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# Standard Specification for Fuel Ethanol (Ed70-Ed85) for Automotive Spark-Ignition Engines<sup>1</sup>

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 ( $\epsilon$ ) 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 a fuel blend, nominally 70 to 85 volume % denatured fuel ethanol and 30 to 15 additional volume % hydrocarbons for use in ground vehicles with automotive spark-ignition engines. **Appendix X1** discusses the significance of the properties specified.

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

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- 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
- D512 Test Methods for Chloride Ion in Water
- D525 Test Method for Oxidation Stability of Gasoline (Induction Period Method)
- D1266 Test Method for Sulfur in Petroleum Products (Lamp 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
- D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
- D3120 Test Method for Trace Quantities of Sulfur in Light

Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry

- D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
- D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
- D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
- D4806 Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel
- D4814 Specification for Automotive Spark-Ignition Engine Fuel
- D4815 Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C<sub>1</sub> to C<sub>4</sub> Alcohols in Gasoline by Gas Chromatography
- D4953 Test Method for Vapor Pressure of Gasoline and 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 pH of Ethanol, Denatured Fuel Ethanol, and Fuel Ethanol (Ed75-Ed85)
- D7319 Test Method for Determination of Total and Potential Sulfate and Inorganic Chloride in Fuel Ethanol by Direct Injection Suppressed Ion Chromatography
- D7328 Test Method for Determination of Total and Potential Inorganic Sulfate and Total Inorganic Chloride in Fuel Ethanol by Ion Chromatography Using Aqueous Sample Injection

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is under the direct responsibility of Subcommittee D02.A0.01 on Gasoline and Gasoline-Oxygenate Blends.

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<sup>2</sup> 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.

**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*:<sup>3</sup>

**40 CFR Part 80** Code of Federal Regulations

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *ethanol, n*—ethyl alcohol, the chemical compound  $C_2H_5OH$ .

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

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *aliphatic ether*—an oxygen-containing, ashless, organic compound in which the oxygen atom is interposed between two carbon atoms (organic groups), has the general formula  $C_nH_{2n+2}O$  with  $n$  being 5 to 8, and in which the carbon atoms are connected in open chains and not closed rings.

3.2.1.1 *Discussion*—Aliphatic compounds can be straight or branched chains and saturated or unsaturated. The term aliphatic ether, as used in this specification, refers only to the saturated compounds.

3.2.2 *denaturants*—natural gasoline, gasoline components, unleaded gasoline, or toxic or noxious materials added to fuel ethanol to make it unsuitable for beverage use but not unsuitable for automotive use.

3.2.3 *denatured fuel ethanol*—fuel ethanol made unfit for beverage use by the addition of denaturants.

3.2.4 *fuel ethanol*—ethanol with impurities common to its production (including water but excluding denaturants).

3.2.5 *fuel ethanol (Ed70-Ed85)*—blend of ethanol and hydrocarbon of which the ethanol portion is nominally 70 to 85 volume % denatured fuel ethanol.

3.2.6 *higher alcohols*—aliphatic alcohols of general formula  $C_nH_{2n+1}OH$  with  $N$  being 3 to 8.

3.2.7 *hydrocarbon*—those components in an ethanol-hydrocarbon blend containing only hydrogen and carbon.

3.2.8  $pH_e$ —a measure of the acid strength of alcohol fuels.

### 4. Fuel Ethanol (Ed70-Ed85) Performance Requirements

4.1 Fuel ethanol (Ed70-Ed85) shall conform to the requirements of **Table 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. The lead maximum is limited for Class 1 and Class 2 fuels to the lower limit of the test method. As greater experience is gained from field use of Ed70-Ed85 vehicles and further vehicle hardware developments for the use of ethanol content fuels occurs, it is expected that many of these requirements will change.

4.1.1 Vapor pressure is varied for seasonal and climatic changes by providing three vapor pressure classes for fuel ethanol (Ed70-Ed85). The seasonal and geographical distribu-

**TABLE 1** Requirements for Fuel Ethanol (Ed70-Ed85)

| Properties  | Class 1 <sup>A</sup>  | Class 2         | Class 3          |
|---|---|-----------------|------------------|
| Ethanol volume %  | 68–83   | 68–83           | 68–83            |
| Vapor pressure, kPa (psi)                                 | 38–59 (5.5–8.5)   | 48–65 (7.0–9.5) | 66–83 (9.5–12.0) |
| All Classes   |   |                 |                  |
| Methanol, volume %, max                                   | 0.5   |                 |                  |
| Higher alcohols ( $C_3$ – $C_8$ ), max, volume %          | 2   |                 |                  |
| Sulfur, max, mg/kg  | 80 <sup>B</sup>   |                 |                  |
| Acidity, (as acetic acid $CH_3COOH$ ), mass % (mg/L), max | 0.005 (40)  |                 |                  |
| Solvent-washed gum content, max, mg/100 mL                | 5   |                 |                  |
| $pH_e$  | 6.5 to 9.0  |                 |                  |
| Unwashed gum content, max, mg/100 mL                      | 20  |                 |                  |
| Inorganic chloride, max, mg/kg                            | 1   |                 |                  |
| Copper, max, mg/L   | 0.07  |                 |                  |
| Water, max, mass %  | 1.0   |                 |                  |
| Appearance  | This product shall be visibly free of suspended or precipitated contaminants (clear and bright). This shall be determined at ambient temperature or 21°C (70°F), whichever is higher. |                 |                  |

<sup>A</sup> See **4.1.1** for volatility class criteria.

