Designation: ~~D4814 – 19~~ D4814 – 19a

Standard Specification for
Automotive Spark-Ignition Engine Fuel[1]

1. Scope*

1.1 This specification covers the establishment of requirements of liquid automotive fuels for ground vehicles equipped with spark-ignition engines.

1.2 This specification describes various characteristics of automotive fuels for use over a wide range of operating conditions. It provides for a variation of the volatility and water tolerance of automotive fuel in accordance with seasonal climatic changes at the locality where the fuel is used. For the period May 1 through Sept. 15, the maximum vapor pressure limits issued by the United States (U.S.) Environmental Protection Agency (EPA) are specified for each geographical area except Alaska and Hawaii. Variation of the antiknock index with seasonal climatic changes and altitude is discussed in Appendix X1. This specification neither necessarily includes all types of fuels that are satisfactory for automotive vehicles, nor necessarily excludes fuels that can perform unsatisfactorily under certain operating conditions or in certain equipment. The significance of each of the properties of this specification is shown in Appendix X1.

1.3 The spark-ignition engine fuels covered in this specification are gasoline and its blends with oxygenates, such as alcohols and ethers and where gasoline is the primary component by volume in the blend. The concentrations and types of oxygenates are not specifically limited in this specification. The composition of both unleaded and leaded fuel is limited by economic, legal, and technical consideration, but their properties, including volatility, are defined by this specification. In many countries, regulatory authorities having jurisdiction have set laws and regulations that limit the concentration of oxygenates and certain other compounds found in spark-ignition engine fuel. In the United States, oxygenate types and concentrations are limited to those approved under the U.S. Environmental Protection Agency's (EPA) substantially similar rule (see X3.3.1), waivers, and partial waivers including some restrictions on vehicle and equipment use (see X3.3.2). With regard to fuel properties, including volatility, this specification can be more or less restrictive than the EPA rules, regulations, and waivers. Refer to Appendix X3 for discussions of EPA rules relating to fuel volatility, lead and phosphorous contents, sulfur content, benzene content, deposit control additive certification, and use of oxygenates in blends with unleaded gasoline. Contact the EPA for the latest versions of the rules and additional requirements.

1.4 This specification does not address the emission characteristics of reformulated spark-ignition engine fuel. Reformulated spark-ignition engine fuel is required in some areas to lower emissions from automotive vehicles, and its characteristics are described in the research report on reformulated spark-ignition engine fuel.[2] However, in addition to the legal requirements found in this research report, reformulated spark-ignition engine fuel should meet the performance requirements found in this specification.

1.5 This specification represents a description of automotive fuel as of the date of publication. 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 D4814, contact ASTM International Headquarters.

1.6 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 mass percent. Test Method D4815 also includes procedures for calculating mass oxygen content and

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

TABLE 1 Vapor Pressure and Distillation Class Requirements[A]

	Vapor Pressure/Distillation Class						ASTM Test Method
	AA	A	B	C	D	E	
Vapor Pressure,[B] at 37.8 °C (100 °F) max, kPa (psi)	54 (7.8)	62 (9.0)	69 (10.0)	79 (11.5)	93 (13.5)	103 (15.0)	D4953, D5191, D5482, or D6378
Distillation Temperatures, °C (°F), at % Evaporated[C]							D86 or D7345[D, E]
10 volume %, max	70. (158)	70. (158)	65 (149)	60. (140.)	55 (131)	50. (122)	
50 volume %							
min[F]	77 (170.)	77 (170.)	77 (170.)	77 (170.)	77 (170.)[G]	77 (170.)[G]	
max	121 (250.)	121 (250.)	118 (245)	116 (240.)	113 (235)	110. (230.)	
90 volume %, max	190. (374)	190. (374)	190. (374)	185 (365)	185 (365)	185 (365)	
End Point, max	225 (437)	225 (437)	225 (437)	225 (437)	225 (437)	225 (437)	
Distillation Residue, volume %, max	2	2	2	2	2	2	D86 or D7345[D, E]
Driveability Index,[H] max, °C (°F)	597 (1250.)	597 (1250.)	591 (1240.)	586 (1230.)	580. (1220.)	569 (1200.)	Derived[I,J]

[A] See 1.7 for determining conformance with specification limits in this table. When using this table to determine the conformance of gasoline volatility, the reader is advised to review other applicable national, state, provincial, or local requirements. (For example, in the U.S. these may include the EPA Substantially Similar rule, California Air Resources Board (CARB), Clean Burning Gasoline (CBG), other state or local and pipeline specifications). See Appendix X3 for a summary of applicable U.S. EPA regulations for spark-ignition engine fuels.

[B] Consult EPA for approved test methods for compliance with EPA vapor pressure regulations.

[C] At 101.3 kPa pressure (760 mm Hg).

[D] Test Method D86 shall be the referee method.

[E] Test Method D7345, results shall be reported as "Predicted D86" as determined by applying the corrections described in Test Method D7345 to convert to D86 equivalent values. The use of Test Method D7345 shall be limited to gasoline and gasoline-ethanol blends up to maximum 20 % by volume ethanol.

[F] Gasolines that may be blended with 1 % to 15 % by volume ethanol or all other gasolines whose disposition with ethanol blending is not known shall meet a minimum 50 % evaporated distillation temperature of 77 °C (170. °F) prior to blending with ethanol. Gasoline-ethanol blends that contain 1 % to 15 % by volume ethanol shall meet a minimum 50 % evaporated distillation temperature of 66 °C (150. °F) after blending.

[G] Gasolines known from the origin to retail that will not be blended with ethanol may meet a minimum 50 % evaporated distillation temperature of 66 °C (150. °F) for volatility classes D and E only. Gasolines meeting these limits are not suitable for blending with ethanol.

