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## Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel<sup>1</sup>

This standard is issued under the fixed designation D4806; 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.

### 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 covered by Specification D4814. The significance of this specification is shown in Appendix X1.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

~~1.2.1 Exception—Federal regulations use the inch-pound units that appear in Note 2, 5.1, and X1.2.1.~~

1.3 The user is advised to check with the national regulatory agencies where the ethanol is denatured and used. The sulfur limit and denaturing formulas in this specification are acceptable for the U.S. market. Other countries or jurisdictions may allow or require other denaturing formulas and sulfur limits.

### 2. Referenced Documents

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

D86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure

D381 Test Method for Gum Content in Fuels by Jet Evaporation

~~D891 Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals~~

~~D1152 Specification for Methanol (Methyl Alcohol)~~ 1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer 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

~~D3505 Test Method for Density or Relative Density of Pure Liquid Chemicals~~

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

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

D4814 Specification for Automotive Spark-Ignition Engine Fuel

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

D5580 Test Method for Determination of Benzene, Toluene, Ethylbenzene, *p/m*-Xylene, *o*-Xylene, C<sub>9</sub> and Heavier Aromatics, and Total Aromatics in Finished Gasoline by Gas Chromatography

D5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products

D6423 Test Method for Determination of pH<sub>e</sub> of Ethanol, Denatured Fuel Ethanol, and Fuel Ethanol (Ed75-Ed85)

D6550 Test Method for Determination of Olefin Content of Gasolines by Supercritical-Fluid Chromatography

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee ~~D02.A0.01~~ D02.A0.02 on Gasoline-Oxygenated Fuels and Gasoline-Oxygenate Blends-Components.

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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.

D7039 [Test Method for Sulfur in Gasoline and Diesel Fuel by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry](#)

D7318 [Test Method for Total Inorganic Sulfate in Ethanol by Potentiometric Titration](#)

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](#)

E29 [Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)

E203 [Test Method for Water Using Volumetric Karl Fischer Titration](#)

E300 [Practice for Sampling Industrial Chemicals](#)

E1064 [Test Method for Water in Organic Liquids by Coulometric Karl Fischer Titration](#)

2.2 *Other Standards:*

United States Code of Federal Regulations, Title 27, ~~Parts~~ Parts 19, 20, and 21<sup>3</sup>

### 3. Terminology

~~3.1 Definitions:~~

~~3.1.1 ethanol, n~~ 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.

~~3.2.2 denatured fuel ethanol, n~~—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.

~~3.2.3 ethanol, n~~—ethyl alcohol, the chemical compound C<sub>2</sub>H<sub>5</sub>OH.

~~3.1.2 gasoline, n~~

~~3.2.4 fuel ethanol, n~~—a grade of undenatured ethanol with other components common to its production (including water) that do not affect the use of the product as a component for automotive spark-ignition engine fuels.

~~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~~

~~3.1.3 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. **D4814**

~~3.1.4 oxygenate, n~~

~~3.2.6 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.

~~3.2.7 oxygenate~~—an oxygen-containing, ashless, organic compound, such as an alcohol or ether, which may be used as a fuel or fuel supplement. **D4814**

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

~~3.2.1 denaturants, n~~—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, n~~—fuel ethanol made unfit for beverage use by the addition of denaturants.

~~3.2.3 fuel ethanol, n~~—ethanol with impurities common to its production (including water but excluding denaturants):

~~3.2.4 impurities, n~~—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, n~~—a measure of the acid strength of alcohol fuels.

~~3.3 Definitions of Terms Specific to This Standard:~~

~~3.3.1 pHe, n~~—a measure of the acid strength of denatured fuel ethanol.

NOTE 1—The user is advised that the definitions used by various industries, marketers, and regulatory bodies can differ from those specific to this specification. It is the responsibility of the user to ensure that the terms used in a particular context are clearly understood.

