Designation: D5798 – 11

StandardSpecification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines[1]

This standard is issued under the fixed designation D5798; 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.

1. Scope*

1.1 This specification covers the requirements for automotive fuel blends of ethanol and gasoline for use in ground vehicles equipped with flexible-fuel spark-ignition engines. Fuel produced to this specification contains 51 to 83 volume % ethanol. This fuel is for use in flexible-fuel vehicles and is sometimes referred to at retail as "Ethanol Flex-Fuel." Appendix X1 discusses the significance of the properties specified.

1.2 The vapor pressure of ethanol fuel blends is varied for seasonal climatic changes. Vapor pressure is increased at lower temperatures to ensure adequate flexible-fuel vehicle operability. Ethanol content and selection of hydrocarbon blendstock are adjusted by the blender to meet these vapor pressure requirements. Hydrocarbon blendstocks for meeting ethanol fuel blends performance requirements are unleaded gasoline, gasoline blendstocks for oxygenate blending (BOBs), natural gasoline or other hydrocarbons in the gasoline boiling range.

1.3 This specification formerly covered Fuel Ethanol (Ed70-Ed85) for Automotive Spark-Ignition Engines, also known commercially as E85. The nomenclature "fuel ethanol" has been changed to "ethanol fuel blends" to distinguish this product from denatured fuel ethanol Specification D4806. To facilitate blending of ethanol fuel blends that meet seasonal vapor pressure requirements, a new lower minimum ethanol content has been established.

1.4 The United States government has established various programs for alternative fuels. Many of the definitions of alternative fuel used by these programs may be more restrictive than the requirements of this specification. See 4.1.2.1 for additional information on alternative fuels containing ethanol.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 The following safety hazard caveat pertains only to the test method portion, 8.1.8, 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:*[2]

D86 Test Method for Distillation of Petroleum Products 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)

D1613 Test Method for Acidity in Volatile Solvents and Chemical Intermediates Used in Paint, Varnish, Lacquer, and Related Products

D1688 Test Methods for Copper in Water

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants

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

D4953 Test Method for Vapor Pressure of Gasoline and

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is under the direct responsibility of Subcommittee D02.A0.02 on Oxygenated Fuels and Components.

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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.

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

Gasoline-Oxygenate Blends (Dry Method)
D5190 Test Method for Vapor Pressure of Petroleum Products (Automatic Method)
D5191 Test Method for Vapor Pressure of Petroleum Products (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
D5501 Test Method for Determination of Ethanol Content of Denatured Fuel Ethanol by Gas Chromatography
D5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
D6423 Test Method for Determination of pHe of Ethanol, Denatured Fuel Ethanol, and Fuel Ethanol (Ed75-Ed85)
D7319 Test Method for Determination of Existent and Potential Sulfate and Inorganic Chloride in Fuel Ethanol 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
E203 Test Method for Water Using Volumetric Karl Fischer Titration
E1064 Test Method for Water in Organic Liquids by Coulometric Karl Fischer Titration

2.2 *Government Standards:*[3]
United States Code of Federal Regulations, Title 40, Part 80

2.3 *SAE Papers:*[4]
SAE 2007–01–4006 A Model for Estimating Vapor Pressures of Commingled Ethanol Fuels

3. Terminology

3.1 For general terminology, refer to Terminology D4175.

3.2 *Definitions:*

3.2.1 *denaturants, n*—materials added to ethanol to make it unsuitable for beverage use under a formula approved by a regulatory agency to prevent the imposition of beverage alcohol tax.

3.2.1.1 *Discussion*—Denaturants are only those materials added by the denaturer to comply with the approved formula; any materials absorbed later are not denaturants. **D4806**

3.2.2 *denatured fuel ethanol*—fuel ethanol made unfit for beverage use by the addition of denaturants under formula(s) approved by the applicable regulatory agency to prevent the imposition of beverage alcohol tax. **D4806**

3.2.3 *ethanol, n*—ethyl alcohol, the chemical compound C_2H_5OH. **D4806**

3.2.4 *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**

3.2.5 *methanol, n*—methyl alcohol, the chemical compound CH_3OH.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *flexible-fuel vehicle, n*—a vehicle designed to operate on either unleaded gasoline or ethanol fuel blends or mixtures of both.