[H] See 5.2.3 for Driveability Index equations for gasoline and gasoline-ethanol blends containing no more than 15 % by volume ethanol.

[I] The DI specification limits are applicable at the refinery or import facility as defined by 40 CFR Part 80.2 and are not subject to correction for precision of the test method.

[J] Since DI is an index and has no units, the standard temperature conversion from U.S. customary to SI units is not appropriate. The following equation is to be used to make the conversion: $DI_{\,^\circ C} = (DI_{\,^\circ F} - 176)/1.8$

oxygenate concentration in volume percent. Appendix X4 provides a procedure for calculating the mass oxygen content of a fuel using measured oxygenate type, oxygenate concentration in volume percent, and measured density or relative density of the fuel.

1.7 The following applies to all specified limits in this standard: 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, 3, and X8.1, and it will not be observed in the remainder of this specification.

1.8 The values stated in SI units are the standard, except when other units are specified by U.S. federal regulation. Values given in parentheses are provided for information only.

NOTE 2—Many of the values shown in Table 1 were originally developed using U.S. customary units and were subsequently soft-converted to SI values. As a result, conversion of the SI values will sometimes differ slightly from the U.S. customary values shown because of round-off. In some cases, U.S. federal regulations specify non-SI units.

1.9 *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.*

1.10 *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:*[3]

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

D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)

D381 Test Method for Gum Content in Fuels by Jet Evaporation

D439 Specification for Automotive Gasoline (Withdrawn 1990)[4]

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[3] 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.

[4] The last approved version of this historical standard is referenced on www.astm.org.

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

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

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

D2885 Test Method for Determination of Octane Number of Spark-Ignition Engine Fuels by On-Line Direct Comparison Technique

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

D3341 Test Method for Lead in Gasoline—Iodine Monochloride Method

D3831 Test Method for Manganese in Gasoline By Atomic Absorption Spectroscopy

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

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

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 in Gasoline by X-Ray Spectroscopy

D5188 Test Method for Vapor-Liquid Ratio Temperature Determination of Fuels (Evacuated Chamber and Piston Based Method)

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 (Mini Method—Atmospheric)

D5500 Test Method for Vehicle Evaluation of Unleaded Automotive Spark-Ignition Engine Fuel for Intake Valve Deposit Formation

D5598 Test Method for Evaluating Unleaded Automotive Spark-Ignition Engine Fuel for Electronic Port Fuel Injector Fouling

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

D6378 Test Method for Determination of Vapor Pressure (VP_X) of Petroleum Products, Hydrocarbons, and Hydrocarbon-Oxygenate Mixtures (Triple Expansion Method)

D6469 Guide for Microbial Contamination in Fuels and Fuel Systems

D6920 Test Method for Total Sulfur in Naphthas, Distillates, Reformulated Gasolines, Diesels, Biodiesels, and Motor Fuels by Oxidative Combustion and Electrochemical Detection (Withdrawn 2018)[4]

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

D7345 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation Method)

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

D7757 Test Method for Silicon in Gasoline and Related Products by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *Government Regulations:*
16 CFR Part 306 Automotive Fuel Ratings, Certification and Posting[5]
CFR 40 Code of Federal Regulations[5]
CCR Title 17, §60100-§60114 California Code of Regulations[6]
2.3 *Other Documents:*
API Recommended Practice 1640 Product Quality in Light Product Storage and Handling Operations[7]
CRC Report No. 638 Intermediate-Temperature Volatility Program, 2003[8]
CRC Report No. 666 Intermediate-Temperature E15 Cold-start and Warm-up Vehicle Driveability Program, 2013[8]
CRC Report No. 667 Diesel Fuel Storage and Handling Guide, September 2014[8]

3. Terminology

3.1 For general terminology, refer to Terminology D4175.

3.2 *Definitions:*

3.2.1 *antiknock index, n*—the arithmetic average of the Research octane number (RON) and Motor octane number (MON), that is, (RON + MON)/2.

3.2.2 *driveability, n*—in vehicles equipped with internal combustion engines, the quality of a vehicle's performance characteristics under a range of conditions as perceived by the operator.

3.2.2.1 *Discussion*—

The performance characteristics may include cold starting and warm-up, acceleration, idling, and hot starting.

3.2.3 *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**

3.2.4 *finished fuel, n*—a homogeneous mixture of blendstocks and fuel additives meeting all specification and regulatory requirements for its intended use at the location where sold.

3.2.5 *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.

3.2.6 *gasoline-alcohol blend, n*—a fuel consisting primarily of gasoline along with a substantial amount (more than 0.35 % by mass oxygen, or more than 0.15 % by mass oxygen if methanol is the only oxygenate) of one or more alcohols.

3.2.7 *gasoline-ethanol blend, n*—a fuel consisting primarily of gasoline along with a substantial amount (more than 0.35 % by mass oxygen) of ethanol.   **D4806**

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

3.2.9 *gasoline-oxygenate blend, n*—a fuel consisting primarily of gasoline along with a substantial amount (more than 0.35 % by mass oxygen, or more than 0.15 % by mass oxygen if methanol is the only oxygenate) of one or more oxygenates.

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

3.2.11 *refinery, n*—a plant at which gasoline or diesel fuel is produced.

3.2.11.1 *Discussion*—

This definition is from U.S. CFR 40 Part 80.2. In the federal definition, a plant not only covers the conventional refinery, but also covers oxygenate blending and other facilities where gasoline is produced.

3.2.12 *water tolerance, n*—the ability to absorb small quantities of water without creating a separate phase in the fuel.

3.2.12.1 *Discussion*—

Improved water tolerance is the ability to absorb larger quantities of water without phase separation.