### 4. Performance Requirements Performance Requirements (Table 1)

4.1 *Denatured Fuel Ethanol*—~~When~~ After fuel ethanol is denatured as specified in Section 5, it shall conform to the following

<sup>3</sup> Order as Code of Federal Regulations Title 27 Parts 1–39: from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401 or the online store at [www.gpo.gov](http://www.gpo.gov).

<sup>3</sup> 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 St., NW, 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>.

**TABLE 1 Performance Requirements**

Property	Limit	Method
Ethanol, volume %, min	92.1	D5501
Methanol, volume %, max	0.5	D5501
Solvent-washed gum content, mg/100 mL, max	5.0	D381
Water, volume %, max	1.0	E203 or E1064
Inorganic Chloride, mass ppm (mg/L), max	10. (8)	D7319 or D7328
Copper, mg/kg, max	0.1	D1688
Acidity (as acetic acid CH <sub>3</sub> COOH), mass % (mg/L), max	0.007 (56) (Note 3)	D1613
pHe	6.5 to 9.0	D6423
Sulfur, mass ppm, max	30.	D2622, D3120, D5453, or D7039
Total sulfate, mass ppm, max	4	D7318, D7319, or D7328

requirements at the time of blending with a gasoline. (See Note 1 and Note 2.)

Ethanol, volume %, min	92.1
Methanol, volume %, max	0.5
Solvent-washed gum, mg/100 mL, max	5.0
Water content, volume %, max	1.0 (Note 3)
Denaturant content, volume %, min	1.96
volume %, max	5.0
Inorganic Chloride content, mass ppm (mg/L), max	10. (8)
Copper content, mg/kg, max	0.1
Acidity (as acetic acid CH <sub>3</sub> COOH), mass % (mg/L), max	0.007 (56) (Note 4)
pHe	6.5 to 9.0
Sulfur, mass ppm, max	30.
Total sulfate, mass ppm, max	4
Appearance	Visibly free of suspended or precipitated contaminants (clear and bright)

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**NOTE 1—For 2—**For purposes of determining conformance with these specification limits, an observed value or a calculated value shall be rounded “to the nearest unit” in the right-most significant digit used in expressing the specification limit, in accordance with the rounding method of Practice E29. For a specification limit expressed as an integer, a trailing zero is significant only if the decimal point is specified. For a specified limit expressed as an integer, and the right-most digit is non-zero, the right-most digit is significant without a decimal point being specified. This convention applies to specified limits in this table (4.1) and will not be observed in the remainder of this specification.

**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—**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 4—**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 3—Denatured fuel ethanol may contain additives, such as corrosion inhibitors and detergents, that can affect the titratable acidity (acidity as acetic acid) of the finished denatured fuel ethanol. Although the base fuel ethanol may meet the acidity specification, the effect of these additives can 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 fuel 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 Alcohol and Tobacco Tax and Trade Bureau (TTB) 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 (AFP) 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 D86, although they may be permitted by TTB 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 volume% of fuel ethanol. Any part of these denaturants that are present at concentrations higher than five volume% of fuel ethanol are considered as part of the base gasoline. The maximum denaturant limits are specified by United States Internal Revenue Service (IRS) regulations.

**NOTE 5**—TTB 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 by an AFP. 27 CFR 21.24 contains the formula for manufacturing completely denatured alcohol, C.D.A. 20.

**5.1 Denaturing Formulas**—Fuel ethanol is rendered unfit for beverage use by the addition of denaturants under formulas approved by the Alcohol and Tobacco Tax and Trade Bureau (TTB) of the U. S. Treasury Department that allow the denatured alcohol to ship from the denaturer free of beverage excise tax and to be distributed and used as a fuel component without TTB permits. TTB regulations concerning the preparation, handling, distribution and use of denatured ethanol formulas are published in the United States Code of Federal Regulations, Title 27, Parts 19, 20, and 21. The denatured fuel ethanol allowed by this specification shall contain a minimum of 1.96 volume % denaturant. The United States Internal Revenue Service (IRS) established a maximum of 2.5 volume % denaturant that qualifies the entire volume of denatured fuel ethanol for full Volumetric Ethanol Excise Tax Credit (VEETC). The user is advised to consult the IRS to determine the amount of the VEETC for denatured fuel ethanol with denaturant levels between 2.5 and 5 volume %. The maximum denaturant allowed by this specification is 5 volume %. The limits for the denaturant addition are shown in Table 2.

