Standard Specification for Grade 82 Unleaded Aviation Gasoline[1]

This standard is issued under the fixed designation D 6227; 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 Grade 82 unleaded aviation gasoline defined by this specification is for use only in engines and associated aircraft that are specifically approved by the engine and aircraft manufacturers, and certified by the National Certifying Agencies to use this fuel. This fuel is not considered suitable for use in other engines and associated aircraft that are certified to use aviation gasolines meeting Specification D 910.

1.2 A fuel may be certified to meet this specification by a producer as Grade 82 UL aviation gasoline, only if blended from component(s) approved for use in Grade 82 UL 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, re-classifying of any other product to Grade 82 UL 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 the standard. The values given in parentheses are provided for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

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

D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test[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 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[4]

D 910 Specification for Aviation Gasolines[2]

D 1266 Test Method for Sulfur in Petroleum Products (Lamp 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 X-Ray Spectrometry[5]

D 2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel[4]

D 3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry[5]

D 3231 Test Method for Phosphorus in Gasoline[5]

D 3237 Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy[5]

D 3338 Test Method for Estimation of Heat of Combustion of Aviation Fuels[5]

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products[5]

D 4171 Specification for Fuel System Icing Inhibitors[5]

D 4294 Test Method for Sulfur in Petroleum Products by Energy Dispersive X-Ray Fluorescence Spectroscopy[5]

D 4529 Test Method for Estimate of Net Heat of Combustion of Aviation Fuels[5]

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

D 4815 Test Method for Determination of MTBE, ETBE, TAME, DIPE, *tertiary*-Amyl Alcohol, and C_1 to C_4 Alcohols in Gasoline by Gas Chromatography[6]

D 4953 Test Method for Vapor Pressure of Gasoline and Gasoline Oxygenate Blends (Dry Method)[6]

D 5059 Test Method 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]

D 5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels, and Oils by Ultra Violet Fluorescence[6]

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[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.J0.02 on Aviation Gasoline Specifications.

Current edition approved Dec. 10, 2000. Published January 2001.. Originally published as D 6227-98. Last previous edition D 6227-99.

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

[3] Discontinued 1969, See *Annual Book of ASTM Standards*, Part 17, Replaced by D 2700.

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

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

[6] *Annual Book of ASTM Standards*, Vol 05.03.

D 5482 Test Method for Vapor Pressure of Petroleum Products (Mini Method/Atmospheric)[6]

D 5599 Test Method for Determination of Oxygenates in Gasoline by Gas Chromatography and Oxygen Selective Flame Ionization Detection[6]

D 5845 Test Method for Determination of MTBE, ETBE, TAME, DIPE, Methanol, Ethanol, and *tert*-Butanol in Gasoline by Infrared Spectroscopy[6]

D 5983 Specification for Methyl *tertiary*-Butyl Ether (MTBE) for Downstream Blending for Use in Automotive Spark-ignition Engine Fuel[6]

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

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

2.2 *Military Standard:*[9]

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.

4. Grades

4.1 The specification covers one grade of unleaded aviation gasoline designated Grade 82 UL. Grade 82 UL is the only aviation gasoline defined by this specification and the grade shows the minimum motor octane rating.

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 D 5983. 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.

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 % min.

Tertiary and tritertiary - butyl - phenols, 25 % max.

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

6.2.1.6 2,4 - dimethyl-6-tertiary-butyl-phenol, 72 % min.

Mixture of tertiary-butyl-methyl-phenols and tertiary-butyl-dimethyl-phenols, 28 % max.

6.2.1.7 2,6-ditertiary-butyl-4-methyl-phenol, 35 % min.

Mixed methyl, ethyl, and dimethyl tertiary-butyl-phenols, 65 % max

6.2.1.8 2,4-di-tertiary butyl-phenol, 60 % min.

Mixed tertiary-butyl-phenol, 40 % max.

6.2.1.9 Butylated ethyl-phenols, 55 % min.

Butylated methyl and dimethyl-phenols, 45 % max.

6.2.1.10 Mixture of a di- and tri-isopropyl-phenols, 75 % min.

Mixture of di- and tri-tertiary butyl-phenols, 25 % max.

6.2.1.11 N,N' di-secondary butyl-para phenylene diamine.

6.2.1.12 N,N' di-isopropyl-para-phenylene-diamine.

6.2.1.13 N-secondary butyl, N'- phenyl ortho - phenylene-diamine.

6.2.2 *Metal Deactivators*—A metal deactivator, N,N' - disalicylidene - 1,2- propane diamine 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 D 4171 (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 D 4171 (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 D 4057 for appropriate sampling procedures.