<sup>B</sup> Qualified small refineries have varying maximum sulfur limits for gasoline up to 0.0450 mass%, which are based on their 1997–1998 sulfur level baseline. If gasoline from qualified refineries is used to blend Ed70–Ed85, the maximum sulfur level shall be 134 mg/kg.

tion for three 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 less than or equal to –5°C (23°F).

4.1.2 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**. The hydrocarbons may contain aliphatic ethers as blending components as are customarily used for automotive spark-ignition engine fuel.

4.1.3 The denaturant for the denatured fuel ethanol used in making fuel ethanol (Ed70-Ed85) shall meet the requirements of Specification **D4806** (see Section 6).

4.1.4 Fuel ethanol (Ed70–Ed85) 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.

4.1.4.1 The intentional addition of lead or phosphorus compounds to fuel ethanol (Ed70–Ed85) 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 **40 CFR Part 80**, Part 80 of Title 40 of the Code of Federal Regulations.

4.1.5 Use of unprotected aluminum in fuel ethanol (Ed70-Ed85) distribution and dispensing equipment will introduce insoluble aluminum compounds into the fuel, causing plugged

<sup>3</sup> Available from the U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

**TABLE 2 Seasonal and Geographical Volatility Specifications for Fuel Ethanol (Ed70-Ed85)**

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         | 3   | 3   | 3     | 3   | 3/2 | 2/1  | 1    | 1/2 | 2/3 | 3   | 3   | 3   |
| South Mainland          | 3   | 3   | 3     | 3   | 3/2 | 2/1  | 1/2  | 2   | 2/3 | 3   | 3   | 3   |
| 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 <sup>4</sup> |     |     |       |     |     |      |      |     |     |     |     |     |
| North Coast             | 2   | 2   | 2     | 2   | 2   | 2/1  | 1    | 1   | 1   | 1/2 | 2   | 2   |
| South Coast             | 3/2 | 2   | 2     | 2   | 2/1 | 1    | 1    | 1   | 1   | 1/2 | 2/3 | 3   |
| Southeast               | 3   | 3/2 | 2     | 2   | 2/1 | 1    | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| Interior                | 2   | 2   | 2     | 2   | 2   | 2/1  | 1    | 1   | 1   | 1/2 | 2   | 2   |
| Colorado                |     |     |       |     |     |      |      |     |     |     |     |     |
| E of 105° Longitude     | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| W of 105° Longitude     | 3   | 3   | 3     | 3   | 3/2 | 2    | 2/1  | 1/2 | 2/3 | 3   | 3   | 3   |
| Connecticut             | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| Delaware                | 3   | 3   | 3/2   | 2   | 2/1 | 1    | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| 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                   | 3   | 3   | 3     | 3/2 | 2   | 2    | 2/1  | 1/2 | 2   | 2/3 | 3   | 3   |
| Illinois                |     |     |       |     |     |      |      |     |     |     |     |     |
| N of 40° Latitude       | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| S of 40° Latitude       | 3   | 3   | 3     | 3/2 | 2/1 | 1    | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| Indiana                 | 3   | 3   | 3     | 3/2 | 2/1 | 1    | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| Iowa                    | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| Kansas                  | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| 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                   | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| Maryland                | 3   | 3   | 3/2   | 2   | 2/1 | 1    | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| Massachusetts           | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| Michigan                |     |     |       |     |     |      |      |     |     |     |     |     |
| Lower Michigan          | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| Upper Michigan          | 3   | 3   | 3     | 3   | 3/2 | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| Minnesota               | 3   | 3   | 3     | 3   | 3/2 | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| Mississippi             | 2   | 2   | 2     | 2/1 | 1   | 1    | 1    | 1   | 1   | 1/2 | 2   | 2   |
| Missouri                | 3   | 3   | 3     | 3/2 | 2/1 | 1    | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| Montana                 | 3   | 3   | 3     | 3   | 3/2 | 2    | 2/1  | 1/2 | 2/3 | 3   | 3   | 3   |
| Nebraska                | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| Nevada                  |     |     |       |     |     |      |      |     |     |     |     |     |
| N of 38° Latitude       | 3   | 3   | 3     | 3/2 | 2   | 2    | 2/1  | 1/2 | 2   | 2/3 | 3   | 3   |
| S of 38° Latitude       | 3   | 3   | 3/2   | 2   | 2/1 | 1    | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| New Hampshire           | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| New Jersey              | 3   | 3   | 3/2   | 2   | 2/1 | 1    | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| New Mexico              |     |     |       |     |     |      |      |     |     |     |     |     |
| N of 34° Latitude       | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| 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       | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| S of 42° Latitude       | 3   | 3   | 3     | 3/2 | 2/1 | 1    | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| North Carolina          | 3   | 3   | 3/2   | 2   | 2/1 | 1    | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| North Dakota            | 3   | 3   | 3     | 3   | 3/2 | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| Ohio                    | 3   | 3   | 3     | 3/2 | 2/1 | 1    | 1    | 1   | 1/2 | 2/3 | 3   | 3   |
| Oklahoma                | 3   | 3   | 3     | 3/2 | 2/1 | 1    | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| Oregon                  |     |     |       |     |     |      |      |     |     |     |     |     |
| E of 122° Longitude     | 3   | 3   | 3     | 3/2 | 2   | 2    | 2/1  | 1/2 | 2   | 2/3 | 3   | 3   |
| 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       | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| S of 41° Latitude       | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| 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            | 3   | 3   | 3     | 3/2 | 2   | 2/1  | 1    | 1/2 | 2   | 2/3 | 3   | 3   |
| Tennessee               | 3   | 3   | 3/2   | 2   | 2/1 | 1    | 1    | 1   | 1/2 | 2   | 2/3 | 3   |
| Texas                   |     |     |       |     |     |      |      |     |     |     |     |     |