



Designation: D5798 – 17

Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines¹

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 U.S. 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 ethanol fuel blend flexible-fuel spark-ignition engines. Fuel produced to this specification contains 51 % to 83 % by 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.

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.

1.5.1 *Exception*—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.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

- [D86 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure](#)
- [D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test](#)
- [D381 Test Method for Gum Content in Fuels by Jet Evaporation](#)
- [D525 Test Method for Oxidation Stability of Gasoline \(Induction Period Method\)](#)
- [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](#)
- [D3231 Test Method for Phosphorus in Gasoline](#)
- [D4057 Practice for Manual Sampling of Petroleum and Petroleum Products](#)
- [D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants](#)
- [D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products](#)
- [D4306 Practice for Aviation Fuel Sample Containers for](#)

¹ This specification is under the jurisdiction of ASTM Committee [D02](#) on Petroleum Products, Liquid Fuels, 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

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 Gasoline-Oxygenate Blends (Dry 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 and Methanol Content in Fuels Containing Greater than 20% Ethanol by Gas Chromatography
- D5854** Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
- D6423** Test Method for Determination of pH_e of Denatured Fuel Ethanol and Ethanol Fuel Blends
- 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
- D7319** Test Method for Determination of Existent and Potential Sulfate and Inorganic Chloride in Fuel Ethanol and Butanol by Direct Injection Suppressed Ion Chromatography
- D7328** Test Method for Determination of Existent and Potential Inorganic Sulfate and Total Inorganic Chloride in Fuel Ethanol by Ion Chromatography Using Aqueous Sample Injection
- 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
- D7795** Test Method for Acidity in Ethanol and Ethanol Blends by Titration
- D7923** Test Method for Water in Ethanol and Hydrocarbon Blends by Karl Fischer Titration
- 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 C₂H₅OH. **D4806**

3.2.4 *finished fuel, n*—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. **D4814**

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

3.2.7 *methanol, n*—methyl alcohol, the chemical compound CH₃OH.

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 blendstock, n*—a blending component composed of hydrocarbons which boil in the gasoline temperature distillation range and trace amounts of naturally occurring compounds or additives composed of hydrogen, carbon, and other elements such as sulfur, oxygen and nitrogen.

3.3.3 *pH_e, n*—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.

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>.

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.

4.1.2.2 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**.

5.1.1 The components used to produce Ethanol Fuel Blends are limited to denatured fuel ethanol and hydrocarbon blendstock as defined in **5.2**.

5.1.2 The intentional addition of lead or phosphorus compounds to ethanol fuel blends is not permitted.

5.2 Hydrocarbon Blendstock blended with the denatured fuel ethanol shall meet the requirements of **Table 2**.

5.2.1 The hydrocarbon blendstock may be unleaded gasoline, gasoline blendstock for oxygenate blending (BOB), natural gasoline or other hydrocarbons in the gasoline boiling range.

TABLE 2 Requirements for Hydrocarbon Blendstock

Properties	Test Methods
Distillation, end point, max, °C (°F)	225 (437) D86
Oxidation stability, minimum, minutes	240 D525
Copper Strip Corrosion, max	No. 1 D130
Silver Strip Corrosion, max	No. 1 D7667, D7671
Vapor pressure	Report ^A D4953, D5191

^A While not a requirement of this specification, the blender will need to know the vapor pressure of the hydrocarbon blendstock in order to choose a suitable blend ratio for the components to meet the vapor pressure requirement of a particular volatility class.

5.3 Vapor pressure is varied for seasonal and climatic changes by providing four vapor pressure classes for ethanol fuel blends.

5.3.1 Class 1 encompasses geographical areas with 6-hour tenth percentile minimum ambient temperature of greater than 5 °C (41 °F).

5.3.2 Class 2 encompasses geographical areas with 6-hour tenth percentile minimum ambient temperature of greater than –5 °C (23 °F) but less than or equal to 5 °C (41°F).

5.3.3 Class 3 encompasses geographical areas with 6-hour tenth percentile minimum ambient temperature greater than –13 °C (9 °F) but less than or equal to –5 °C (23°F).

5.3.4 Class 4 encompasses geographical areas with 6-hour tenth percentile minimum ambient temperature less than or equal to –13 °C (9 °F).

5.3.5 There is a 10 % probability that the highest temperature of the six coldest consecutive hourly temperature readings of a 24 h day will be colder than the 6 h tenth percentile minimum ambient temperature.

5.3.6 See **5.4.4** and **5.5.2** for seasonal and geographical distributions.

5.4 Regulatory and Other Requirements in the United States:

5.4.1 Ethanol content requirements for ethanol alternative fuel blends can be found in **4.1.2.1**.

TABLE 1 Requirements for Ethanol Fuel Blends^A

Properties	Class 1 ^B	Class 2	Class 3	Class 4	Test Methods
Vapor pressure, kPa (psi)	38–62 (5.5–9.0)	48–65 (7.0–9.5) All Classes ^C	59–83 (8.5–12.0)	66–103 (9.5–15.0)	D4953 or D5191
Ethanol Content, volume %		51–83			D5501
Water Content, max, mass %		1.0			E203, E1064, or D7923
Methanol Content, max, volume %		0.5			D5501
Sulfur Content, max, mg/kg		80			D5453 or D7039
Acidity, (as acetic acid CH ₃ COOH), mass % (mg/L) [mg/kg], max		0.005 (40) [50]			D1613 or D7795
Solvent-washed gum content, max, mg/100 mL		5			D381
Unwashed gum content, max, mg/100 mL		20			D381
pH _e		6.5 to 9.0			D6423
Inorganic chloride content, max, mg/kg		1			D7319 or D7328
Copper content, max, mg/L		0.07			D1688

^A For information on alternative fuels, see **4.1.2.1**.

^B See **5.3.1** 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.