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TABLE 2 Detailed Requirements for all Volatility Classes[A,B]

Property	Limit	ASTM Test Method
Lead content, max, g/L (g/U.S. gal)[C]		
Unleaded	0.013 (0.05)	D3237 or D5059
Leaded	1.1 (4.2)	D3341 or D5059
~~Sulfur, max, % by mass~~		~~D1266, D2622, D3120, D5453, D6920, or D7039~~
Sulfur, max, % by mass		D1266, D2622, D3120, D5453, D6920, D7039, or D7220
Unleaded	0.0080	
Leaded	0.15	
Manganese content, max, mg/L (mg/U.S. gal)[D]	See 6.3	D3831[E]
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, minimum, minutes	240.	D525

[A] See Appendix X1 for information on Antiknock Index.
[B] See X3.7 for information on U.S. Environmental Protection Agency regulations for benzene in gasoline.
[C] See Appendix X3 for U.S. EPA maximum limits for lead and phosphorus contents in unleaded gasoline (X3.2.1) and maximum average lead limits for leaded gasoline (X3.2.2). The reader is advised to review other applicable national, state, provincial, or local requirements.
[D] See X3.8 for information on U.S. EPA and California Air Resources Board regulations for manganese in gasoline.
[E] See Note 8.

3.3 *Applicability*—To determine when a fuel contains a substantial amount of an oxygenate, a gasoline-oxygenate blend is defined as a fuel that contains more than 0.35 % by mass oxygen, or more than 0.15 % by mass oxygen if methanol is the only oxygenate. The definitions in this section do not apply to fuels that contain an oxygenate as the primary component; for example, fuel methanol (M85).

Note 3—The criteria in 3.3 were selected with consideration given to current oxygenate levels in the marketplace, state labeling practices, and consistency with U.S. federal legislation and regulations.

Note 4—Refer to Test Method D4815 to calculate the mass oxygen content of a fuel using oxygenate concentration in percent by mass. Refer to Appendix X4 to calculate mass oxygen content of a fuel using oxygenate concentration in percent by volume.

4. Ordering Information

4.1 The purchasing agency shall:

4.1.1 State the antiknock index as agreed upon with the seller,

4.1.2 Indicate the season and locality in which the fuel is to be used,

4.1.3 Indicate the lead level required (Table 2), and

4.1.4 State the concentration and types of oxygenates present as agreed upon with the seller.

5. Performance Requirements

5.1 Some requirements and test methods applicable to automotive spark-ignition engine fuel depend on whether the fuel is a gasoline, or a gasoline-oxygenate blend. Test Methods D4815 and D5599, gas chromatographic test methods, are the recommended procedures to detect the types and amounts of oxygenates. Once the type of fuel is known, the appropriate requirements and test methods can be identified by reference to Table 1, Table 3, and Section 7.

5.2 Volatility of fuels is varied for seasonal climatic changes and conformance to U.S. EPA volatility regulations by providing six vapor pressure/distillation classes and six vapor lock protection classes for fuel. Volatility of fuel is specified by an alphanumeric designation that uses a letter from Table 1 and a number from Table 3.

5.2.1 The seasonal and geographic distribution of the combined vapor pressure/distillation-vapor lock classes is shown in Table 4. For sea-level areas outside of the United States, the following ambient temperatures are for guidance in selecting the appropriate alphanumeric designation:

Alphanumeric Volatility Designation	10th Percentile 6 h Minimum Daily Temperature, °C (°F)	90th Percentile Maximum Daily Temperature, °C (°F)
A-1	>16 (60.)	≥43 (110.)
B-2	>10. (50.)	<43 (110.)
C-3	>4 (40.)	<36 (97)
D-4	> –7 (20.)	<29 (85)
E-5	≤ –7 (20.)	<21 (69)

The 6 h minimum temperature is the highest temperature of the six coldest consecutive hourly temperature readings of a 24 h day. The 6 h minimum temperature provides information on the cold-soak temperature experienced by a vehicle. The 10th percentile of this temperature statistic indicates a 10 % expectation that the 6 h minimum temperature will be below this value

TABLE 3 Vapor Lock Protection Class Requirements[A, B, C]

	Vapor Lock Protection Class						ASTM Test Method
	1	2	3	4	5	6	
Temperature, °C (°F) for a Vapor-Liquid Ratio of 20, min	54 (129)	50. (122)	47 (116)	42 (107)	39 (102)	35 (95)	D5188
Special Requirements for Area V of D4814 Temperature, °C (°F) for a Vapor-Liquid Ratio of 20, min	54 (129)	50. (122)	47 (116)	47 (116)	41 (105)	35 (95)	D5188

[A] See 1.7 for determining conformance with numerical specification limits in this table. When using this table to determine the conformance of the temperature for a vapor-liquid ratio of 20, the reader is advised to review other applicable national, state, provincial, or local requirements (for example, EPA's "Substantially Similar" rule, CARB regulations, and other state and local regulations).
[B] Gasoline, or blend of oxygenate and gasoline as sold to the consumer, shall meet these limits. Certain gasolines meeting these limits of this table may not be suitable for blending with ethanol.
[C] Gasolines and gasoline-oxygenate blends sold at retail sites located in Area V shown in Fig. X1.2 (generally high elevations) shall use the special limits shown in Row 2 of this table, regardless of ethanol content.

during a month. The 90th percentile maximum temperature is the highest temperature expected during 90 % of the days, and provides information relative to peak vehicle operating temperatures during warm and hot weather. For areas above sea level, the 10th percentile 6 h minimum temperature should be increased by 3.6 °C⁄1000 m (2 °F⁄1000 ft) of altitude, and the 90th percentile maximum should be increased by 4.4 °C⁄1000 m (2.4 °F⁄1000 ft) of altitude before comparing them to the sea level temperature. These corrections compensate for changes in fuel volatility caused by changes in barometric pressure due to altitude. Tables 5-7 show the U.S. federal ozone nonattainment areas at several vapor lock protection levels that require reduced vapor pressure in the summertime. Tables 8-11 show at several vapor lock protection levels the areas that require federal reformulated spark-ignition engine fuel in the summertime. Table 12 shows the areas with restrictive local vapor pressure limits that have been approved under the EPA state implementation plan (SIP).