3.3.1.1 *Discussion*—In the United States, these vehicles have U.S. EPA emissions certifications using gasoline complying with U.S. EPA requirements and ethanol fuel blends that meet the requirements of Specification D5798.

3.3.2 *hydrocarbon, n*—a compound composed solely of hydrogen and carbon.

3.3.2.1 *Discussion*—The hydrocarbons used in ethanol fuel blends will be unleaded gasoline, gasoline blendstock for oxygenate blending (BOB), natural gasoline or other hydrocarbons in the gasoline boiling range. The hydrocarbon blend components will also contain trace quantities of other elements.

3.3.3 pH_e—a measure of the acid strength of alcohol fuels.

4. Ordering Information

4.1 The purchasing agency shall:

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

4.1.2 If requested, ensure that the ethanol concentration meets the requirements for an alternative fuel for federal fleets.

4.1.2.1 The composition of alternative fuels in the United States is regulated by various government agencies and regulations including the U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA). With regard to fuel properties including volatility, this specification can be more or less restrictive than DOE or EPA rules, regulations and waivers. To qualify as an alternative fuel for federal fleet use in the United States, the ethanol blend is required to meet the U.S. Department of Energy's definition of alternative fuels, enacted under the Energy Policy Act of 1992 (Title III, Sec. 301). For ethanol, the Act defines "alternative fuel" as a mixture containing denatured ethanol at a volume of "85 percent or more (or such other percentage, but not less than 70 percent, as determined by the Secretary, by rule...)." Correcting for denaturant content, a blend of 70 to 85 volume % denatured fuel ethanol contains 68 to 83 volume % ethanol as measured by Test Method D5501. The U.S. government has other programs and definitions for alternative fuels. Users of this specification are advised to check with the applicable regulatory agency for specific alternative fuel requirements.

5. Ethanol Fuel Blends Performance Requirements

5.1 Ethanol fuel blends shall conform to the requirements of Table 1. Ethanol content requirements for ethanol alternative fuel blends can be found in 4.1.2.1.

NOTE 1—Most of the requirements cited are based on the best technical information currently available. Requirements for sulfur, phosphorus, and lead are based on the use of gasoline defined in Specification D4814 and the understanding that control of these elements will affect catalyst lifetime.

[3] A printed copy of the Code of Federal Regulations may be purchased from the U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol Street, N.W., Mail Stop: SDE, Washington, DC 20401 or the online store at http://bookstore.gpo.gov/. The Code of Federal Regulations may be browsed online at http://www.gpoaccess.gov/cfr/index.html.

[4] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

TABLE 1 Requirements for Ethanol Fuel Blends[A]

Properties	Class 1[B]	Class 2	Class 3	Class 4	Test Methods
Vapor pressure, kPa (psi)	38–59 (5.5–8.5)	48–65 (7.0–9.5)	59–83 (8.5–12.0)	66–103 (9.5–15.0)	D4953, D5190, or D5191
		All Classes[C]			
Ethanol Content, volume %		51–83			D5501
Methanol Content, max, volume %		0.5			D5501
Sulfur Content, max, mg/kg		80			D5453
Acidity, (as acetic acid CH3COOH), mass % (mg/L), max		0.005 (40)			D1613
Solvent-washed gum content, max, mg/100 mL		5			D381
pH_e		6.5 to 9.0			D6423
Unwashed gum content, max, mg/100 mL		20			D381
Inorganic chloride content, max, mg/kg		1			D7319 or D7328
Copper content, max, mg/L		0.07			D1688
Water content, max, mass %		1.0			E203 or E1064

[A] For information on alternative fuels, see 4.1.2.1.
[B] See 5.1.1 for volatility class criteria.
[C] Ethanol content and selection of hydrocarbon blendstock are adjusted by the blender to meet vapor pressure requirements. See X1.3.2 for additional information and guidance for blending.

