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Standard Specification for Automotive Spark-Ignition Engine Fuel¹

This standard is issued under the fixed designation D 4814; 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.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification guides in establishing requirements of 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 September 15, the maximum vapor pressure limits issued by the U.S. Environmental Protection Agency (EPA) are specified for each geographical area except Alaska and Hawaii. Variation of 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. This specification does not apply to fuels that contain an oxygenate as the primary component, such as Fuel Methanol (M85). The concentrations and types of oxygenates are not specifically limited in this specification. However, depending on oxygenate type, as oxygenate content increases above some threshold level, the likelihood for vehicle problems also increases. 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 addition, the composition of unleaded fuel is subject to the rules, regulations, and Clean Air Act waivers of the U.S. Environmental Protection Agency (EPA). 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, and use of oxygenates in blends with unleaded gasoline. Contact EPA for the latest versions of the rules and additional requirements.

1.4 This specification represents a description of automo-

tive 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 D 4814, contact ASTM Headquarters.

1.5 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 D 4815 provides a procedure for determining oxygenate concentration in mass percent. Test Method D 4815 also includes procedures for calculating mass oxygen content and 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.

1.6 The test method in Annex A1 is state-of-the-art; however, it may be revised and eventually balloted for publication as a separate standard.

1.7 The values stated in SI units are the standard, except when other units are specified by 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, federal regulations specify non-SI units.

1.8 The following safety hazard caveat pertains only to the test method portion, Annex A1 of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 86 Test Method for Distillation of Petroleum Products²
D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test²

¹ This specification is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.A on Gasoline and Oxygenated Fuels.

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² Annual Book of ASTM Standards, Vol 05.01.

D 287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)²
 D 381 Test Method for Existent Gum in Fuels by Jet Evaporation²
 D 439 Specification for Automotive Gasoline³
 D 525 Test Method for Oxidation Stability of Gasoline (Induction Period Method)²
 D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)²
 D 1298 Test Method for Density, Relative Density (Specific Gravity) or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method²
 D 2500 Test Method for Cloud Point of Petroleum Oils²
 D 2533 Test Method for Vapor-Liquid Ratio of Spark-Ignition Engine Fuels²
 D 2622 Test Method for Sulfur in Petroleum Products by X-Ray Spectrometry⁴
 D 2699 Test Method for Knock Characteristics of Motor Fuels by the Research Method⁵
 D 2700 Test Method for Knock Characteristics of Motor and Aviation Fuels by the Motor Method⁵
 D 2885 Test Method for Research and Motor Method Octane Ratings Using On-Line Analyzers⁵
 D 3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry⁴
 D 3231 Test Method for Phosphorus in Gasoline⁴
 D 3237 Test Method for Lead in Gasoline by Atomic Absorption Spectrometry⁴
 D 3341 Test Method for Lead in Gasoline—Iodine Monochloride Method⁴
 D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter⁴
 D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products⁴
 D 4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination⁴
 D 4815 Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C₁ to C₄ Alcohols in Gasoline by Gas Chromatography⁶
 D 4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)⁶
 D 5059 Test Methods for Lead in Gasoline by X-Ray Spectroscopy⁶
 D 5188 Test Method for Vapor-Liquid Ratio Temperature Determination of Fuels (Evacuated Chamber Method)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 the Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels, and Oils by Ultraviolet Fluorescence⁶
 D 5482 Test Method for Vapor Pressure of Petroleum Products (Mini Method-Atmospheric)⁶

E 1 Specification for ASTM Thermometers⁷

3. Terminology

3.1 Definitions:

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

3.1.2 *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.

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

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

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

3.1.6 *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 *Applicability*—In order to determine when a fuel contains a substantial amount of an oxygenate, a gasoline-oxygenate blend is defined as a fuel which contains more than 0.35 mass percent oxygen, or more than 0.15 mass percent 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 3.2 were selected with consideration given to current oxygenate levels in the marketplace, state labeling practices, and consistency with federal legislation and regulations.

NOTE 4—Refer to Test Method D 4815 to calculate the mass oxygen content of a fuel using oxygenate concentration in mass percent. Refer to Appendix X4 to calculate mass oxygen content of a fuel using oxygenate concentration in volume percent.

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 3), 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 Method D 4815, a gas chromatographic test method, is the recommended procedure to detect the types and amounts of

³ Discontinued—See 1990 *Annual Book of ASTM Standards*, Vol 05.01.

⁴ *Annual Book of ASTM Standards*, Vol 05.02.