5.2.2 The EPA vapor pressure regulations can cause the distillation of the fuel to be less volatile, which for some vehicles, results in a worse warm-up driveability performance.

5.2.3 Driveability Index (DI) is intended to provide control of distillation parameters and ethanol content that influence cold start and warm-up driveability. It is a function of the 10 %, 50 %, and 90 % evaporated distillation temperatures measured by Test Methods D86 or D7345 and the ethanol content measured by the test methods shown in 7.1.9. Equations are provided for gasoline and gasoline-ethanol blends containing up to 10 % by volume ethanol and for gasoline-ethanol blends containing greater than 10 % by volume and no more than ~~15 %~~ 15 % by volume ethanol when distillation temperatures are determined in Celsius or Fahrenheit degrees.

5.2.3.1 For fuels containing 0 % to 10 % by volume ethanol:
For degrees Celsius:

$$\text{Driveability Index } (\text{DI}_C) = 1.5\ T_{10} + 3.0\ T_{50} + 1.0\ T_{90} + 1.33 \times (\text{Ethanol \% by Volume}) \tag{1}$$

For degrees Fahrenheit:

$$\text{Driveability Index } (\text{DI}_F) = 1.5\ T_{10} + 3.0\ T_{50} + 1.0\ T_{90} + 2.4 \times (\text{Ethanol \% by Volume}) \tag{2}$$

5.2.3.2 For fuels greater than 10 % and no more than 15 % by volume ethanol:
For degrees Celsius:

$$\text{Driveability Index } (\text{DI}_C) = 1.5\ T_{10} + 3.0\ T_{50} + 1.0\ T_{90} +$$
$$(1.33 + [(\text{Ethanol \% by Volume} - 10)⁄5] \times (5.26 - 1.33)) \times (\text{Ethanol \% by Volume}) \tag{3}$$

For degrees Fahrenheit:

$$\text{Driveability Index } (\text{DI}_F) = 1.5\ T_{10} + 3.0\ T_{50} + 1.0\ T_{90} +$$
$$(2.4 + [(\text{Ethanol \% by Volume} - 10)⁄5] \times (9.49 - 2.4)) \times (\text{Ethanol \% by Volume}) \tag{4}$$

where:
T_{10} = distillation temperature at 10 % evaporated,
T_{50} = distillation temperature at 50 % evaporated, and
T_{90} = distillation temperature at 90 % evaporated.

5.2.4 Test Method D5188 is the method for determining vapor-liquid ratio temperatures by an evacuated chamber method for gasoline-oxygenate blends, as well as for gasoline. The methods for estimating temperature-*V/L* ($T_{V/L=20}$) (see Appendix X2) are applicable for gasoline and gasoline-ethanol blends (1 % to 15 % by volume), but not for gasoline-ether blends.

5.3 Antiknock index (AKI) is very important to engine performance. The matching of engine octane requirement to fuel octane level (AKI) is critical to the durability and performance of engines; this cannot be accomplished with a single specified minimum

TABLE 4 Schedule of U.S. Seasonal and Geographical Volatility Classes[A]

NOTE 1—This schedule, subject to agreement between purchaser and seller, denotes the volatility properties of the fuel at the time and place of bulk delivery to the fuel dispensing facilities for the end user. For Sept. 16 through April 30 (the time period not covered by U.S. EPA Phase II vapor pressure requirements), volatility properties for the previous month or the current month are acceptable for the end user from the 1st through the 15th day of the month. From the 16th day through the end of the month, volatility properties of the fuel delivered to the end user shall meet the requirements of the specified class(es). To ensure compliance with EPA Phase II vapor pressure requirements, vapor pressure for finished gasoline tankage at refineries, importers, pipelines, and terminals during May and for the entire distribution system, including retail stations, from June 1 to Sept. 15 shall meet only the current month's class. Shipments should anticipate this schedule.

NOTE 2—Where alternative classes are listed, either class or intermediate classes are acceptable; the option shall be exercised by the seller.

NOTE 3—See Appendix X2 of Research Report: D02-1347[2] for detailed description of areas. Contact EPA for the latest information on areas requiring reformulated fuel.

