



# Standard Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines<sup>1</sup>

This standard is issued under the fixed designation D 5798; 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 75 to 85 volume % denatured fuel ethanol and 25 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.

1.3 The following safety hazards 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:<sup>2</sup>

- D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure
- D 130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
- D 381 Test Method for Gum Content in Fuels by Jet Evaporation
- D 512 Test Methods for Chloride Ion In Water
- D 525 Test Method for Oxidation Stability of Gasoline (Induction Period Method)
- D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
- D 1613 Test Method for Acidity in Volatile Solvents and Chemical Intermediates Used in Paint, Varnish, Lacquer,

### and Related Products

- D 1688 Test Methods for Copper in Water
- D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
- D 2988 Test Methods for Water-Soluble Halide Ion in Halogenated Organic Solvents and Their Admixtures
- D 3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
- D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products
- D 4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
- D 4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
- D 4806 Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel
- D 4814 Specification for Automotive Spark-Ignition Engine Fuel
- D 4815 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
- D 4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)
- D 5190 Test Method for Vapor Pressure of Petroleum Products (Automatic Method)
- D 5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)
- D 5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
- D 5501 Test Method for Determination of Ethanol Content of Denatured Fuel Ethanol by Gas Chromatography
- D 5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
- D 6423 Test Method for Determination of pH<sub>E</sub> of Ethanol, Denatured Fuel Ethanol, and Fuel Ethanol (Ed75-Ed85)
- E 203 Test Method for Water Using Volumetric Karl Fischer Titration
- E 1064 Test Method for Water in Organic Liquids by

<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.

**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<sub>2</sub>H<sub>5</sub>OH.

**3.1.2 methanol, n**—methyl alcohol, the chemical compound CH<sub>3</sub>OH.

**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<sub>n</sub>H<sub>2n+2</sub>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 (Ed75-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<sub>n</sub>H<sub>2n+1</sub>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 p*H*<sub>e</sub>**—a measure of the acid strength of alcohol fuels.

**4. Fuel Ethanol (Ed75-Ed85) Performance Requirements**
**4.1 Fuel ethanol (Ed75-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 **D 4814** 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 Ed75-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 (Ed75-Ed85). The seasonal and geographical distribution 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).

**TABLE 1 Requirements for Fuel Ethanol (Ed75-Ed85)**

Properties	Class 1 <sup>A</sup>	Class 2	Class 3
Ethanol + higher alcohols, min, volume %	79	74	70
Hydrocarbon/aliphatic ether, volume %	17–21	17–26	17–30
Vapor pressure, kPa (psi)	38–59 (5.5–8.5)	48–65 (7.0–9.5)	66–83 (9.5–12.0)
Sulfur, max, mg/kg	80 <sup>B</sup>	80 <sup>B</sup>	80 <sup>B</sup>
All Classes			
Methanol, volume %, max	0.5		
Higher alcohols (C <sub>3</sub> –C <sub>8</sub> ), max, volume %	2		
Acidity, (as acetic acid CH <sub>3</sub> COOH), mass % (mg/L), max	0.005 (40)		
Solvent-washed gum content, max, mg/100 mL	5		
p <i>H</i> <sub>e</sub>	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 Ed75–Ed85, the maximum sulfur level shall be for Class 1: 92 mg/kg; for Class 2: 113 mg/kg; and for Class 3: 130 mg/kg.

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 **D 86**, oxidation stability of 240-min minimum by Test Method **D 525**, and No. 1 maximum copper strip corrosion by Test Method **D 130**. 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 (Ed75-Ed85) shall meet the requirements of Specification **D 4806** (see Section 6).

**4.1.4** Fuel ethanol (Ed75–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 (Ed75–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 (Ed75-Ed85) distribution and dispensing equipment will introduce insoluble aluminum compounds into the fuel, causing plugged vehicle fuel filters. Furthermore, this effect can be exaggerated

<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 (Ed75-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>A</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												