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

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

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

TABLE 1 Requirements for Grade 82 UL Aviation Gasoline[A]

Property	Requirement	ASTM Test Method[B]
Knock value, lean mixture		D 2700
Motor method octane number, min	82.0	
Color	purple	D 2392
Dye content[C]		
Blue dye[D], mg/L, max	7.5	
Red dye[E], mg/L, max	1.9	
Distillation temperature,° C (°F) at % evaporated		D 86
10 volume %, max	70 (158)	
50 volume %	66 (150)- 121 (250)	
90 volume %, max	190 (374)	
End point, max	225 (437)	
Residue, volume % max	2	
Distillation recovery, volume %, min	95	
Distillation loss, volume %, max	3.0	
Net heat of combustion, min MJ/kg (BTU/lb)	40.8 (17 540)	D 3338[F], D 4529[F], or D 4809[G]
Freezing point, °C (°F), max	–58 (–72)	D 2386
Vapor pressure, kPa (psi), max	62 (9.0)[H]	D 4953, D 5190, D 5191, or
kPa (psi), min	38 (5.5)	D 5482
Lead content, g/L (g/U.S. gal), max[I]	0.013 (0.05)	D 3237 or D 5059
Copper strip corrosion, 3 h at 50°C (122°F), max	No. 1	D 130
Sulfur, mass %, max	0.07	D 1266, D 2622, D 3120, D 4294, or D 5453
Potential gum (5-h aging), max, mg/100mL[J]	6	D 873
Alcohols and ether content[K,L]		D 4815, D 5599, or D 5845
Total combined methanol and ethanol, mass %, max	0.3	
Combined aliphatic ethers, methanol, and ethanol, as mass % oxygen, max	2.7	

[A] The requirements stated herein are subject to rounding in accordance with Practice E 29 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] Use either Eq 1 or Table 1 in Test Method D 4529, or Eq 2 in Test Method D 3338. See X2.7.2 for limitations and oxygen corrections required when Test Methods D 3338 and D 4529 are applied to fuels blended with aliphatic ethers.
[G] Test Method D 4809 may be used as an alternative. In case of dispute, Test Method D 4809 shall be used.
[H] 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) 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*.
[I] See X2.10.1 for maximum limits for lead and phosphorus in unleaded gasoline.
[J] D 381 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

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 *Motor Octane*— Test Method D 2700.

10.1.2 *Color*—Test Method D 2392.

10.1.3 *Distillation*— Test Method D 86.

10.1.4 *Net Heat of Combustion*—Test Method D 3338, D 4529, or D 4809.

10.1.5 *Freezing Point*— Test Method D 2386.

10.1.6 *Vapor Pressure*— Test Method D 4953, D 5190, D 5191 or D 5482.

10.1.7 *Lead Content*— Test Method D 3237 or D 5059 (Test Method C).

10.1.8 *Copper Strip Corrosion*—Test Method D 130 (3 h at 50°C (122°F)).

10.1.9 *Sulfur*—Test Method D 1266, D 2622, D 3120, D 4294, or D 5453.

10.1.10 *Potential Gum*— 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.

10.1.11 *Alcohols/Ethers Detection*—Test Method D 4815, D 5599, or D 5845.

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 to operate on Grade 82 UL defined by this specification.

X1.2 To ensure ready identification of fuel meeting this specification, it is dyed purple.

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 D 2700) provides satisfactory antiknock properties on engines certified for low octane fuels. Rich mixture ratings by Test Method D 909 were developed for older large displacement, high output engines for which this fuel is not suitable.

X2.2.3 The motor Test Method D 2700 is an engine method for determining the knock characteristics at a lean fuel-air ratio of fuels for use in spark-ignition engines. It was originally developed (as Test Method D 357) to test motor gasolines for motor octane number, but an extensive program revealed that the octane number rating of current aviation gasolines could also be determined by the motor method. Knock characteristics of a test fuel are established by comparing its knocking tendency with those for blends of ASTM reference fuels of known octane number under prescribed operating conditions.