State	Jan.	Feb.	Mar.	Apr.	May[B]	June	July	Aug.	Sept. 1–15	Sept. 16–30	Oct.	Nov.	Dec.
Alabama	D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-3	A-3	A-2	A-2	A-2/C-3	C-3	C-3/D-4	D-4
Alaska	E-6	E-6	E-6	E-6	E-6/D-4	D-4	D-4	D-4	D-4	D-4/E-6	E-6	E-6	E-6
Arizona:[C]													
N 34° Latitude and E111° Longitude	D-4	D-4	D-4/C-3	C-3/A-2	A-2 (B-2)	A-1	A-1	A-1	A-2	A-2/B-2	B-2/C-3	C-3/D-4	D-4
Remainder of State	D-4	D-4/C-3	C-3/B-2	B-2/A-2	A-2 (B-2)	A-1[D]	A-1[D]	A-1[D]	A-1[E]	A-1	A-1/B-2	B-2/C-3	C-3/D-4
Arkansas	E-5/D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-3	A-2	A-2	A-2	A-2/C-3	C-3/D-4	D-4	D-4/E-5
California:[C ,F]													
North Coast	E-5/D-4	D-4	D-4	D-4/A-3	A-3 (C-3)	A-3[G]	A-2[E]	A-2[E]	A-2[E]	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
South Coast	D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-2[E ,H]	A-2[E]	A-2[E ,H]	A-2[E,H]	A-2/B-2	B-2/C-3	C-3/D-4	D-4
Southeast	D-4	D-4/C-3	C-3/B-2	B-2/A-2	A-2 (B-2)	A-1[D]	A-1[D,I]	A-1[D,I]	A-1[D,I]	A-1	A-1/B-2	B-2/C-3	C-3/D-4
Interior	E-5/D-4	D-4	D-4	D-4/A-3	A-3 (C-3)	A-2[E,H]	A-2[E,H]	A-2[E ,H]	A-2[E,H]	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
Colorado	E-5	E-5/D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-2[E]	A-2[E]	A-2[E]	A-2[E]	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
Connecticut	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/D-4	D-4	D-4/E-5	E-5
Delaware	E-5	E-5	E-5/D-4	D0-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
District of Columbia	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-3[K]	A-3[K]	A-3[K]	A-3[K]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Florida	D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-3	A-3	A-2	A-2	A-2/C-3	C-3	C-3/D-4	D-4
~~Georgia~~	~~D-4~~	~~D-4~~	~~D-4/C-3~~	~~C-3/A-3~~	~~A-3 (C-3)~~	~~A-3[G]~~	~~A-3[G]~~	~~A-2[E]~~	~~A-2[E]~~	~~A-2/C-3~~	~~C-3~~	~~C-3/D-4~~	~~D-4~~
Georgia	D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-3	A-3	A-2	A-2	A-2/C-3	C-3	C-3/D-4	D-4
Hawaii	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3
Idaho:													
N 46° Latitude	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-2	A-2	A-2	A-2/C-3	C-3/D-4	D-4/E-5	E-5
S 46° Latitude	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-2	A-2	A-2	A-2	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
Illinois:													
N 40° Latitude	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
S 40° Latitude	E-5	E-5	E-5/D-4	D-4/A-3	A-3 (C-3)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/C-3	C-3/D-4	D-4	D-4/E-5
Indiana[C]	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Iowa	E-5	E-5	E-5/D-4	D-4/A-3	A-3 (C-3)	A-3	A-3	A-3	A-3	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Kansas[C]	E-5	E-5/D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-2[E]	A-2[E]	A-2[E]	A-2[E]	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
Kentucky	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Louisiana	D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-3	A-3	A-2	A-2	A-2/C-3	C-3	C-3/D-4	D-4
Maine	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/D-4	D-4	D-4/E-5	E-5
Maryland	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J,K]	A-3[J,K]	A-3[J,K]	A-3[J,K]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Massachusetts	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/D-4	D-4	D-4/E-5	E-5
Michigan[C]	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-3	A-3	A-3	A-3/D-4	D-4	D-4/E-5	E-5
Minnesota	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-3	A-3	A-3	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Mississippi	D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-3	A-3	A-2	A-2	A-2/C-3	C-3	C-3/D-4	D-4
Missouri[C]	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-3[G]	A-2[E]	A-2[E]	A-2[E]	A-2/C-3	C-3/D-4	D-4	D-4/E-5
Montana	E-5	E-5	E-5/D-4	D-4/A-3	A-3 (C-3)	A-2	A-2	A-2	A-2	A-2/C-3	C-3/D-4	D-4/E-5	E-5
Nebraska	E-5	E-5	E-5/D-4	D-4/A-3	A-3 (C-3)	A-2	A-2	A-2	A-2	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
Nevada:													
N 38° Latitude	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-2[E]	A-2[E]	A-2[E]	A-2[E]	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
S 38° Latitude	D-4	D-4/C-3	C-3/B-2	B-2/A-2	A-2 (B-2)	A-1	A-1	A-1	A-1	A-1	A-1/B-2	B-2/C-3	C-3/D-4
New Hampshire	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/D-4	D-4	D-4/E-5	E-5
New Jersey	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/D-4	D-4	D-4/E-5	E-5
New Mexico:													
N 34° Latitude	E-5/D-4	D-4	D-4/C-3	C-3/A-2	A-2 (B-2)	A-1	A-1	A-2	A-2	A-2/B-2	B-2/C-3	C-3/D-4	D-4
S 34° Latitude	D-4	D-4/C-3	C-3/B-2	B-2/A-2	A-2 (B-2)	A-1	A-1	A-1	A-1	A-1/B-2	B-2/C-3	C-3/D-4	D-4
New York	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/D-4	D-4	D-4/E-5	E-5
North Carolina	E-5/D-4	D-4	D-4	D-4/A-3	A-3 (C-3)	A-3	A-3	A-2	A-2	A-2/C-3	C-3/D-4	D-4	D-4/E-5
North Dakota	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-2	A-2	A-2	A-2/C-3	C-3/D-4	D-4/E-5	E-5
Ohio	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-3	A-3	A-3	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Oklahoma	E-5/D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-2	A-2	A-2	A-2	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
Oregon:													
E122° Longitude	E-5	E-5/D-4	D-4	D-4/A-4	A-4 (D-4)	A-3	A-2	A-2	A-2	A-2/C-3	C-3/D-4	D-4/E-5	E-5
W 122° Longitude	E-5	E-5/D-4	D-4	D-4/A-4	A-4 (D-4)	A-3[G]	A-3[G]	A-3[G]	A-3[G]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Pennsylvania[C]	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3	A-3/D-4	D-4	D-4/E-5	E-5
Rhode Island	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3	A-3/D-4	D-4	D-4/E-5	E-5
South Carolina	D-4	D-4	D-4	D-4/A-3	A-3 (C-3)	A-3	A-3	A-2	A-2	A-2/C-3	C-3/D-4	D-4	D-4
South Dakota	E-5	E-5	E-5/D-4	D-4/A-3	A-3 (C-3)	A-2	A-2	A-2	A-2	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
Tennessee	E-5/D-4	D-4	D-4	D-4/A-3	A-3 (C-3)	A-3	A-3	A-2	A-2	A-2/C-3	C-3/D-4	D-4	D-4/E-5