⁵ *Annual Book of ASTM Standards*, Vol 05.04.

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

⁷ *Annual Book of ASTM Standards*, Vol 14.03.

TABLE 1 Vapor Pressure and Distillation Class Requirements

Vapor Pressure/ Distillation Class	Vapor Pressure, ^A max, kPa(psi)	Distillation Temperatures, °C(°F), at % Evaporated ^B					Distillation Residue, vol %, max
		10 vol %, max	50 vol %		90 vol %, max	End Point, max	
			min	max			
AA	54(7.8)	70(158)	77(170)	121(250)	190(374)	225(437)	2
A	62(9.0)	70(158)	77(170)	121(250)	190(374)	225(437)	2
B	69(10.0)	65(149)	77(170)	118(245)	190(374)	225(437)	2
C	79(11.5)	60(140)	77(170)	116(240)	185(365)	225(437)	2
D	93(13.5)	55(131)	77(170)	113(235)	185(365)	225(437)	2
E	103(15.0)	50(122)	77(170)	110(230)	185(365)	225(437)	2

^A Consult EPA for approved test methods for compliance with EPA vapor pressure regulations.

^B At 101.3 kPa pressure (760 mm Hg).

TABLE 2 Vapor Lock Protection Class Requirements

Vapor Lock Protection Class	Vapor/Liquid Ratio (V/L) ^{A,B}	
	Test Temperature, °C(°F)	V/L, max
1	60(140)	20
2	56(133)	20
3	51(124)	20
4	47(116)	20
5	41(105)	20

^A At 101.3 kPa pressure (760 mm Hg).

^B The mercury confining fluid procedure of Test Method D 2533 shall be used for gasoline-oxygenate blends. Either glycerin or mercury confining fluid may be used for gasoline. Test Method D 5188 may be used for all fuels. The procedure for estimating temperature-V/L (see Appendix X2) may only be used for gasoline.

oxygenates. Once the type of fuel is known, the appropriate requirements and test methods can be identified by reference to Tables 1 and 2 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 five 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 2.

5.2.1 The seasonal and geographic distribution of the combined vapor pressure/distillation-vapor lock classes is shown in Table 4.

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 poorer warmup driveability performance.

5.2.3 Test Method D 2533 contains procedures for measuring temperature-V/L of both gasoline and gasoline-oxygenate blends. For gasoline-oxygenate blends, the procedure requires that mercury be used as the confining fluid in place of glycerin. Either confining fluid may be used for gasoline. Test Method D 5188 is an alternative method for determining vapor-liquid ratio temperatures by an evacuated chamber method for gasoline-oxygenate blends, as well as gasoline. In case of dispute, Test Method D 2533 is the referee method. The method for estimating temperature-V/L (see Appendix X2) is only applicable for gasoline.

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 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 Additional fuel requirements are shown in Table 3.

5.5 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 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. Water tolerance is specified in Table 5.

5.6 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.

5.7 Water Tolerance:

5.7.1 The term water tolerance is used to indicate the ability of a gasoline-oxygenate blend to dissolve water without phase separation. This may not be a problem with gasoline-ether blends, but it is of primary concern for alcohol-containing blends, as blends of gasoline with low-molecular weight alcohols generally will dissolve about 0.1 to 0.7 mass % of water under normal conditions, depending on the nature and amount of the alcohol(s) used, the specific hydrocarbons present, and the temperature of the blend. When blends are exposed to a greater amount of water than they can dissolve, they separate into an alcohol-rich aqueous phase, the volume of which can be significantly greater than that of the additional water, and an alcohol-poor hydrocarbon phase. As the aqueous phase can be highly corrosive to many metals and the engine cannot operate on it, such separation is very undesirable. Blends containing low-molecular weight alcohols are generally hygroscopic and can eventually absorb enough moisture from ambient air to cause separation. The problem of phase separation can usually be avoided if the fuels are sufficiently water-free initially and care is taken during distribution to prevent contact with water. To help ensure this, gasoline-oxygenate blends shall be tested at the lowest temperatures to which they can be subjected, dependent on the time and place of intended use, as indicated in Table 5. The values in Table 5 are the 10th percentile 6-h minimum temperatures, with each reading specifically defined as the highest temperature of the six coldest consecutive hourly temperature readings of a 24-h day. For April through September (and occasionally

TABLE 3 Detailed Requirements for all Volatility Classes^A

Lead Content, max, g/L (g/U.S. gal) ^B		Copper Strip Corrosion, max	Existent Gum, max, mg/100 mL	Sulfur, max, mass %		Oxidation Stability, Minimum, minutes	Water Tolerance
Unleaded	Leaded			Unleaded	Leaded		
0.013(0.05)	1.1(4.2)	No. 1	5	0.10	0.15	240	^C

^A See Appendix X1 for information on Antiknock Index.

