, kg/m^3~~		~~Report~~		~~D1298 or D4052~~
Density at 15 °C, kg/m^3		Report		D1298 or D4052
Distillation				D86
Fuel Evaporated				
10 volume % at °C	max	70		
50 volume % at °C	min	66		
	max	121		
90 volume % at °C	max	190		
End point, °C	max	225		
Recovery, volume %	min	95.0		
Residue, volume %	max	2.0		
Loss, volume %	max	3.0		
~~Vapor pressure 38°C, kPa~~	~~min~~	~~38~~		~~D4953, D5191, D5482~~
Vapor pressure 38 °C, kPa	min	38		D4953, D5191
	max	62[G]		
Freezing point, °C	max	–58		D2386
Sulfur, mass %	max	0.07		D1266, D2622, D3120, D4294, D5453, or D7220
Lead content, g/L		0.013[H]		D3237 or D5059
Net heat of combustion, MJ/kg		40.8		D3338,[I] D4529,[I] or D4809[I]
~~Corrosion, copper strip (3 h at 50°C)~~	~~max~~	~~No. 1~~		~~D130~~
Corrosion, copper strip (3 h at 50 °C)	max	No. 1		D130
Potential gum (5–h aging) mg/100 mL[J]	max	6		D873
Alcohols and ether content[K,L]				D4815, D5599, or D5845
Total combined methanol and ethanol, mass %, max		0.3		
Combined aliphatic ethers, methanol, and ethanol, as mass % oxygen, max		2.7		
		0.3		

[A] The requirements stated herein are subject to rounding in accordance with Practice E29 and are not subject to correction for tolerance of the test method.
[B] The test methods indicated in this table are referred to in Section 10.
[C] The maximum dye concentrations shown do not include solvent in dyes supplied in liquid form.
[D] Essentially 1,4-dialkylamino-anthraquinone.
[E] Essentially alkyl derivatives of azobenzene-4-azo-2-naphthol.
[F] Essentially p-diethylaminoazobenzene or 1,3 benzenediol 2, 4–bis[(alkylphenyl) azo-.
[G] Fuel with a vapor pressure greater than 62 kPa (9.0 psi) but not exceeding 93 kPa (13.5 psi) is permissible, if the ambient temperature is not more than ~~29°C (85°F)~~29 °C (85 °F) at the time and place of delivery and all federal and local regulations are met. The vapor pressure of permissible fuel exceeding 62 kPa (9.0 psi) shall be shown on all product transfer documents, *including the delivery document to the aircraft.*
[H] See X2.10.1 for maximum limits for lead and phosphorus in unleaded gasoline.
[I] Use either Eq 1 or Table 1 in Test Method D4529, or Eq 2 in Test Method D3338. See X2.7.2 for limitations and oxygen corrections required when Test Methods D3338 and D4529 are applied to fuels blended with aliphatic ethers.
[J] Test Method D381 existent gum test can provide a means of detecting deteriorated quality or contamination, or both, with heavier products following distribution from refinery to airport; refer to X2.9.1.
[K] No deliberate addition of alcohols is allowed except for isopropyl alcohol, which is allowed as an additive (see 6.2.4.2)
[L] For additional information and limitations, see X2.8

6.2.2 *Metal Deactivators*—A metal deactivator, N,N'-disalicylidene-1,2-propanediamine may be added to the gasoline in an amount not to exceed 3.0 mg/L.

6.2.3 *Corrosion Inhibitors*—Corrosion inhibitors that conform to MIL-PRF-25017F may be added to the gasoline in amounts not exceeding the maximum allowable concentrations listed in the latest revision of QPL-25017.

6.2.4 *Fuel System Icing Inhibitor:*

6.2.4.1 Diethylene glycol monomethyl ether, conforming to the requirements of Specification D4171 (Type III), may be used in concentrations of 0.10 to 0.15 volume %.

6.2.4.2 Isopropyl alcohol conforming to the requirements of Specification D4171 (Type II) may be used in concentrations recommended by the aircraft manufacturers when required by the aircraft owner operator.