TABLE 4 *Continued*

State	Jan.	Feb.	Mar.	Apr.	May[B]	June	July	Aug.	Sept. 1–15	Sept. 16–30	Oct.	Nov.	Dec.
Texas:[C]													
E99° Longitude	D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-3[G,K]	A-2[E,H]	A-2[E,H]	A-2[E,H]	A-2/B-2	B-2/C-3	C- 3/D-4	D-4
W 99° Longitude	D-4	D-4/C-3	C-3/B-2	B-2/A-2	A-2 (B-2)	A-1[D]	A-1[D]	A-1[D]	A-1[D]	A-1/B-2	B-2/C-3	C-3/D-4	D-4
Utah	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-2[E]	A-2[E]	A-2[E]	A-2[E]	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5
Vermont	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-3	A-3	A-3	A-3/D-4	D-4	D-4/E-5	E-5
Virginia	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-3[G,K]	A-3[G,K]	A-3[G,K]	A-3[G,K]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Washington:													
E122° Longitude	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-2	A-2	A-2	A-2/C-3	C-3/D-4	D-4/E-5	E-5
W 122° Longitude	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-3	A-3	A-3	A-3/C-3	C-3/D-4	D-4/E-5	E-5
West Virginia	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3	A-3	A-3	A-3	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Wisconsin	E-5	E-5	E-5/D-4	D-4/A-4	A-4 (D-4)	A-3[J]	A-3[J]	A-3[J]	A-3[J]	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Wyoming	E-5	E-5	E-5/D-4	D-4/A-3	A-3 (C-3)	A-2	A-2	A-2	A-2	A-2/B-2	B-2/C-3	C-3/D-4	D-4/E-5

[A] For the period May 1 through September 15, the specified vapor pressure classes comply with 1992 U.S. EPA Phase II volatility regulations. Reformulated spark-ignition engine fuel blended to meet the requirements of the EPA "Complex Model" shall also meet the Phase II volatility regulations. EPA regulations (under the Phase II regulations) allow 1.0 psi higher vapor pressure for gasoline-ethanol blends containing 9 % to 10 % by volume ethanol for the same period, except for fuels blended to meet the "Complex Model" regulations. See Appendix X3 for additional federal volatility regulations.
[B] Values in parentheses are permitted for retail stations and other end users.
[C] See Table 12 for specific area requirements.
[D] See Table 7 for specific area requirements.
[E] See Table 6 for specific area requirements.
[F] Details of State Climatological Division by CARB air basin and county as indicated (Descriptions of the California Air Basins are found in the California Code of Regulations):
California, North Coast—CARB North Coast, Lake County, San Francisco Bay Area, and North Central Coast Air Basins (Alameda, Contra Costa, Del Norte, Humboldt, Lake, Marin, Mendocino, Monterey, Napa, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, Sonoma, and Trinity Counties and part of Solano County).
California, interior—CARB Northeast Plateau, Sacramento Valley, Mountain Counties, Lake Tahoe, and San Joaquin Valley Air Basins (Amador, Butte, Calaveras, Colusa, El Dorado, Fresno, Glenn, Kings, Lassen, Madera, Mariposa, Merced, Modoc, Nevada, Placer, Plumas, Sacramento, San Joaquin, Shasta, Sierra, Siskiyou, Stanislaus, Sutter, Tehama, Tulare, Tuolumne, Yolo, and Yuba Counties, and parts of Kern and Solano Counties).
California, South Coast—CARB South Central Coast, San Diego, and South Coast Air Basins (Los Angeles, Orange, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties, and parts of Riverside and San Bernardino Counties).
California, Southeast—CARB Great Basin Valleys, Salton Sea, and Mojave Desert Air Basins (Alpine, Imperial, Inyo, and Mono Counties, and parts of Kern, Los Angeles, Riverside, San Bernardino Counties).
[G] See Table 5 for specific area requirements.
[H] See Table 10 for specific requirements.
[I] See Table 11 for specific area requirements.
[J] See Table 8 for specific area requirements.
[K] See Table 9 for specific area requirements.

TABLE 5 U.S. Ozone Nonattainment Areas Requiring Volatility Class AA-3

Note 1—See 40 CFR Part 81.300 for description of the geographic boundary for each area.

California[A] —Alameda, Contra Costa, Marin, Monterey, Napa, San Francisco, San Benito, San Mateo, Santa Clara, Santa Cruz, and Solano (part) counties
~~Georgia—Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, Paulding, and Rockdale counties~~
Missouri—Franklin, Jefferson, Saint Charles, and Saint Louis counties; and the city of St. Louis
Oregon—Clackamas (part), Marion (part), Multnomah (part), Polk (part), and Washington (part) counties
Texas—Hardin, Jefferson, and Orange counties
Virginia—Smyth County (part)

[A] See Table 12 for local vapor pressure limits.

level of antiknock index. Appendix X1 includes a discussion of antiknock indexes of fuels currently marketed and relates these levels to the octane needs of broad groups of engines and vehicles. Also discussed is the effect of altitude and weather on vehicle antiknock requirements.

