Designation: D8076 – 21a

Standard Specification for 100 Research Octane Number Test Fuel for Automotive Spark-Ignition Engines[1]

This standard is issued under the fixed designation D8076; 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 the requirements of a high octane number test fuel suitable for spark-ignition engines to be utilized in ground vehicles that will require 100 research octane number (RON) minimum rated fuel.

1.1.1 The fuels described by this specification are intended for developing technologies that lead to reduced vehicle energy consumption, such as higher compression ratio, higher power density, increased turbocharger boost pressure, smaller swept displacement volume, and operation at lower engine speeds.

1.1.2 The fuels described in this test fuel specification may not meet all of the performance or regulatory requirements for use in vehicles using commercial gasoline.

1.2 The fuels covered in this specification may contain oxygenates, such as alcohols and ethers, up to 50 % by volume. This specification covers fuels that may contain both fossil and bio-derived components.

1.3 This specification provides a description of high RON test fuel for automotive spark-ignition engines that are not currently in the marketplace but are being developed and require a defined standard test fuel. The high RON fuel could become available in the marketplace if/when such engines are introduced in commerce. The specification is under continuous review, which can result in revisions based on changes in fuel, automotive requirements, or test methods, or a combination thereof. All users of this specification, therefore, should refer to the latest edition.

NOTE 1—If there is any doubt as to the latest edition of Specification D8076, contact ASTM International Headquarters.

1.4 The values stated in SI units are the standard.

1.4.1 *Exception*—Non-SI values are provided for information only. U.S. federal regulations frequently specify non-SI units.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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

D381 Test Method for Gum Content in Fuels by Jet Evaporation

D525 Test Method for Oxidation Stability of Gasoline (Induction Period Method)

D1152 Specification for Methanol (Methyl Alcohol) (Withdrawn 2021)[3]

D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)

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

D3237 Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy

D3831 Test Method for Manganese in Gasoline By Atomic

[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.A0.01 on Gasoline and Gasoline-Oxygenate Blends.

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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.

[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

Absorption Spectroscopy
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
D4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
D4806 Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel
D4814 Specification for Automotive Spark-Ignition Engine Fuel
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
D5842 Practice for Sampling and Handling of Fuels for Volatility Measurement
D5845 Test Method for Determination of MTBE, ETBE, TAME, DIPE, Methanol, Ethanol and *tert*-Butanol in Gasoline by Infrared Spectroscopy
D5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
D5983 Specification for Methyl Tertiary-Butyl Ether (MTBE) for Blending With Gasolines for Use as Automotive Spark-Ignition Engine Fuel
D6378 Test Method for Determination of Vapor Pressure (VP_X) of Petroleum Products, Hydrocarbons, and Hydrocarbon-Oxygenate Mixtures (Triple Expansion Method)
D6550 Test Method for Determination of Olefin Content of Gasolines by Supercritical-Fluid Chromatography
D7039 Test Method for Sulfur in Gasoline, Diesel Fuel, Jet Fuel, Kerosine, Biodiesel, Biodiesel Blends, and Gasoline-Ethanol Blends by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry
D7220 Test Method for Sulfur in Automotive, Heating, and Jet Fuels by Monochromatic Energy Dispersive X-ray Fluorescence Spectrometry
D7319 Test Method for Determination of Existent and Potential Sulfate and Inorganic Chloride in Fuel Ethanol and Butanol by Direct Injection Suppressed Ion Chromatography
D7328 Test Method for Determination of Existent and Potential Inorganic Sulfate and Total Inorganic Chloride in Fuel Ethanol by Ion Chromatography Using Aqueous Sample Injection
D7618 Specification for Ethyl Tertiary-Butyl Ether (ETBE) for Blending with Aviation Spark-Ignition Engine Fuel
D7667 Test Method for Determination of Corrosiveness to Silver by Automotive Spark-Ignition Engine Fuel—Thin Silver Strip Method
D7671 Test Method for Corrosiveness to Silver by Automotive Spark–Ignition Engine Fuel–Silver Strip Method
D7862 Specification for Butanol for Blending with Gasoline for Use as Automotive Spark-Ignition Engine Fuel
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *Government Regulations:*
United States Code of Federal Regulations Title 40 Protection of Environment[4]
California Code of Regulations Title 17—Public Health—Section 60100–60114 Description of California Air Basins[5]

