



Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel¹

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1. Scope

1.1 This specification covers nominally anhydrous denatured fuel ethanol intended to be blended with unleaded or leaded gasolines at 1 to 10 volume % for use as a spark-ignition automotive engine fuel. The significance of this specification is shown in Appendix X1.

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:

- D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure²
- D 381 Test Method for Gum Content in Fuels by Jet Evaporation²
- D 512 Test Methods for Chloride Ion in Water³
- D 891 Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals⁴
- D 1152 Specification for Methanol (Methyl Alcohol)⁵
- D 1193 Specification for Reagent Water³
- D 1613 Test Method for Acidity in Volatile Solvents and Chemical Intermediates Used in Paint, Varnish, Lacquer, and Related Products⁵
- D 1688 Test Methods for Copper in Water³
- D 3505 Test Method for Density or Relative Density of Pure Liquid Chemicals⁵
- D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter⁶
- D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products⁶
- D 4814 Specification for Automotive Spark-Ignition Engine Fuel⁶
- D 5453 Test Method for Determination of Total Sulfur in

Light Hydrocarbons, Motor Fuels, and Oils by Ultraviolet Fluorescence⁷

D 5501 Test Method for the Determination of Ethanol Content of Denatured Fuel Ethanol by Gas Chromatography⁷

D 5580 Test Method for Determination of Benzene, Toluene, Ethylbenzene, *p/m*-Xylene, *o*-Xylene, C₉ and Heavier Aromatics, and Total Aromatics in Finished Gasoline by Gas Chromatography⁷

D 6423 Test Method for Determination of pH of Ethanol, Denatured Fuel Ethanol, and Fuel Ethanol (Ed75–Ed85)⁸

D 6550 Test Method for Determination of Olefin Content of Gasolines by Supercritical-Fluid Chromatography⁸

E 203 Test Method for Water Using Volumetric Karl Fischer Reagent⁴

E 300 Practice for Sampling Industrial Chemicals⁴

E 1064 Test Method for Water in Organic Liquids by Coulometric Karl Fischer Titration⁴

2.2 Other Standards:

United States Code of Federal Regulations, Title 27, Parts 20 and 21⁹

United States Federal Specification O-E-760b Ethyl Alcohol (Ethanol): Denatured Alcohol: and Proprietary Solvent¹⁰

3. Terminology

3.1 Definitions:

3.1.1 *ethanol, n*—ethyl alcohol, the chemical compound C₂H₅OH.

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-ethanol blend, n*—a fuel consisting primarily of gasoline along with a substantial amount (more than 0.35 mass % oxygen) of denatured fuel ethanol.

3.1.4 *oxygenate, n*—an oxygen-containing ashless, organic compound, such as an alcohol or ether, which may be used as

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² Annual Book of ASTM Standards, Vol 05.01.

³ Annual Book of ASTM Standards, Vol 11.01.

⁴ Annual Book of ASTM Standards, Vol 15.05.

⁵ Annual Book of ASTM Standards, Vol 06.04.

⁶ Annual Book of ASTM Standards, Vol 05.02.

⁷ Annual Book of ASTM Standards, Vol 05.03.

⁸ Annual Book of ASTM Standards, Vol 05.04.

⁹ Order as Code of Federal Regulations Title 27 Parts 200-End: from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

¹⁰ Order from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

a fuel or fuel supplement.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *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.

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

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

3.2.4 *impurities*—in commercially produced fuel ethanol compounds other than ethanol or denaturants present such as methanol and fusel oil (for example, amyl and isoamyl alcohols).

3.2.5 *pHe*—a measure of the acid strength of alcohol fuels.

4. Performance Requirements

4.1 *Denatured Fuel Ethanol*—When fuel ethanol is denatured as specified in Section 5, it shall conform to the following requirements at the time of blending with a gasoline.

Ethanol, volume %, min	92.1
Methanol, volume %, max	0.5
Solvent-washed gum, mg/100 mL, max	5.0
Water content, volume %, max	1 (Note 1)
Denaturant content, volume %, min	1.96
volume %, max	4.76
Inorganic Chloride content, mass ppm (mg/L), max	40 (32)
Copper content, mg/kg, max	0.1
Acidity (as acetic acid CH ₃ COOH), mass % (mg/L), max	0.007 (56) (Note 3)
pHe	6.5 to 9.0
Appearance	Visibly free of suspended or precipitated contaminants (clear and bright)

NOTE 1—In some cases, a lower water content may be necessary to avoid phase separation of a gasoline-ethanol blend at very low temperatures. This reduced water content, measured at the time of delivery, shall be agreed upon between the supplier and purchaser.