5.4 The denatured fuel ethanol used in gasoline-ethanol blends shall conform to the requirements of Specification D4806.

5.5 Additional fuel requirements are shown in Table 2.

5.6 The properties of gasoline-oxygenate blends can differ considerably from those of gasoline. Consequently, additional requirements are needed for gasoline-oxygenate blends. These requirements involve evaluation of compatibility with plastic and elastomeric materials in fuel systems, corrosion of metals, and especially in the case of gasoline-alcohol blends, water tolerance. Requirements for metal corrosion (other than copper and silver) and material compatibility are not given because test methods and appropriate limits are still under development. When these have been developed, they will be included in this specification.

TABLE 6 U.S. Ozone Nonattainment Areas Requiring Volatility Class AA-2

NOTE 1—See 40 CFR Part 81.300 for description of the geographic boundary for each area.

Arizona[A] —Maricopa County
California[A] —Alameda, Butte, Contra Costa, Fresno, Kern (part), Kings, Madera, Marin, Merced, Monterey, Napa, San Benito, San Francisco, San Joaquin, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Stanislaus, Tulare, and Yuba counties
Colorado—Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer (part), and Weld (part) counties
~~Georgia—Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, Paulding, and Rockdale counties~~
Kansas[A] —Johnson and Wyandotte counties
Missouri—Franklin, Jefferson, Saint Charles, and Saint Louis counties; and the city of St. Louis
Nevada—Washoe County
Texas—Hardin, Jefferson, and Orange counties
Utah—Davis and Salt Lake counties

[A] See Table 12 for local vapor pressure limits.

TABLE 7 U.S. Ozone Nonattainment Areas Requiring Volatility Class AA-1

NOTE 1—See 40 CFR Part 81.300 for description of the geographic boundary for each area.

Arizona[A] —Maricopa County
California[A] —Imperial and Kern (part) counties
Texas[A] —El Paso County

[A] See Table 12 for local vapor pressure limits.

TABLE 8 U.S. Federal RFG Areas Requiring Volatility Class A-3

NOTE 1—See 40 CFR Part 81.300 for description of the geographic boundary for each area.

NOTE 2—No waiver for gasoline-ethanol blends.

Connecticut—All counties
Delaware—All counties
Illinois—Cook, Du Page, Grundy (part), Jersey, Kane, Kendall (part), Lake, Madison, McHenry, Monroe, St. Clair, and Will counties
Indiana[A] —Lake and Porter counties
Kentucky—Bullitt (part), Jefferson, and Oldham (part) counties
Maine—Androscoggin, Cumberland, Kennebec, Knox, Lincoln, Sagadahoc, and York Counties
Maryland—Cecil County
Massachusetts—All counties
New Hampshire—Hillsborough, Merrimack, Rockingham, and Strafford counties
New Jersey—All counties
New York—Bronx, Dutchess, Essex (part), Kings, Nassau, New York, Orange, Putnam, Queens, Richmond, Rockland, Suffolk, and Westchester counties
Pennsylvania—Bucks, Chester, Delaware, Montgomery, and Philadelphia counties
Rhode Island—All counties
Wisconsin—Kenosha, Milwaukee, Ozaukee, Racine, Washington, and Waukesha counties

[A] See Table 12 for local vapor pressure limits.

5.7 Depending on oxygenate type and concentration in the blend, vehicle driveability with gasoline-oxygenate blends can differ significantly from that with gasolines having similar volatility characteristics.

5.8 Deposit control additives are added to fuel to help keep carburetors, fuel injectors, and intake valves clean.

5.8.1 In the United States, deposit control additives are required to be certified by the EPA as summarized in X3.5. Each additive is certified for use at a lowest additive concentration (LAC), which is the lowest level certified to be effective in preventing deposit formation. All parties who blend deposit control additives into fuel must complete mandatory volume additive reconciliation (VAR) accounting to establish that the product was additized at a concentration that was at least equal to the LAC.

TABLE 9 U.S. Federal RFG Areas Requiring Volatility Class AA-3

NOTE 1—See 40 CFR Part 81.300 for description of the geographic boundary for each area.

NOTE 2—No waiver for gasoline-ethanol blends.

District of Columbia
Maryland—Anne Arundel, Baltimore, Calvert, Carroll, Charles, Frederick, Harford, Howard, Kent, Montgomery, Prince George's, and Queen Anne's counties
Texas—Brazoria, Chambers, Collin, Dallas, Denton, Fort Bend, Galveston, Harris, Liberty, Montgomery, Tarrant, and Waller counties
Virginia—Arlington, Charles City, Chesterfield, Fairfax, Hanover, Henrico, James City, Loudoun, Prince William, Stafford, and York counties and independent cities of Alexandria, Chesapeake, Colonial Heights, Fairfax, Falls Church, Hampton, Hopewell, Manassas, Manassas Park, Newport News, Norfolk, Poquoson, Portsmouth, Richmond, Suffolk, Virginia Beach, and Williamsburg

TABLE 10 U.S. Federal RFG Areas Requiring Volatility Class AA-2

NOTE 1—See 40 CFR Part 81.305 for description of the geographic boundary for each area.

NOTE 2—No waiver for gasoline-ethanol blends.

California[A]—El Dorado (part), Los Angeles, Orange, Placer (part), Riverside (part), Sacramento, San Bernardino (part), San Diego, Solano (part), Sutter (part), Ventura, and Yolo Counties
Texas—Brazoria, Chambers, Collin, Dallas, Denton, Fort Bend, Galveston, Harris, Liberty, Montgomery, Tarrant, and Waller counties

[A] See Table 12 for local vapor pressure limits.

TABLE 11 U.S. Federal RFG Area Requiring Volatility Class AA-1

NOTE 1—See 40 CFR Part 81.300 for description of the geographic boundary for each area.

NOTE 2—No waiver for gasoline-ethanol blends.