^B 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).

^C Water tolerance limits in terms of maximum temperature for phase separation are given in Table 5 (consult Annex A1).

October, and year-round for Hawaii), Table 5 specifies a minimum phase separation temperature of 10°C (50°F), even though the 10th percentile 6-h minimum temperature can be higher. Use of this temperature limit also reduces the risk of separation of the fuel in storage tanks where temperatures may be lower than ambient.

NOTE 5—The values in Table 5 are taken from the U.S. Army Belvoir Research Development and Engineering Center's Report No. 316, entitled "A Predictive Study for Defining Limiting Temperatures and Their Application in Petroleum Product Specifications." This can be obtained as Publication AD756-420 from the National Technical Information Service, Springfield, VA 22151.

5.7.2 The test procedure (see Annex A1) consists of cooling the fuel under specified conditions to the appropriate temperature listed in Table 5. It is important to note that when cooling to a low temperature some gasolines and many gasoline-oxygenate blends, especially those containing ethers, can take on a hazy appearance. This haze must be carefully distinguished from the test criterion described in Annex A1 of separation into two distinct phases with a more or less distinct common boundary, and must not be considered grounds for rejection of the fuel. This test also must not be confused with that described in Section 6, which is conducted at 21°C (70°F) or above, and for which the appearance of haze is proper grounds for rejection.

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 ambient temperature or 21°C (70°F), whichever is higher.

6.2 Fuel to be used in this test shall not be cooled below about 15°C (59°F) or its temperature at the time the sample was taken, whichever is lower, as cooling of gasoline-oxygenate blends can produce changes in appearance that are not reversed on rewarming.

7. Test Methods

7.1 The requirements of this specification shall be determined in accordance with the methods listed below. Refer to the listed test methods to determine applicability or required modifications for use with gasoline-oxygenate blends.

7.1.1 *Distillation*—Test Method D 86.

7.1.2 *Vapor-Liquid Ratio*—Test Method D 2533 has procedures for determining vapor-liquid (V/L) ratios for both gasoline and gasoline-oxygenate blends. Because some oxygenates are miscible with the glycerin used in one procedure, another procedure using mercury as the confining fluid is provided for gasoline-oxygenate blends. Either procedure may be used to determine V/L for gasoline. Test Method D 5188 is an evacuated chamber method for determining

temperatures for vapor-liquid ratios between 8 to 1 and 75 to 1. It may be used for gasoline and gasoline-oxygenate blends.

7.1.3 *Vapor Pressure*—Test Methods D 4953, D 5190, D 5191 or D 5482.

7.1.4 *Corrosion, for Copper*, Test Method D 130, 3 h at 50°C (122°F).

7.1.5 *Existent Gum*—Test Method D 381, air jet apparatus.

7.1.6 *Sulfur*—Test Methods D 1266, D 2622, D 3120, or D 5453. With Test Method D 3120, fuels with sulfur content greater than 100 ppm (0.0100 mass %) must be diluted with isooctane. The dilution of the sample may result in a loss of precision. Test Method D 3120 cannot be used when the lead concentration is greater than 0.4 g/L (1.4 g/U.S. gal).

7.1.7 *Lead*—Test Methods D 3341 or D 5059 (Test Methods A or B). For lead levels below 0.03 g/L (0.1 g/U.S. gal) use Test Methods D 3237 or D 5059 (Test Method C).

7.1.8 *Oxidation Stability*—Test Method D 525.

7.1.9 *Oxygenate Detection*—Test Method D 4815 is designed for the quantitative determination of methyl *tert*-butyl ether (MTBE), ethyl *tert*-butyl ether (ETBE), *tert*-amyl methyl ether (TAME), diisopropylether, methyl alcohol, ethyl alcohol, isopropyl alcohol, *n*-propyl alcohol, isobutyl alcohol, *tert*-butyl alcohol, sec-butyl alcohol, *n*-butyl alcohol, and *tert*-amyl alcohol. Results are reported in mass percent, but Test Method D 4815 includes procedures for calculating oxygenate concentration in volume percent and mass oxygen content using mass percent oxygenate results.