7. Detailed Requirements

7.1 The aviation gasoline shall conform to the requirements in Table 1.

8. Workmanship

8.1 The finished fuel shall be visually free of water, sediment, and suspended matter.

NOTE 1—See Practice D4057 for appropriate sampling procedures.

9. Reports

9.1 The type and number of reports to ensure conformance with the requirements of this specification shall be mutually agreed to by the purchaser and the supplier of the 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 *Research Octane*—Test Method D2699.

10.1.2 *Motor Octane*—Test Method D2700.

10.1.3 *Color*—Test Method D2392.

10.1.4 *Distillation*—Test Method D86.

10.1.5 *Net Heat of Combustion*—Test Method D3338, D4529, or D4809.

10.1.6 *Freezing Point*—Test Method D2386.

10.1.7 *Vapor Pressure*—Test Method D4953, D5191 or D5482.

10.1.8 *Lead Content*—Test Method D3237 or D5059 (Test Method C).

10.1.9 *Copper Strip Corrosion*—Test Method D130 (3 h at ~~50°C (122°F)).~~50 °C (122 °F)).

10.1.10 *Sulfur*—Test Method D1266, D2622, D3120, D4294, D5453, or D7220.

10.1.11 *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.

10.1.12 *Alcohols/Ethers Detection*—Test Method D4815, D5599, or D5845.

11. Keywords

11.1 aviation gasoline; ether, fuel; gasoline/alcohol blends; gasoline/ether blends; gasoline/oxygenate blends, octane requirement; unleaded aviation gasoline

APPENDIXES

(Nonmandatory Information)

X1. REASONS FOR SPECIFICATION

X1.1 *Introduction*—Aviation gasoline defined by this specification is for use only in engines and associated aircraft specifically designed or approved to operate on Grade UL82 or Grade UL87 defined by this specification.

X2. SIGNIFICANT FACTORS FOR UNLEADED AVIATION GASOLINE

X2.1 Introduction

X2.1.1 This specification was developed to identify broad distillation range refinery products, including refined hydrocarbons derived from crude petroleum, or blends thereof, with synthetic hydrocarbons and specific aliphatic ether blends, suitable for low octane unleaded aviation gasoline applications. The requirements of Table 1 are quality limits established on the basis of development and certification tests performed on airframes and engines specifically designed to use these fuels.

X2.1.2 Engines certified for low octane fuels and their associated aircraft operate within a variety of mechanical, physical, and chemical environments. The properties of unleaded aviation gasoline (Table 1) must be properly balanced to give satisfactory engine performance over a wide range of conditions.

X2.2 Antiknock Quality

X2.2.1 The fuel-air mixture in the cylinder of a spark-ignition engine will, under certain conditions, spontaneously ignite ahead of the flame front. This will cause a knock, which is usually inaudible in aircraft engines. This knock, if permitted to continue, may result in serious loss of power and damage to the aircraft engine.

X2.2.2 Traditional leaded aviation gasolines have been defined by both lean and rich mixture ratings. A minimum lean mixture rating of 82.0 determined by the motor method (Test Method D2700) provides satisfactory antiknock properties on engines certified for low octane fuels. Rich mixture ratings by Test Method D909 were developed for older large displacement, high output

TABLE X2.1 Significant Factors for Unleaded Aviation Gasoline

Factors of Significance	Test Method	Sections
Introduction		X2.1
Antiknock quality	motor and research methods	X2.2
Fuel metering and volatility	vapor pressure	X2.4.1
	distillation	X2.4.2
Corrosion of fuel system and engine parts	copper strip	X2.5.1
	sulfur	X2.5.2
Low temperature performance	fuel icing inhibitor	X2.6.1
	fuel freezing point	X2.6.2
Heat of combustion	net heat of combustion	X2.7
Oxygenates	ethers	X2.8.2
	alcohols	X2.8.3
Cleanliness, handling, and storage stability	existent gum	X2.9.1
	potential gum	X2.9.2
	dyes	X2.9.3
Miscellaneous	lead content	X2.10.1