California[A]—Los Angeles (part), Riverside (part), and San Bernardino (part) counties

[A] See Table 12 for local vapor pressure limits.

5.8.2 Outside the U.S., the user of this document should consult the regulatory authorities in those countries for similar deposit control requirements.

6. Workmanship

6.1 The finished 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 5—Test Method D4176 can be helpful for evaluating the product.

6.1.1 *Avoiding Water Haze and Phase Separation*—Finished spark-ignition engine 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. See Appendix X8 for additional information on water haze and phase separation.

NOTE 6—Finished fuel should be resistant to phase separation or undissolved matter at the lowest temperatures to which it is likely to be subjected, dependent on the time and place of its intended use. See Table X8.1 for guidance.

NOTE 7—Solubility is temperature dependent. As this fuel cools, water or water-alcohol and some high molecular weight additives can become insoluble.

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

**TABLE 12 U.S. Federally Approved State Implementation Plan
Areas Requiring More Restrictive Maximum Vapor Pressure
Limits**

NOTE 1—Some areas are awaiting official EPA approval for the more restrictive local vapor pressure limits.

Arizona—Maricopa County, Pinal(part), and Yavapai (part)–48.2 kPa (7.0 psi) max June 1 - Sept. 30, 62.0 kPa (9.0 psi) max Oct. 1 - Mar. 31 and May, 69.0 kPa (10.0 psi) max Apr.[A(Apr. only)]

California—48.26 kPa (7.00 psi) max April 1, May 1, or June 1 - Sept. 30 or Oct. 31 depending on air basin

Indiana—Clark and Floyd counties area – 53.8 kPa (7.8 psi) max May 1 terminal/June 1 retail - Sept. 15[A]

Kansas—Johnson and Wyandotte counties–48.2 kPa (7.0 psi) max June 1 - Sept. 15[A]

Michigan—Lenawee, Livingston, Macomb, Monroe, Oakland, Saint Clair, Washtenaw, and Wayne counties–48.2 kPa (7.0 psi) max June 1 - Sept 15[A]

Missouri—Clay, Jackson, and Platte counties–48.2 kPa (7.0 psi) max June 1 - Sept. 15[A]

Pennsylvania—Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, and Westmoreland counties–53.8 kPa (7.8 psi) max May 1 Terminal/June 1 Retail - Sept. 15

Texas—El Paso County–48.2 kPa (7.0 psi) max May 1 terminal/June 1 retail - Sept. 15

Texas—Anderson, Angelina, Aransas, Atascosa, Austin, Bastrop, Bee, Bell, Bexar, Bosque, Bowie, Brazos, Burleson, Caldwell, Calhoun, Camp, Cass, Cherokee, Colorado, Comal, Cooke, Coryell, De Witt, Delta, Ellis, Falls, Fannin, Fayette, Franklin, Freestone, Goliad, Gonzales, Grayson, Gregg, Grimes, Guadalupe, Harrison, Hays, Henderson, Hill, Hood, Hopkins, Houston, Hunt, Jackson, Jasper, Johnson, Karnes, Kaufman, Lamar, Lavaca, Lee, Leon, Limestone, Live Oak, Madison, Marion, Matagorda, McLennan, Milam, Morris, Nacogdoches, Navarro, Newton, Nueces, Panola, Parker, Polk, Rains, Red River, Refugio, Robertson, Rockwall, Rusk, Sabine, San Jacinto, San Patricio, San Augustine, Shelby, Smith, Somervell, Titus, Travis, Trinity, Tyler, Upshur, Van Zandt, Victoria, Walker, Washington, Wharton, Williamson, Wilson, Wise, and Wood counties–53.8 kPa (7.8 psi) max May 1 terminal/June 1 retail - October 1

[A] A 1.0 psi higher vapor pressure is allowed for gasoline-ethanol blends containing 9 % to 10 % by volume ethanol.

6.2.1 Manufacturers and blenders of gasoline and gasoline-oxygenate blends shall avoid gasoline blending stocks (for example, purchased used toluene solvents) or denatured fuel ethanol (for example, improperly recycled ethanol) contaminated by silicon-containing materials, or both. Silicon contamination of gasoline and gasoline-oxygenate blends has led to fouled vehicle components (for example, spark plugs, exhaust oxygen sensors, catalytic converters) requiring parts replacement and repairs. Test Method D7757 is a procedure for determining silicon content but no specification limits have been established for silicon.

6.2.2 Manufacturers and blenders of gasoline and gasoline-oxygenate blends shall avoid gasoline blending stocks or denatured fuel ethanol contaminated by chloride salts. Chloride salts can contribute inorganic chloride ions to the blend component or the finished fuel. Contamination of the blend components or the finished fuel with inorganic chlorides has led to corrosion issues with vehicle fuel and emissions systems requiring parts replacement and repairs. Approved standard test methods are not available to determine the concentration of inorganic chloride in spark-ignition engine fuels.

6.3 For markets where vehicles meeting U.S. Tier 2, Euro 5, or more stringent emissions standards are required or in widespread use, MMT shall be limited in automotive spark-ignition engine fuel to a maximum manganese concentration of 0.25 mg/L, until such time as data are produced to support its use at higher concentrations, and incorporated into this specification. (See Note 8.)

NOTE 8—This level represents the lower limit of the Test Method D3831 scope.

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 or D7345.

7.1.1.1 When using Test Method D7345, results shall be reported as "Predicted D86" as determined by applying the corrections described in Test Method D7345 to convert to D86 equivalent values. In case of dispute, Test Method D86 shall be the referee method.

7.1.1.2 The use of Test Method D7345 shall be limited to gasoline and gasoline-ethanol blends up to maximum 20 % by volume ethanol.