NOTE 2—If denatured fuel ethanol is prepared by the addition of denaturants to undenatured fuel ethanol after it has been produced rather than during the dehydration process, the 15.56/15.56°C (60/60°F) specific gravity in air of the undenatured fuel ethanol shall be in the range from 0.7937–0.7977.

NOTE 3—Denatured fuel ethanol may contain additives such as corrosion inhibitors and detergents that may affect the titratable acidity (acidity as acetic acid) of the finished fuel ethanol. Although the base fuel ethanol may meet the acidity specification, the effect of these additives may produce an apparent high titratable acidity of the finished product. Contact the ethanol supplier if there is a question regarding the titratable acidity of your denatured fuel ethanol to verify that the base ethanol meets the acidity requirements of 4.1.

4.2 *Other Properties*—Limits more restrictive than those specified above, or the specification of additional properties such as color, may be agreed upon between the supplier and the purchaser.

5. Denaturants

5.1 The only denaturants used for fuel ethanol shall be natural gasoline, gasoline components, or unleaded gasoline at a minimum concentration of two parts by volume per 100 parts by volume of fuel ethanol. One denatured formula specifically designed for fuel use by the Bureau of Alcohol, Tobacco, and

Firearms (BATF) of the U.S. Treasury Department is Formula C.D.A. 20. It requires that for every 100 gal of ethanol of not less than 195 proof, a total of 2.0 gal of denaturant be added. Another fuel alcohol rendered unfit for beverage use and manufactured at an alcohol fuel plant requires the addition of 2 gal or more of materials listed by the director to each 100 gal of ethanol. The fuel ethanol formulas approved by the U.S. Treasury Department include materials, which are not allowed by this ASTM specification. This specification prohibits the use of hydrocarbons with an end boiling point higher than 225°C (437°F) as determined by Test Method D 86, although they may be permitted by BATF regulations. Some kerosines, for instance, promote piston scuff in automotive engines. The denaturants permitted by this specification may be included as part of the 10 volume % denatured fuel ethanol blended with a gasoline if they do not exceed five parts by volume per 100 parts by volume of fuel ethanol. This is permitted in the United States by law. Any part of these denaturants that are present at concentrations higher than five parts by volume per 100 parts by volume of fuel ethanol are considered as part of the base gasoline.

NOTE 4—BATF regulations concerning the preparation, use, and handling of denatured ethanols are published in the United States Code of Federal Regulations, Title 27, Parts 19, 20, and 21. 27 CFR 19.1005 contains regulations for rendering fuel alcohol unfit for beverage use. 27 CFR 21.24 contains the formula for manufacturing completely denatured alcohol, C.D.A. 20.

5.2 *Prohibited Denaturants*—Although this specification permits only hydrocarbons in the gasoline boiling range to be used as denaturants, specific mention must be made of some materials that have extremely adverse effects on fuel stability, automotive engines and fuel systems. These materials shall not be used as denaturants for fuel ethanol under any circumstances. They are as follows: methanol which does not meet Specification D 1152, pyrroles, turpentine, ketones and tars (high-molecular weight pyrolysis products of fossil or nonfossil vegetable matter). While any significant amount of methanol will lower the water tolerance and increase the vapor pressure of a gasoline-ethanol blend, these effects become more serious when methanol is present at more than 2.5 parts by volume per 100 parts by volume of fuel ethanol. Also, methanol which does not meet Specification D 1152 frequently contains impurities such as turpentine and tars. Similarly, ketone denaturants tend to degrade fuel stability or increase the tendency of a gasoline-ethanol blend to corrode metals and attack elastomers. These effects become more serious if the concentration of a ketone such as 4-methyl pentanone (methyl isobutyl ketone) exceeds one part by volume per 100 parts by volume of fuel ethanol. There is no information available on the effects of denaturants other than those mentioned above, but unless a denaturant, such as a higher aliphatic alcohol or ether, is known to have no adverse effect on a gasoline-ethanol blend or on automotive engines or fuel systems, it shall not be used.

6. Sampling

6.1 Samples may be obtained by an appropriate procedure of Practice D 4057 or Practice E 300, except that water displacement (in section on Sampling for Specific Tests in