5.1.1 Vapor pressure is varied for seasonal and climatic changes by providing four vapor pressure classes for ethanol fuel blends. The seasonal and geographical distribution for four vapor pressure classes is shown in Table 2. Class 1 encompasses geographical areas with 6-h tenth percentile minimum ambient temperature of greater than 5°C (41°F). Class 2 encompasses geographical areas with 6-h tenth percentile minimum ambient temperature of greater than −5°C (23°F) but less than +5°C (41°F). Class 3 encompasses geographical areas with 6-h tenth percentile minimum ambient temperature greater than −13°C (9°F) but less than or equal to −5°C (23°F). Class 4 encompasses geographical areas with 6-h tenth percentile minimum ambient temperature less than or equal to −13°C (9°F).

5.1.2 The hydrocarbons blended with the denatured fuel ethanol shall have a maximum boiling point of 225°C (437°F) by Test Method D86, oxidation stability of 240-min minimum by Test Method D525, and No. 1 maximum copper strip corrosion by Test Method D130, and No. 1 maximum silver strip corrosion by the test method listed in Annex A1 in Specification D4814.

5.1.3 The denaturant for the denatured fuel ethanol used in making ethanol fuel blends shall meet the requirements of Section 5 in Specification D4806.

5.1.4 Ethanol fuel blends of any volatility class shall meet the same limits for lead and phosphorus as required by U.S. Environmental Protection Agency (EPA) regulations for unleaded gasoline.

5.1.4.1 The intentional addition of lead or phosphorus compounds to ethanol fuel blends is not permitted. EPA regulations limit their maximum concentrations in unleaded gasoline to 0.05 g lead/US gal (0.013 g/L) and 0.005 g phosphorus/US gal (0.0013 g/L), respectively. Details of the EPA regulations and test methods are available in the United States Code of Federal Regulations, Title 40, Part 80.

6. Workmanship

6.1 Ethanol fuel blends shall be visually free of sediment and suspended matter. They shall be clear and bright at the ambient temperature or 21°C (70°F), whichever is higher.

6.2 The specification defines only a basic purity for ethanol fuel blends. The product shall be free of any adulterant or contaminant that can render the material unacceptable for its commonly used applications.

6.2.1 Manufacturers and blenders of ethanol fuel blends shall avoid ethanol (for example, improperly recycled ethanol), or denaturants and hydrocarbon blend components contaminated by silicon-containing materials, or both. Silicon contamination of gasoline, denatured ethanol, and their blends has led to fouled vehicle components (for example, spark plugs, exhaust oxygen sensors, catalytic converters) requiring parts replacement and repairs. There is no ASTM approved test method for determining silicon compounds in gasoline, gasoline-oxygenate blends, denaturants, hydrocarbon blend components, or denatured fuel ethanol, although some laboratories are possibly using non-ASTM test methods.

7. Sampling, Containers, and Sample Handling

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

7.2 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 sampling, as applicable.

7.3 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

TABLE 2 Seasonal and Geographical Volatility Specifications for Ethanol Fuel Blends

NOTE 1—This schedule, subject to agreement between the purchaser and the seller, denotes the vapor pressure class of the fuel at the time and place of bulk delivery to fuel-dispensing facilities for the end user. Shipments should anticipate this schedule.