2.3 *Other Documents:*
CRC Report No. 660 Fuel Antiknock Quality—Engine Response to RON Versus MON Scoping Tests, Final Report, May 2011[6]

3. Terminology

3.1 For general terminology, refer to Terminology D4175.

3.2 *Definitions:*

3.2.1 *dry vapor pressure equivalent (DVPE), n*—value calculated by a defined correlation equation that is expected to be comparable to the vapor pressure value obtained by Test Method D4953, Procedure A. **D4953**

3.2.2 *gasoline, n*—a volatile mixture of liquid hydrocarbons, generally containing small amounts of additives, suitable for use as a fuel in spark-ignition, internal combustion engines. **D4814**

3.2.3 *gasoline-oxygenate blend, n*—a fuel consisting primarily of gasoline along with a substantial amount (more than 0.35 % by mass oxygen) of one or more oxygenates. **D4814**

3.2.4 *octane sensitivity, n*—the mathematical difference between research octane number (RON) and motor octane number (MON) (octane sensitivity = RON – MON).

3.2.4.1 *Discussion*—A typical value for sensitivity is 6 to 10. A larger value is referred to as high sensitivity.

[4] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, or electronically at https://www.govinfo.gov/app/collection/cfr.

[5] Available from California's Office of Administrative Law, https://oal.ca.gov/publications/ccr/.

[6] Available from Coordinating Research Council, 5755 North Point Parkway, Suite 265, Alpharetta, GA 30022, http://www.crcao.org.

3.2.4.2 *Discussion*—The terms octane sensitivity and octane number sensitivity are used synonymously.

3.2.5 *oxygenate, n*—a molecule composed solely of carbon, hydrogen, and oxygen. D4814

3.2.5.1 *Discussion*—The fuel described in this standard may contain oxygenates.

4. Ordering Information

4.1 The volatility of the fuel shall be agreed upon between buyer and seller.

4.2 State the concentration and types of oxygenates present as agreed upon between buyer and seller.

5. Performance Requirements for High Octane Number Test Fuel

5.1 High octane number test fuel shall conform to the requirements of Table 1, and meet the volatility requirements of Table 2. The significance of each of the properties of this specification is shown in Appendix X1.

5.1.1 The user is advised to review applicable national, state, provincial, or local fuel requirements.

5.1.1.1 In the United States there may be additional Clean Air Act requirements that must be fulfilled prior to introduction of the high octane number fuel into commerce. See Appendix X3 in Specification D4814 for information on U.S. Environmental Protection Agency (EPA) regulations for spark-ignition engine fuels.

5.1.2 The following applies to all specified limits in this specification: For purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded to the nearest unit in the right-most significant digit used in expressing the specification limit, in accordance with the rounding method of Practice E29. For a specification limit expressed as an integer, a trailing zero is significant only if the decimal point is specified. For a specified limit expressed as an integer, and the right-most digit is non-zero, the right-most digit is significant without a decimal point being specified. This convention applies to specified limits in Tables 1 and 2.

5.2 RON and octane sensitivity are critical performance parameters for the fuels described in this specification. Engine knock and laboratory octane number are described in X1.2 and X1.3, respectively.

TABLE 2 Vapor Pressure and Distillation Requirements[A]

Property	Vapor Pressure/ Distillation	ASTM Test Methods
Vapor pressure, at 37.8 °C (100 °F), kPa (psi), max	62 (9.0)	D4953, D5191, D5482, or D6378
Distillation temperatures, °C (°F), at % evaporated and 101.3 kPa pressure (760 mm Hg)		
10 % by volume, max	70. (158)	
50 % by volume		D86
min	66 (150.)	
max	121 (250.)	
90 % by volume, max	190. (374)	
End point, max	225 (437)	
Distillation residue, % by volume, max	2	D86

[A] See 5.1.2 for determining conformance with numerical specification limits in this table.

5.2.1 For engines with increased compression ratio, higher boost pressure, operating at slower speeds, and smaller swept displacement volume, a high RON, combined with high octane sensitivity, are well correlated with knock resistance.