7.1.10 *Water Tolerance*—See Annex A1 for a test method.

8. Precision and Bias

8.1 The precision of each required test method with gasoline is included in the standard applicable to each method. In many cases, the precision applicable to gasoline-oxygenate blends has not been established yet.

9. Keywords

9.1 alcohol; antiknock index; automotive fuel; automotive gasoline; automotive spark-ignition engine fuel; copper strip corrosion; corrosion; distillation; driveability; EPA regulations; ethanol; ether; existent gum; fuel; gasoline; gasoline-alcohol blend; gasoline-ethanol blend; gasoline-ether blend; gasoline-oxygenate blend; induction period; lead; leaded fuel; methanol; MTBE; octane number; octane requirement; oxidation stability; oxygenate; oxygenate detection; phase separation; phosphorous; sulfur; $T_{V/L} = 20$; unleaded fuel; vapor-liquid ratio; vapor lock; vapor pressure; volatility; water tolerance



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TABLE 4 Schedule of Seasonal and Geographical Volatility Classes^A

This schedule, subject to agreement between purchaser and seller, denotes the volatility properties of the fuel at the time and place of delivery to the end user. It also denotes the vapor pressure for finished gasoline tankage at refineries, importers, pipelines, and terminals during May and for the entire distribution system for June 1 to Sept. 15. Shipments should anticipate this schedule.

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

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 ^D	A-3 ^D	A-2 ^E	A-2 ^E	A-2/C-3	C-3	C-3/D-4	D-4
Alaska	E-5	E-5	E-5	E-5	E-5/D-4	D-4	D-4	D-4	D-4	D-4/E-5	E-5	E-5	E-5
Arizona													
N 34° Latitude and E 111° 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 ^F	A-1 ^F	A-1 ^F	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
^C California:													
North Coast	E-5/D-4	D-4	D-4	D-4/A-3	A-3 (C-3)	A-3 ^D	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	A-2 ^E	A-2 ^E	A-2 ^E	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 ^F	A-1 ^F	A-1 ^F	A-1 ^F	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	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
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	A-3	A-3	A-3	A-3/D-4	D-4	D-4/E-5	E-5
Delaware	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
District of Columbia	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-3 ^D	A-3 ^D	A-3 ^D	A-3 ^D	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 ^D	A-3 ^D	A-3 ^D	A-3 ^D	A-3/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 ^D	A-3 ^D	A-2 ^E	A-2 ^E	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	A-3	A-3	A-3	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	A-3	A-3	A-3	A-3/C-3	C-3/D-4	D-4	D-4/E-5
Indiana	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
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	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	A-3	A-3	A-3	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 ^D	A-3 ^D	A-2 ^E	A-2 ^E	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	A-3	A-3	A-3	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 ^D	A-3 ^D	A-3 ^D	A-3 ^D	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	A-3	A-3	A-3	A-3/D-4	D-4	D-4/E-5	E-5
Michigan	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	E-5	E-5/D-4	D-4	D-4/A-3	A-3 (C-3)	A-3 ^D	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	A-3	A-3	A-3	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	A-3	A-3	A-3	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	A-3	A-3	A-3	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 ^D	A-3 ^D	A-2 ^E	A-2 ^E	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:													
E 122° 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	D-4/E-5
W 122° Longitude	E-5	E-5/D-4	D-4	D-4/A-4	A-4 (D-4)	A-3 ^D	A-3 ^D	A-3 ^D	A-3 ^D	A-3/C-3	C-3/D-4	D-4/E-5	E-5
Pennsylvania	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
Rhode Island	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
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 ^D	A-3 ^D	A-2 ^E	A-2 ^E	A-2/C-3	C-3/D-4	D-4	D-4/E-5
Texas:													
E 99° Longitude	D-4	D-4	D-4/C-3	C-3/A-3	A-3 (C-3)	A-3 ^D	A-2 ^E	A-2 ^E	A-2 ^E	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 ^F	A-1 ^F	A-1 ^F	A-1 ^F	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 ^D	A-3 ^D	A-3 ^D	A-3 ^D	A-3/C-3	C-3/D-4	D-4/E-5	E-5



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TABLE 4 (Continued)

State	Jan.	Feb.	Mar.	Apr.	May ^a	June	July	Aug.	Sept. 1-15	Sept. 16-30	Oct.	Nov.	Dec.
Washington:													
E 122° 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	A-3	A-3	A-3	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. EPA regulations allow 1.0 psi higher vapor pressure for gasoline-ethanol blends containing 9 to 10 vol % ethanol for the same period. See Appendix X3 for additional federal volatility regulations.