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

State	Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Alabama	2	2	2	2	2/1	1	1	1	1	1/2	2	2
Alaska												
Southern Region	4	4	4	4/3	3/2	2/1	1	1/2	2/3	3/4	4	4
South Mainland	4	4	4	4	4/2	2/1	1/2	2	2/4	4	4	4
Arizona												
N of 34° Latitude	3	3	3	3/2	2	2/1	1	1	1/2	2/3	3	3
S of 34° Latitude	2	2	2	2/1	1	1	1	1	1	1/2	2	2
Arkansas	3	3	3/2	2/1	1	1	1	1	1/2	2	2/3	3
California[A]												
North Coast	2	2	2	2	2/1	1	1	1	1	1/2	2	2
South Coast	2	2	2	2/1	1	1	1	1	1	1/2	2	2
Southeast	2	2	2/1	1	1	1	1	1	1	1	1/2	2
Interior	2	2	2	2/1	1	1	1	1	1	1/2	2	2
Colorado												
E of 105° Longitude	4	4/3	3	3/2	2	2/1	1	1	1/2	2/3	3	3/4
W of 105° Longitude	4	4	4/3	3	3/2	2	2/1	1/2	2/3	3/4	4	4
Connecticut	4	4	4/3	3/2	2	2/1	1	1	1/2	2	2/3	3/4
Delaware	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	4
District of Columbia	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	3
Florida												
N of 29° Latitude	2	2	2	2/1	1	1	1	1	1	1/2	2	2
S of 29° Latitude	2	2/1	1	1	1	1	1	1	1	1	1/2	2
Georgia	3	3/2	2	2/1	1	1	1	1	1	1/2	2	2/3
Hawaii	1	1	1	1	1	1	1	1	1	1	1	1
Idaho	4	4	4/3	3/2	2	2	2/1	1/2	2	2/3	3/4	4
Illinois												
N of 40° Latitude	4	4	4/3	3/2	2	2/1	1	1	1/2	2/3	3/4	4
S of 40° Latitude	4	4/3	3	3/2	2/1	1	1	1	1/2	2/3	3/4	4
Indiana	4	4	4/3	3/2	2/1	1	1	1	1/2	2/3	3/4	4
Iowa	4	4	4	4/2	2	2/1	1	1	1/2	2/3	3/4	4
Kansas	4	4/3	3	3/2	2	2/1	1	1	1/2	2/3	3/4	4
Kentucky	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	3
Louisiana	2	2	2	2/1	1	1	1	1	1	1/2	2	2
Maine	4	4	4	4/2	2	2/1	1	1/2	2	2/3	3/4	4
Maryland	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	3
Massachusetts	4	4	4/3	3/2	2	2/1	1	1	1/2	2	2/4	4
Michigan												
Lower Michigan	4	4	4/3	3/2	2	2/1	1	1/2	2	2/3	3/4	4
Upper Michigan	4	4	4	4/3	3/2	2/1	1	1/2	2	2/3	3/4	4
Minnesota	4	4	4	4/3	3/2	2/1	1	1/2	2	2/4	4	4
Mississippi	2	2	2	2/1	1	1	1	1	1	1/2	2	2
Missouri	4	4/3	3	3/2	2/1	1	1	1	1/2	2/3	3	3
Montana	4	4	4	4/3	3/2	2	2/1	1/2	2/3	3/4	4	4
Nebraska	4	4	4/3	3/2	2	2/1	1	1/2	2	2/3	3/4	4
Nevada												
N of 38° Latitude	4	4	4/3	3/2	2	2	2/1	1/2	2	2/3	3/4	4
S of 38° Latitude	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	3
New Hampshire	4	4	4/3	3/2	2	2/1	1	1/2	2	2/3	3/4	4
New Jersey	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	3
New Mexico												
N of 34° Latitude	4	4/3	3	3/2	2	2/1	1	1	1/2	2/3	3	3/4
S of 34° Latitude	3	3	3/2	2/1	1	1	1	1	1	1/2	2/3	3
New York												
N of 42° Latitude	4	4	4	4/2	2	2/1	1	1/2	2	2/3	3/4	4
S of 42° Latitude	4	4	4/3	3/2	2/1	1	1	1	1/2	2	2/3	3/4
North Carolina	3	3	3/2	2	2/1	1	1	1	1/2	2/3	3	3
North Dakota	4	4	4	4/3	3/2	2/1	1	1/2	2	2/4	4	4
Ohio	4	4	4/3	3/2	2/1	1	1	1	1/2	2/3	3/4	4
Oklahoma	3	3	3	3/2	2/1	1	1	1	1/2	2	2/3	3
Oregon												
E of 122° Longitude	4	4/3	3	3/2	2	2	2/1	1/2	2	2/3	3	3/4
W of 122° Longitude	3	3/2	2	2	2	2/1	1	1	1/2	2	2	2/3
Pennsylvania												
N of 41° Latitude	4	4	4	4/2	2	2/1	1	1/2	2	2/3	3/4	4
S of 41° Latitude	4	4	4/3	3/2	2	2/1	1	1	1/2	2	2/3	3/4
Rhode Island	3	3	3	3/2	2/1	1	1	1	1/2	2	2/3	3
South Carolina	2	2	2	2/1	1	1	1	1	1	1/2	2	2
South Dakota	4	4	4	4/2	2	2/1	1	1/2	2	2/3	3/4	4
Tennessee	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	3
Texas												