5.2.2 A minimum motor octane number (MON) is required to ensure antiknock performance for all engines at high ambient temperature and certain other conditions (see CRC Report No. 660).

5.3 Volatility requirements for the high octane number test fuel are specified in Table 2. Different limits on dry vapor pressure equivalent (DVPE), T50, and other volatility parameters may be agreed upon between buyer and seller. For guidance on volatility requirements for specific climatic conditions, consult section 5.2.1 of Specification D4814.

5.4 *Oxygenate Blendstock Requirements:*

5.4.1 Denatured fuel ethanol used in blending high octane number fuel shall conform to the requirements of Specification D4806.

5.4.2 Butanol used in blending high octane number fuel shall conform to the requirements of Specification D7862.

5.4.3 Methyl *tert*-butyl ether (MTBE) used in blending high octane number fuel shall conform to the requirements of Specification D5983.

5.4.4 Methanol used in blending high octane number fuel shall conform to the requirements of Specification D1152.

TABLE 1 High Octane Number Test Fuel Specifications[A]

Property	Limit	ASTM Test Method
Research octane number, min	100.	D2699
Motor octane number, min	86	D2700
Sensitivity, min	8	D2699, D2700
Inorganic chloride, mg/kg, max	1	D7319 or D7328 as modified in 7.1.12
Lead content, g/L (g/U.S. gal), max	0.013 (0.05)	D3237 or D5059
Sulfur, mg/kg, max	10	D1266, D2622, D3120, D5453, D7220, or D7039
Manganese content, mg/L, max[B]	0.25[C]	D3831
Copper strip corrosion, max	No. 1	D130
Silver strip corrosion, max	No. 1	D7667 or D7671
Solvent-washed gum content, mg/100 mL, max	5	D381
Oxidation stability, minutes, min	240.	D525

[A] See 5.1.2 for determining conformance with numerical specification limits in this table.
[B] See Appendix X2 for information on U.S. EPA and California Air Resources Board regulations for manganese in gasoline.
[C] This level represents the lower limit of the Test Method D3831 scope.

5.4.5 Ethyl *tert*-butyl ether (ETBE) used in blending high octane number fuel shall conform to the requirements of Specification D7618.

5.5 Deposit control additives are added to spark-ignition engine fuel to help keep fuel injectors and intake valves clean.

5.5.1 In the United States, deposit control additives used in gasoline are required to be certified by the EPA. As this specification is for a test fuel, requirements for deposit control additives have not been determined.

6. Workmanship

6.1 The test fuel shall be visually free of undissolved water, sediment, and suspended matter; it shall be clear and bright at the fuel temperature at the point of custody transfer or at a lower temperature agreed upon by the purchaser and seller.

NOTE 2—Test Method D4176 can be helpful for evaluating the product.

6.1.1 *Avoiding Water Haze and Phase Separation*—The test fuel should not contain a separate water or water-alcohol phase at the time it is introduced into a vehicle or equipment fuel tank or under the conditions the fuel is used. Water that is dissolved in fuel at the point of use does not generally cause engine problems. However, if excess water is present in spark-ignition fuel, a separate phase, either 'free water' or a water-alcohol mixture, can form. Either condition can lead to engine damage, engine failing to start, or failing to operate properly. A separated water-rich phase can be observed as a haze, as water droplets, or as a distinct lower layer. This lower aqueous phase can be corrosive to many metals and the engine cannot operate on it. Similarly, the upper hydrocarbon phase may no longer meet volatility and antiknock properties.

6.2 The test fuel shall also be free of any adulterant or contaminant that can render the fuel unacceptable for its commonly used applications.

7. Test Methods

7.1 The requirements of this specification shall be determined in accordance with the methods listed below. The scopes of some of the test methods listed below do not include gasoline-ethanol blends or other gasoline-oxygenate blends. Refer to the listed test methods to determine applicability or required modifications for use with gasoline-oxygenate blends. The precision of these test methods can differ from the reported precisions when testing gasoline-ethanol blends or other gasoline-oxygenate blends.

7.1.1 *Distillation*—Test Method D86.