TABLE X2.1 Significant Factors for Unleaded Aviation Gasoline

Factors of Significance	Test Method	Sections
Introduction		X2.1
Antiknock quality	motor method	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

X2.3 *Fuel Metering and Vaporization - General Comments*:

X2.3.1 In most spark-ignition engines, the aviation gasoline is metered in liquid form through carburetors or low pressure injectors. Fuel vaporization starts in the carburetor or downstream of the injector and continues in the intake manifold from which the fuel-air enters the cylinders of the engine. The volatility, the tendency to evaporate or change from a liquid to a gaseous state, is an extremely important characteristic of aviation fuel.

X2.3.2 Gasolines that vaporize too readily may boil in fuel lines or in fuel metering devices, particularly as altitude increases, and cause vapor lock with resultant power loss. 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.

X2.4 *Volatility*:

X2.4.1 *Vapor Pressure*— The vapor pressure of an aviation gasoline is the measure of the tendency of the more volatile components to evaporate. Fuels having a vapor pressure no higher than 93 kPa (13.5 psi) will be free of vapor locking tendencies under operating conditions of the aircraft developed for such fuels. The minimum vapor pressure of 38 kPa (5.5 psi) adopted in this specification is consistent with the requirements of other aviation gasolines.

X2.4.2 *Distillation*— Gasoline is made up of a broad range of hydrocarbon components. Distillation temperatures are a measure of a fuel's volatility. The method of measuring distillation temperatures is useful in comparing fuels, but is not intended to separate or identify quantitatively the individual hydrocarbons present.

X2.4.2.1 A maximum value is set on the 10 % evaporated point to ensure ease of starting and a reasonable degree of flexibility during the warm-up period.

X2.4.2.2 To guard against too high a volatility which might lead to carburetor icing or vapor lock, or both, (also protected against by the vapor pressure) a minimum value is set for the 50 % evaporated points.

X2.4.2.3 A maximum value is specified for the 50 % evaporated temperature to ensure average volatility sufficient to permit adequate evaporation of the fuel in the engine induction system. Insufficient evaporation may lead to loss of power.

X2.4.2.4 A maximum temperature is prescribed for the 90 % evaporated point to prevent too much liquid fuel being delivered to the cylinders, resulting in power loss, and to prevent poor distribution to the various cylinders. Such a condition might lead to engine roughness, perhaps accompanied by knocking and damage to the engine. Excessive dilution of the lubricating oil may result from too high a 90 % evaporated point.

X2.4.2.5 A maximum is placed on the final boiling point (end point), which together with the maximum prescribed for the 90 % evaporated point, is used to prevent incorporation of excessively high boiling components in the fuel, which may lead to mal-distribution, spark plug fouling, power loss, and lubricating oil dilution.

X2.4.2.6 A maximum value is specified for the distillation residue to prevent the inclusion of undesirable high-boiling components essentially impossible to burn in the chamber. The presence of such residue may reflect the degree of care with which the product is refined or handled. The amount of residue, along with the end-point temperature, can be used as an indication of contamination with high-boiling materials.

X2.4.2.7 The stipulation of a minimum recovery and a maximum loss in this specification in conjunction with the vapor pressure requirement is intended to protect against excessive losses by evaporation in storage, handling, and in the aircraft tank. It is also a check on the distillation test technique.

X2.5 *Corrosion of Fuel System and Engine Parts*:

X2.5.1 *Copper Strip*— The requirement that aviation gasoline must pass the copper strip corrosion test provides assurance that copper components of the fuel system will not be corroded by sulfur compounds in the fuel.

X2.5.2 *Sulfur*—Total sulfur content of aviation fuels is significant because the products of combustion of sulfur can cause corrosive wear of engine parts.

X2.6 *Low Temperature Performance*:

X2.6.1 *Fuel System Icing Inhibitor*—Diethylene glycol monomethyl ether, approved in 6.2.4.1, and isopropyl alcohol, approved in 6.2.4.2, shall conform to the requirements shown in Specification D 4171.

X2.6.2 *Fuel Freezing Point*—A freezing point requirement is specified to preclude solidification of any of the materials cited in 6.1 and 6.2, at extremely low temperatures with the consequent interference with fuel flow to the engine.

X2.7 *Heat of Combustion*:

X2.7.1 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, reductions in heat energy are 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.