TABLE 2 *Continued*

State	Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
N of 31° Latitude	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	3
S of 31° Latitude	2	2	2	2/1	1	1	1	1	1	1/2	2	2
Utah	4	4/3	3	3/2	2	2/1	1	1	1/2	2/3	3	3/4
Vermont	4	4	4/3	3/2	2	2/1	1	1/2	2	2/3	3/4	4
Virginia	3	3	3/2	2	2/1	1	1	1	1/2	2	2/3	3
Washington												
E of 122° Longitude	4	4/3	3/2	2	2	2/1	1	1	1/2	2/3	3	3/4
W of 122° Longitude	3	3/2	2	2	2	2/1	1	1	1/2	2	2	2/3
West Virginia	4	4/3	3	3/2	2	2/1	1	1/2	2	2/3	3	3/4
Wisconsin	4	4	4	4/2	2	2/1	1	1/2	2	2/3	3/4	4
Wyoming	4	4	4	4/3	3/2	2	2/1	1/2	2	2/4	4	4

[A] Details of State Climatological Division by county as indicated:

California, North Coast—Alameda, Contra Costa, Del Norte, Humbolt, 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, Merced, 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 Bernardino, 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)

for tests sensitive to trace contamination. Refer to Practice D5854 for procedures on container selection and sample mixing and handling. Where practical, ethanol fuel blends should be sampled in glass containers. If samples must be collected in metal containers, do not use soldered metal containers. This is because the soldering flux in the containers and the lead in the solder can contaminate the sample. Plastic containers should be avoided.

7.4 A minimum sample size of about 1 L (1 US qt) is recommended.

8. Test Methods

8.1 Determine the requirements enumerated in this specification in accordance with the following test methods. The scope of some of the test methods listed below does not include ethanol fuel blends. The precision of these test methods can differ from the reported precisions when testing ethanol fuel blends.

8.1.1 *Ethanol Content*—Test Method D5501.

8.1.2 *Vapor Pressure*—Test Method D4953, D5190, or D5191.

8.1.3 *Acidity*—Test Method D1613.

8.1.4 pH_e —Test Method D6423.

8.1.5 *Gum Content, Solvent Washed and Unwashed*—Test Method D381.

8.1.6 *Inorganic Chloride Content*—Test Methods D7319 or D7328.

8.1.7 *Water Content*—Test Method E203 or E1064.

8.1.8 *Copper Content*—Modification of Test Method D1688.

8.1.8.1 The modifications of Test Method D1688, Test Method A (atomic absorption, direct) consists of mixing reagent-grade ethanol (which may be denatured in accordance with TTB Formula 3A or 30) in place of water as the solvent of diluent for the preparation of reagents and standard solutions. However, this shall not be done to prepare the stock copper solution described in the section on Copper Solution, Stock in Test Method D1688. Because a violent reaction can occur between the acid and the ethanol, use water, as specified, in the acid solution part of the procedure to prepare the stock copper solution. Use ethanol for the rinse and final dilution only.

8.1.9 *Sulfur Content*—Test Method D5453.

8.1.10 *Methanol Content*—Test Method D5501.

9. Keywords

9.1 acidity; alcohol; automotive spark-ignition engine fuel; chloride; copper corrosion; E85; ether; ethanol fuel blends for flexible-fuel automotive spark-ignition engines; flexible-fuel; hydrocarbon; inorganic chloride; lead; MTBE; oxidation stability; oxygenates; pH_e; phosphorus; solvent washed gum content; sulfur; vapor pressure; volatility; water

APPENDIX

(Nonmandatory Information)

X1. SIGNIFICANCE OF SPECIFICATION FOR ETHANOL FUEL BLENDS FOR FLEXIBLE-FUEL AUTOMOTIVE SPARK-IGNITION ENGINES

X1.1 Ethanol

X1.1.1 The ethanol content of ethanol fuel blends is a critical parameter as it affects the capability of the fuel metering system of the flexible–fuel vehicle to establish the proper air/fuel ratio for optimum vehicle operation. Ethanol content can also affect the lubricating properties of the fuel, the water tolerance of the fuel, and the ability to meet cold and cool area volatility requirements.