7.1.2 *Vapor Pressure*—Test Methods D4953, D5191, D5482, or D6378.

7.1.2.1 When using Test Method D6378, determine VP_4 at 37.8 °C (100 °F) using a sample from a 1 L container and convert to DVPE (D5191 equivalence) using the following equation:

$$\text{Predicted DVPE} = VP_{4\ 37.8\ °C} - 1.005\ \text{kPa} \quad (1)$$

$$\text{Predicted DVPE} = VP_{4\ 37.8\ °C} - 0.15\ \text{psi} \quad (2)$$

7.1.3 *Corrosion, for Copper*—Test Method D130, 3 h at 50 °C (122 °F).

7.1.4 *Solvent-Washed Gum Content*—Test Method D381, air jet apparatus.

7.1.5 *Sulfur*—Test Methods D1266, D2622, D3120, D5453, D7039, or D7220.

7.1.6 *Lead*—Test Methods D3237 or D5059 (Test Method C), which are appropriate for lead levels below 0.03 g/L (0.1 g/U.S. gal).

7.1.7 *Oxidation Stability*—Test Method D525.

7.1.8 *Oxygenate Detection*—Test Methods D4815, D5599, or D5845. These test methods are designed for the quantitative determination of methyl *tert*-butyl ether (MTBE), ethyl *tert*-butyl ether (ETBE), *tert*-amyl methyl ether (TAME), diisopropyl ether (DIPE), methyl alcohol, ethyl alcohol, and *tert*-butyl alcohol. In addition, Test Methods D4815 and D5599 are designed for the quantitative determination of *n*-propyl alcohol, *iso*propyl alcohol, *n*-butyl alcohol, *sec*-butyl alcohol, *iso*butyl alcohol, and *tert*-pentyl alcohol. Results for all of these test methods are reported in percent by mass. Test Method D4815 includes procedures for calculating oxygenate concentration in percent by volume and percent-by-mass oxygen content using the percent-by-mass oxygenate results.

7.1.9 *Corrosion, for Silver*—Test Methods D7667 or D7671.

7.1.10 *Research Octane Number*—Test Method D2699.

7.1.11 *Motor Octane Number*—Test Method D2700.

7.1.12 *Chloride*—Test Method D7319 modified to use a pre-concentration column to concentrate the chloride and eliminate the fuel matrix with deionized water, or Test Method D7328 modified to increase fuel sample volume from 2 mL to 20 mL but still dissolve the residue from evaporation in 2 mL of water to concentrate tenfold. Note that precision and bias in the test method may not be applicable to this modification.

7.1.13 *Manganese*—Test Method D3831.

7.2 Tests applicable to gasoline are not necessarily applicable to its blends with oxygenates. Consequently, the type of fuel under consideration must first be identified in order to select applicable tests. Test Method D4815 provides a procedure for determining oxygenate concentration in percent by mass. Test Method D4815 also includes procedures for calculating percent-by-mass oxygen content and oxygenate concentration in percent by volume. Appendix X4 in Specification D4814 provides a procedure for calculating the percent-by-mass oxygen content of a fuel using measured oxygenate type, oxygenate concentration in percent by volume, and measured density or relative density of the fuel.

8. Sampling, Containers, and Sample Handling

8.1 The user is strongly advised to review all intended test methods prior to sampling to understand the importance and effects of sampling technique, proper containers, and special handling required for each test method.

8.2 Correct sampling procedures are critical to obtain a sample representative of the lot intended to be tested. Use appropriate procedures in Practice D4057 for manual method sampling and in Practice D4177 for automatic method sampling, as applicable.

8.3 The correct sample volume and appropriate container selection are important decisions that can impact test results.

Refer to Practice D4306 for aviation fuel container selection for tests sensitive to trace contamination. Refer to Practice D5854 for procedures on container selection and sample mixing and handling. For octane number determination, protection from light is important. Collect and store sample fuels in an opaque container, such as a metal can, or minimally reactive plastic container to minimize exposure to UV emissions from sources such as sunlight or fluorescent lamps.

8.4 For volatility determination of a sample, refer to Practice D5842 for special precautions recommended for representative sampling and handling techniques.