^b Values in parentheses are permitted for retail stations and other end users.

^c Details of State Climatological Division by county as indicated:

California, North Coast—Alameda, Contra Costa, Del Norte, Humboldt, Lake, Marin, Mendocino, Monterey, Napa, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, Sonoma, Trinity

California, Interior—Lassen, Modoc, Plumas, Sierra, Siskiyou, Alpine, Amador, Butte, Calaveras, Colusa, El Dorado, Fresno, Glenn, Kern (except that portion lying east of Los Angeles County Aqueduct), Kings, Madera, Mariposa, Marced, Placer, Sacramento, San Joaquin, Shasta, Stanislaus, Sutter, Tehama, Tulare, Tuolumne, Yolo, Yuba, Nevada

California, South Coast—Orange, San Diego, San Luis Obispo, Santa Barbara, Ventura, Los Angeles (except that portion north of the San Gabriel Mountain range and east of the Los Angeles County Aqueduct)

California, Southeast—Imperial, Riverside, San Bernadino, Los Angeles (that portion north of the San Gabriel Mountain range and east of the Los Angeles County Aqueduct), Mono, Inyo, Kern (that portion lying east of the Los Angeles County Aqueduct)

^d AA-3 for the following ozone nonattainment areas:

(See Federal Register 56, 215, 56694, November 6, 1991, for description of the geographic boundary for each area.)

Alabama—Birmingham
California—Monterey Bay
California—San Francisco-Bay Area
District of Columbia—Washington
Florida—Jacksonville
Florida—Miami-Fort Lauderdale-West Palm Beach
Florida—Tampa-St. Petersburg-Clearwater
Georgia—Atlanta
Louisiana—Baton Rouge
Louisiana—Beauregard Parish
Louisiana—Grant Parish
Louisiana—Lafayette
Louisiana—Lafourche Parish
Louisiana—Lake Charles
Louisiana—New Orleans
Louisiana—St. James Parish
Louisiana—St. Mary Parish
Maryland—Baltimore
Maryland—Kent and Queen Anne's Counties
Maryland—Philadelphia-Wilmington-Trenton Area

Maryland—Washington Area
Missouri—Kansas City
Missouri—St. Louis
North Carolina—Charlotte-Gastonia
North Carolina—Greensboro-Winston Salem-High Point
North Carolina—Raleigh-Durham
Oregon—Portland-Vancouver AQMA
Oregon—Salem
Tennessee—Memphis
Tennessee—Nashville
Texas—Beaumont-Port Arthur
Texas—Dallas-Fort Worth
Texas—Houston-Galveston-Brazoria
Texas—Victoria
Virginia—Norfolk-Virginia Beach-Newport News
Virginia—Richmond
Virginia—Smyth County
Virginia—Washington Area

^e AA-2 for the following ozone nonattainment areas:

(See Federal Register 56, 215, 56694, November 6, 1991, for description of the geographic boundary for each area.)

Alabama—Birmingham
Arizona—Phoenix
California—Chico
California—Los Angeles-South Coast Air Basin
California—Monterey Bay
California—Sacramento Metro
California—San Diego
California—San Francisco-Bay Area
California—San Joaquin Valley
California—Santa Barbara-Santa Maria-Lompoc
California—Ventura County
California—Yuba City
Colorado—Denver-Boulder
Georgia—Atlanta
Kansas—Kansas City
Louisiana—Baton Rouge
Louisiana—Beauregard Parish
Louisiana—Grant Parish
Louisiana—Lafayette
Louisiana—Lafourche Parish

Louisiana—Lake Charles
Louisiana—New Orleans
Louisiana—St. James Parish
Louisiana—St. Mary Parish
Missouri—Kansas City
Missouri—St. Louis
Nevada—Reno
North Carolina—Charlotte-Gastonia
North Carolina—Greensboro-Winston Salem-High Point
North Carolina—Raleigh-Durham
Tennessee—Memphis
Tennessee—Nashville
Texas—Beaumont-Port Arthur
Texas—Dallas-Fort Worth
Texas—Houston-Galveston-Brazoria
Texas—Victoria
Utah—Salt Lake City

^f AA-1 for the following ozone nonattainment areas:

(See Federal Register 56, 215, 56694, November 6, 1991, for description of the geographic boundary for each area.)

Arizona—Phoenix
California—Imperial County
California—Southeast Desert Modified AQMA
Texas—El Paso