X2.7.2 The calculation method presented here provides a correction for oxygen content when Test Methods D 3338 and D 4529 are adopted to determine the net heat of combustion of oxygenated blends.

$$Q = W_1\,(QP_1) + W_2(QP_2) + W_3(QP_3) + W_4\,(QP_4) + W_5\,(QP_5) \tag{X2.1}$$

where:

Q = net heat of combustion, MJ/kg (BTU/lb) of the gasoline - ether blend,
W_1 = oxygenate-free hydrocarbon mass fraction (or mass % ÷ 100),
QP_1 = net heat of combustion, MJ/kg (BTU/lb) of oxygenate-free hydrocarbon fraction, calculated from measured properties of the fuel,
W_2 = MTBE mass fraction (or mass % ÷ 100),
QP_2 = net heat of combustion of MTBE listed in the research report[10] is 35.12 MJ/kg (15 100 BTU/lb),
W_3 = TAME mass fraction (or mass % ÷ 100),
QP_3 = net heat of combustion of TAME listed in the research report[10] is 36.49 MJ/kg (15 690 BTU/lb),
W_4 = ETBE mass fraction (or mass % ÷ 100),
QP_4 = net heat of combustion of ETBE listed in the research report[10] is 36.36 MJ/kg (15 635 BTU/lb),
W_5 = DIPE mass fraction (or mass % ÷ 100), and
QP_5 = net heat of combustion of DIPE listed in the research report is 38.13 mJ/kg (16 393 BTU/lb).

and where:
$W_1 + W_2 + W_3 + W_4 + W_5 = 1$

X2.7.3 If the properties of the oxygenate-free hydrocarbon fraction of the fuel are not known or if only the gasoline-ether blend properties are available, it is not possible to calculate the net heat of combustion of the gasoline-ether blend using Test Method D 3338 or D 4529. Under these circumstances, the net heat of combustion should be measured using Test Method D 4809. See SAE J1498, for further discussion.[11]

X2.7.4 The research report[10] establishes the practical minimum value of net heat of combustion of 40.8 MJ/kg (17 540 BTU/lb) adopted in this specification. However, the value includes the maximum anticipated ether concentrations, and in most cases, actual net heating values will exceed this minimum.

X2.8 *Oxygenates*:

[10] Available from ASTM Headquarters. Request RR: D02–1427.

[11] *Heating Value of Fuels*, February 1998. Available from Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA 15096–0001.

X2.8.1 Oxygenates are oxygen-containing, ashless compounds, such as alcohols and ethers, which can be used as a fuel supplement.

X2.8.2 Aliphatic ethers allowed up to the specification limit include methyl *tertiary*-butyl ether (MTBE), *tertiary*-amyl methyl ether (TAME), ethyl *tertiary*-butyl ether (ETBE), and diisopropyl ether (DIPE).

X2.8.3 The deliberate addition of alcohols is prohibited by this specification, except that isopropyl alcohol is allowed as a fuel system icing inhibitor field additive (see 6.2.4.2) and is limited by aircraft manufacturers to a maximum concentration of 1.0 volume %. Alcohols are prohibited because of their excessive water solubility, increase in vapor pressure, material incompatibility, and in addition for methanol, corrosivity. Low concentrations of methanol and ethanol are only permitted by this specification because they are unreacted components from the manufacturing of aliphatic ethers. The total of the combination of methanol and ethanol shall not exceed 0.3 mass % oxygenate as determined by Test Method D 4815, D 5599, or D 5845.

X2.9 *Fuel Cleanliness, Handling and Storage Stability*:

X2.9.1 *Existent Gum*— The amount of non-volatile residue remaining after evaporation by a high temperature air jet. This residue may represent solid or heavy liquid contaminants or insoluble residue formed by oxidation in storage.

X2.9.2 *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.

X2.9.3 *Dyes*—Colors are 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 composition of the approved dyes as well as the maximum quantity of each permissible dye is specified in Table 1. The allowable color levels are established by Test Method D 2392. The color purple was selected for this grade because the former purple grade, Grade 115/145, has been removed from Specification D 910 and is no longer widely available.

X2.9.4 *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.

X2.9.5 Guide D 6469 provides personnel with limited microbiological background and an understanding of the systems, 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.

X2.10 *Miscellaneous*:

X2.10.1 *Lead Content*— A number of analytical test methods are permitted to cover the unintentional presence of lead in unleaded fuel. The intentional addition of lead or phosporus compounds to unleaded fuel is not permitted. Industry practice currently limits maximum concentrations to 0.013 g of lead per litre (0.05 g/U.S. gal) and 0.0013 g of phosphorus per litre (0.005 g/U.S. gal) (see Test Method D 3231), respectively.

X2.10.2 *Aromatic Content*—Low boiling aromatics, which are common constituents of aviation gasolines, are known to affect elastomers to a greater extent than other components.