9. Keywords

9.1 alcohol; automotive fuel; automotive spark-ignition engine fuel; copper strip corrosion; corrosion; distillation; EPA regulations; ethanol; ether; fuel; gasoline; gasoline-alcohol blend; gasoline-ethanol blend; gasoline-ether blend; gasoline-oxygenate blend; high octane number fuel; induction period; lead; methanol; MTBE; octane number; octane number requirement; oxidation stability; oxygenate; oxygenate detection; solvent-washed gum; sulfur; unleaded fuel; vapor pressure; volatility

APPENDIXES

(Nonmandatory Information)

X1. SIGNIFICANCE OF ASTM SPECIFICATION FOR 100 RON TEST FUEL FOR AUTOMOTIVE SPARK-IGNITION ENGINES

X1.1 General

X1.1.1 Antiknock rating and volatility define the general characteristics of automotive spark-ignition engine fuel. Other characteristics relate to the following: limiting the concentration of undesirable components so that they will not adversely affect engine performance and ensuring the stability of fuel, as well as its compatibility with materials used in engines and their fuel systems.

X1.1.2 Fuel for spark-ignition engines is a complex mixture composed of relatively volatile hydrocarbons that vary widely in their physical and chemical properties and may contain oxygenates. Fuel is exposed to a wide variety of mechanical, physical, and chemical environments. Thus, the properties of fuel must be balanced to give satisfactory engine performance over an extremely wide range of operating conditions. The prevailing standards for fuel represent compromises among the numerous quality and performance requirements. This ASTM specification is established on the basis of the broad experience and close cooperation of producers of fuel, manufacturers of automotive equipment, and users of both.

X1.2 Engine Knock

X1.2.1 The fuel-air mixture in the cylinder of a spark-ignition engine will, under certain conditions, autoignite in localized areas ahead of the flame front that is progressing from the spark. This is engine spark knock which can cause a ping that may be audible to the customer. Spark knock occurs because the temperature and pressure in the cylinder are too high for the knock or autoignition resistance of the fuel. Knock can cause abnormally high pressures and temperatures and can result in damage to engine components.

X1.2.2 The antiknock rating of a fuel is a measure of its resistance to knock. The antiknock requirement of an engine depends on engine design and operation, as well as atmospheric conditions. Fuel with an antiknock rating higher than that required for knock-free operation does not improve performance.

X1.2.3 A decrease in antiknock rating may cause vehicle performance loss. However, vehicles equipped with knock limiters can show a performance improvement as the antiknock quality of the fuel is increased in the range between customer-audible knock and knock-free operation. The loss of power and the damage to an automotive engine due to knocking are generally not significant until the knock intensity becomes very severe. Heavy and prolonged knocking may cause power loss and damage to the engine.

X1.3 Laboratory Octane Number

X1.3.1 The two recognized laboratory engine test methods for determining the antiknock rating of fuels are the research method (Test Method D2699) and the motor method (Test Method D2700). The following paragraphs describe their significance as applied to various equipment and operating conditions.

X1.3.2 RON is determined by a method that measures fuel antiknock level in a single-cylinder engine at a moderate inlet mixture temperature and a relatively low engine speed. RON tends to indicate fuel antiknock performance in engines at wide-open throttle and low-to-medium engine speeds and is the primary antiknock rating for the engines to be developed using fuels described by this standard.

X1.3.3 MON is determined by a method that measures fuel antiknock level in a single-cylinder engine at a higher inlet mixture temperature and at relatively higher engine speed. It indicates fuel antiknock performance in engines operating at wide-open throttle and high engine speeds. Also, MON tends to indicate fuel antiknock performance under part-throttle, road-load conditions.

X1.3.4 Octane sensitivity is the mathematical difference between the research and motor octane numbers and is considered a measure of the autoignition temperature sensitivity of a fuel. In high compression ratio, highly boosted engines operating at low engine speeds, if RON is held constant, a fuel

with greater octane sensitivity (all other factors being equal) will generally provide greater knock resistance.

X1.4 Volatility

X1.4.1 In most spark-ignition internal combustion engines, the fuel is metered in liquid form through a fuel injector, and is mixed with air and partially vaporized before entering the cylinders of the engine, or is injected directly into the air in the engine cylinders. Consequently, volatility is an extremely important characteristic of motor fuel.