X1.1.2 The inclusion of impurities, some denaturants, and contaminants, except for the deliberately added hydrocarbons or additives, or both, can impact adversely on the properties and performance of ethanol fuel blends as an automotive spark-ignition engine fuel. The quantities of some of these materials are controlled by specified property limits. The limits on water, methanol, and on types of denaturants, as well as minimums on the amount of ethanol and hydrocarbons limit, but do not prevent, the presence of trace materials.

X1.2 Hydrocarbon

X1.2.1 Hydrocarbons are deliberately added to provide higher vapor pressure for improved cold startability and warm up driveability. The addition of hydrocarbon to fuel ethanol changes its volatility and can affect the flammability of fuel tank vapors.

X1.2.2 The hydrocarbons used in ethanol fuel blends will be unleaded gasoline, gasoline blendstock for oxygenate blending (BOB), natural gasoline or other hydrocarbons in the gasoline boiling range (Specification D4814). The hydrocarbons shall be stable and noncorrosive.

X1.2.3 The inclusion of impurities and contaminants, except for the deliberately added denatured fuel ethanol or additives, or both, can impact adversely on the properties and performance of ethanol fuel blends as an automotive spark-ignition engine fuel. The quantities of some of these materials are controlled by specified property limits. The limits on water, types of hydrocarbons as well as minimums on the amount of ethanol and hydrocarbons limit, but do not prevent, the presence of trace materials.

X1.3 Vapor Pressure

X1.3.1 The addition of volatile hydrocarbons is required for adequate cold startability. The addition of hydrocarbons that are too volatile can contribute to hot fuel handling problems. Higher vapor pressures are required at colder ambient temperatures while lower volatility fuels are less prone to hot fuel handling problems at higher (summertime) ambient temperatures. Excessive vapor pressure contributes to evaporative emissions. Lower and upper limits on vapor pressure for the four volatility classes are used to define the acceptable range of volatile components to ensure adequate vehicle performance.

X1.3.2 The following four charts can be used to estimate the vapor pressure of ethanol fuel composition. Figs. X1.1 and X1.2 are in SI units and Figs. X1.3 and X1.4 are in United States customary units. The charts enable blenders who know the vapor pressure of the gasoline component to estimate the correct proportion of gasoline and denatured fuel ethanol to achieve the vapor pressure required in this specification. These curves were developed using the predictive equations found in SAE paper 2007-01-4006.

X1.4 Acidity

X1.4.1 Very dilute aqueous solutions of organic acids, such as acetic acid, are highly corrosive to a wide range of metals and alloys. It is therefore necessary to keep such acids at a very low level.

X1.5 pH_e

X1.5.1 When the pH_e of ethanol fuel blends used in automotive spark-ignition engines is below 6.5, fuel pumps can malfunction as a result of a film forming between the brushes and commutator, fuel injectors can fail from corrosive wear, and excessive engine cylinder wear can occur. When the pH_e is above 9.0, fuel pump plastic parts can fail.

X1.6 Gum Content, Solvent Washed and Unwashed

X1.6.1 The test for solvent washed gum content measures the amount of residue after the 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 the additives, and diesel fuel. Unwashed gum content consists of fuel-insoluble and fuel-soluble gum. The fuel-insoluble portion can clog fuel filters. Both can be deposited on surfaces when the fuel evaporates.

X1.6.2 Solvent washed gum can contribute to deposits on the surface of carburetors, fuel injectors, and intake manifolds, ports, valves, and valve guides. The impact of solvent washed gum on malfunctions of modern engines that can operate on ethanol fuel blends has not been fully established but is based on limited experience gained with high alcohol fuels in field tests and from historic gasoline limits. Performance effects depend on where the deposits form; the presence of other deposit precursors, such as airborne debris, blowby and exhaust gas recirculation gases; oxidized engine oil; and the amount of deposit.

X1.6.3 The difference between the unwashed and solvent washed and 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.

X1.6.4 The unwashed gum content limit is intended to limit high-boiling contaminants, like diesel fuel, that can affect