X1.5 Vapor Pressure

X1.5.1 The vapor pressure of fuel must be sufficiently high to ensure ease of engine starting, but it must not be so high as to contribute to vapor lock or excessive evaporative emissions and running losses.

X1.5.2 Test Methods D4953, D5191, D5482, or D6378 provide procedures for determining the vapor pressures of gasoline or gasoline-oxygenate blends.

X1.6 Distillation

X1.6.1 Test Method D86 for distillation provides another measure of the volatility of fuels. Table 1 designates the limits for endpoint temperature and the temperatures at which 10 %, 50 %, and 90 % by volume of the fuel is evaporated. These distillation characteristics, along with vapor pressure, affect the following vehicle performance characteristics: starting, driveability, vapor lock, dilution of the engine oil, fuel economy, and carburetor icing.

X1.6.2 The 10 % evaporated temperature of fuel should be low enough to ensure starting under normal temperatures.

X1.6.3 Fuels having the same 10 % and 90 % evaporated temperatures can vary considerably in driveability performance because of differences in the boiling temperatures of the intermediate components, or fractions. Driveability and idling quality are affected by the 50 % evaporated temperature. The 90 % evaporated and endpoint temperatures should be low enough to minimize dilution of the engine oil.

X1.7 Corrosion

X1.7.1 While fuels shall meet the copper strip and silver strip corrosion requirements to minimize corrosion in fuel systems due to reactive sulfur compounds in the fuel, some fuel contaminants can corrode other fuel system metals. ASTM test methods to evaluate corrosion of these other metals have not been established.

X1.7.1.1 Reactive sulfur compounds present in automotive spark-ignition engine fuel under some circumstances can corrode or tarnish silver alloy in-tank fuel level sender units, resulting in an erroneous signal to the fuel gauge.

X1.8 Solvent-Washed Gum Content

X1.8.1 The test for solvent-washed gum content measures the amount of residue after evaporation of the fuel and following a heptane wash. The heptane wash removes the heptane-soluble, nonvolatile material such as additives, carrier oils used with additives, and heavier hydrocarbons. Solvent-washed gum consists of heptane-insoluble gum. The portion of the gum that is also insoluble in spark-ignition engine fuel (gasoline or gasoline-oxygenate blends) can clog fuel filters. Both soluble and insoluble gum can be deposited on surfaces when the fuel evaporates.

X1.8.2 Solvent-washed gum can contribute to deposits on the surfaces of carburetors, fuel injectors, and intake manifolds, ports, valves, and valve guides. The impact of solvent-washed gum on malfunctions of modern engines is not well established and the current specification limit is historic rather than the result of recent correlative studies. It depends on where the deposits form, the presence of other deposit precursors such as airborne debris, blowby and exhaust gas recirculation gases, and oxidized engine oil, and the amount of deposits.

X1.8.3 The difference between the unwashed and solvent-washed gum content values can be used to assess the presence and amount of nonvolatile material in the fuel. Additional analytical testing is required to determine if the material is additive, carrier oil, diesel fuel, and so forth.

X1.8.4 Unwashed gum content is a useful measure and indicator of contamination of gasoline with polymeric material not intended for gasoline. Appendix X7 in Specification D4814 describes a method to detect such contamination.

X1.9 Sulfur

X1.9.1 The limit on sulfur content is included to protect exhaust emission control systems. Fuel sulfur also can promote engine wear, deterioration of engine oil, and corrosion of exhaust system parts.

X1.10 Oxidation Stability

X1.10.1 The induction period as measured in the oxidation stability test is used as an indication of the resistance of fuel to gum formation in storage. Experience indicates that fuels with an induction period equal to or greater than that in Table 2 generally have acceptable short-term storage stability. However, correlation of the induction period with the formation of gum in storage can vary markedly under different storage conditions and with different fuels.

X1.11 Inorganic Chloride

X1.11.1 Inorganic (ionic) chloride is corrosive to many metals and it is desirable to minimize inorganic chloride compounds in fuels.

X1.11.2 An inorganic chloride limit of 1 mg/kg, maximum, has been found to be adequate in protecting fuel system components.

X1.12 Lead

X1.12.1 EPA regulations limit maximum concentrations to 0.05 g lead/U.S. gal (0.013 g/L) and fuels meeting this standard shall not exceed this level.

X1.13 Manganese

X1.13.1 Vehicles to be developed using this test fuel are anticipated to meet U.S. Tier 2, Euro 5, or more stringent

emissions standards. Therefore, MMT is limited to a maximum manganese concentration of 0.25 mg/L, until such time as data are produced to support its use at higher concentrations.

X2. EPA AND CARB GASOLINE MANGANESE REGULATIONS

X2.1 The EPA granted a Clean Air Act Section 211(f)(1) waiver for the use of manganese in conventional U.S. unleaded gasoline in 1995, at a maximum permissible manganese concentration of 8.3 mg/L (0.031 g/gal).[7] Manganese limits for other fuels are as follows:

(1) The use of MMT in conventional fuel containing oxygenates is under review by the EPA.

(2) MMT is not permitted in U.S. reformulated gasoline.[8]

(3) MMT is not permitted in California gasoline.[9]

[7] Federal Register, Vol 60, p. 36414, July 17, 1995.

[8] Code of Federal Regulations, Title 40, Part 80, Section 41.

[9] California Code of Regulations, Title 13, Section 2254.

X3. ILLUSTRATIONS OF SPECIFIC GRADES MEETING 100 RON MINIMUM

X3.1 Table X3.1 illustrates five test fuel blends that are compliant with the requirements of Tables 1 and 2 of this specification. Other fuel formulations, including different refinery streams and different blendstocks, are not shown here, but may be used to meet the requirements in Tables 1 and 2.

X3.2 Typical Tier 3 regular and premium gasoline emissions test fuels were used as base fuels for blending. Gasoline emissions test fuels have properties defined in Table VI–26–Gasoline Emissions Test Fuel Properties, Federal Register, Vol 79, No. 81, April 28, 2014, p. 23528.[10]

X3.3 The emissions test fuel gasolines contained 10 % by volume ethanol (E10). General testing gasoline emissions test fuel can be defined by a (RON+MON)/2 range of 87.0 – 88.4. Premium gasoline emissions test fuel can be defined by a minimum (RON+MON)/2 of 91.0 with no maximum.

X3.4 Finished gasolines were produced by blending specific ratios of the general testing and premium gasoline emissions test fuels, as shown in Table X3.1 and an additional blendstock. Details of the specific fuel blends are given in Table X3.1 and described below. Except for the E25 and E30, all blends required the addition of ethanol to ensure the finished fuel contained 10 % by volume ethanol.

X3.5 The E25 (25 % by volume ethanol) and E30 (30 % by volume ethanol) fuels were produced by adding Specification D4806-compliant ethanol to the gasoline emissions test fuel blends.

X3.6 The E10/IBA20 (10 % by volume ethanol and 20 % by volume isobutanol (IBA)) fuel was produced by adding Specification D4806-compliant ethanol and Specification D7862-compliant isobutanol to the gasoline emissions test fuel blends.

X3.7 The E10/IPA20 (10 % by volume ethanol and 20 % by volume isopropanol (IPA)) fuel was produced by adding specification D4806-compliant ethanol and isopropanol conforming to the specifications of the Committee on Analytical Reagents of the American Chemical Society[11] to the gasoline emissions test fuel.

X3.8 The E10/DIB20 (10 % by volume ethanol and 20 % by volume diisobutylene (DIB)) fuel was produced by adding Specification D4806-compliant ethanol and diisobutylene conforming to the specifications of the Committee on Analytical Reagents of the American Chemical Society[11] to the gasoline emissions test fuel blends. The DIB was a 3:1 by volume mixture of the following isomers: 2,4,4-trimethyl-1-pentene and 2,4,4-trimethyl-2-pentene.

X3.9 Values presented in the table were measured from hand blends with the standard test method indicated or were estimated. Estimated values are indicated by an asterisk (*).

[10] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

[11] *ACS Reagent Chemicals, Specifications and Procedures for Reagents and Standard-Grade Reference Materials*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

TABLE X3.1 Fuel Properties of Illustrative 100 RON Test Fuel Blends

Property	Limit	ASTM Test Method Used	E25	E30	E10/IBA20	E10/IPA20	E10/DIB20
Ethanol % by volume		D4815	24–27	28–31	9–11	9–11	9–11
Other oxygenates % by volume		D4815	0	0	17–23	17–23	0
Olefins % by volume		D6550	0.1	0.1	0.1	0.1	18.6–21.4
Percent premium Tier 3 gasoline as gasoline blendstock		—	60	0	100	58	100
Percent regular Tier 3 gasoline as gasoline blendstock		—	40	100	0	42	0
Research octane number, min	100.	D2699	101.	100.	101.	100.	101.
Motor octane number, min	86	D2700	88	87	88	89	88
Octane Sensitivity, min	8	D2699, D2700	13	13	13	11	13
Inorganic chloride, mg/kg, max	1	[A]	<1*	<1*	<1*	<1*	<1*
Lead content, g/L (g/U.S. gal), max	0.013 (0.05)	[A]	<0.013* (<0.05*)	<0.013* (<0.05*)	<0.013* (<0.05*)	<0.013* (<0.05*)	<0.013* (<0.05*)
Sulfur, mg/kg, max	10	[A]	<10*	<10*	<10*	<10*	<10*
Manganese content, mg/L, max	0.25	[A]	<0.25*	<0.25*	<0.25*	<0.25*	<0.25*
Copper strip corrosion, max	No. 1	[A]	No. 1*	No. 1*	No. 1*	No. 1*	No. 1*
Silver strip corrosion, max	No. 1	[A]	No. 1*	No. 1*	No. 1*	No. 1*	No. 1*
Solvent-washed gum content, mg/100 mL, max	5	[A]	<5*	<5*	<5*	<5*	<5*
Oxidation stability, minutes, min	240.	[A]	>1000*	>1000*	>1000*	>1000*	>1000*
Vapor pressure at 37.8 °C (100 °F), kPa (psi), max	62 (9.0)	D5191	52 (7.5)	52 (7.5)	46 (6.8)	50 (7.2)	49 (7.1)
Distillation temperatures, °C (°F), at % evaporated and 101.3 kPa pressure (760 mm Hg)	—	D86					
10 % by volume, max	70. (158)		60. (140)	60. (140)	65. (149)	63. (145)	62. (143)
50 % by volume	—		72. (163)	73. (164)	91. (196)	76. (169)	101. (213)
min	66 (150.)						
max	121 (250.)						
90 % by volume, max	190. (374)		157. (315)	152. (305)	158. (316)	154. (310)	156. (313)
End point, max	225 (437)		192. (378)	191. (376)	189. (372)	190. (374)	188. (371)
Distillation residue, % by volume, max	2	D86	0.7	1.0	0.9	0.5	0.7

[A] See Table 1 for allowable test methods.

SUMMARY OF CHANGES

Subcommittee D02.A0 has identified the location of selected changes to this standard since the last issue (D8076 – 21) that may impact the use of this standard. (Approved April 1, 2021.)

(1) Revised definition for oxygenate in subsection 3.2.5 and added a new discussion.

Subcommittee D02.A0 has identified the location of selected changes to this standard since the last issue (D8076 – 20) that may impact the use of this standard. (Approved Jan. 1, 2021.)

(1) Revised definition for octane sensitivity in subsection 3.2.4 and added a new discussion.

Subcommittee D02.A0 has identified the location of selected changes to this standard since the last issue (D8076 – 19a) that may impact the use of this standard. (Approved Sept. 1, 2020.)

(1) Added Appendix X3.

Subcommittee D02.A0 has identified the location of selected changes to this standard since the last issue (D8076 – 19) that may impact the use of this standard. (Approved Dec. 15, 2019.)

(1) Revised Referenced Documents, Table 1, and subsection 7.1.5 to remove all references to withdrawn Test Method D6920.

Subcommittee D02.A0 has identified the location of selected changes to this standard since the last issue (D8076 – 18) that may impact the use of this standard. (Approved Dec. 1, 2019.)

(1) Revised Table 1.

(2) Revised definition for octane sensitivity in 3.2.4.