**5.1.1** To avoid imposition of the beverage excise tax, TTB regulations require the denaturer to add specific quantities of approved denaturants to the ethanol prior to shipping. The denaturant content is determined by the ratio of metered denaturant and ethanol volumes at the time of denaturing. The TTB regulations stipulate the record keeping requirements for the denaturer. These regulations include records of the quantities of ethanol and denaturant added in the denaturing process. The TTB periodically audits the denaturing facilities and associated records for compliance with these regulations. The regulations do not require the receiver to analytically verify that the material added was an approved denaturant or that it was added within the necessary concentration range. Approved analytical methods or calculations do not exist to permit any of the following: (1) to confirm compliance with this section of the specification after the denaturing process, (2) to determine that the denaturant used was approved by the TTB or allowed in this specification, (3) to quantify the ratio of denaturant added during the denaturing process, or (4) to distinguish between the hydrocarbons added as part of the denaturing process and those absorbed later in the distribution system.

**5.1.2** A buyer may ask the denaturer to denature within a specific range (for example, 1.96 to 2.5 volume %). A buyer may also ask the denaturer to certify the range used for the denaturant addition. A buyer or distributor may commingle receipts certified within the same range and provide a certification of conformance with the product from that commingling. The blender may use this certification of conformance for the product to demonstrate compliance with the denaturant limit in the IRS Notice 2009-06 titled, “Calculation of Volume of Alcohol for Fuel Credits; Denaturants.” If the product is shipped directly from a denaturer to a blender, the initial certification from the denaturer may be used to demonstrate compliance. Compliance with the denaturant limit

**TABLE 2 Denaturant Limits**

Limit, volume %	Source	Requirement
1.96 min	TTB	TTB Formulas require a minimum of two parts of approved denaturant to 100 parts of ethanol with a minimum of 195 proof ethanol.
	ASTM	The minimum amount of denaturant allowed by this specification.
2.5 max <sup>4</sup>	IRS <sup>4</sup>	The maximum amount of denaturant the IRS considers part of the denatured fuel ethanol for full VEETC credit.
5 max	ASTM	The maximum amount of denaturant allowed by this specification.

<sup>4</sup> See Appendix X3 for additional information on the IRS limit.

cannot be determined analytically. Compliance must be based on the information from the original denaturer.

**5.2 Allowable Denaturants**—The only denaturants allowed for the denatured fuel ethanol defined by this specification are natural gasoline, gasoline blendstocks or unleaded gasoline. Small amounts of the same or similar hydrocarbons absorbed by the denatured fuel ethanol as it moves through the distribution system is not denaturant. The fuel ethanol formulas approved by the TTB for fuel use include denaturing materials which are not allowed by this ASTM specification. It is the denaturer's responsibility to consult the regulations to ensure legal denaturing of the fuel ethanol and to ensure compliance with this specification with regard to allowed denaturants.

**5.3 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 D1152, 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 D1152, 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.—This specification prohibits the use of hydrocarbons with an end boiling point higher than 225°C as determined by Test Method D86, although they may be permitted by TTB regulations. Some kerosines, for instance, promote piston scuff in automotive engines. 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, pyrroles, turpentine, ketones, and tars (high-molecular weight pyrolysis products of fossil or nonfossil vegetable matter). 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. Workmanship

6.1 The denatured fuel ethanol shall be visually free of sediment and suspended matter. It shall be clear and bright at the ambient temperature or 21°C, whichever is higher.

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

## 7. Sampling, Containers, and Sample Handling

7.1 The reader/user is strongly advised to review all intended test methods prior to sampling to 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 or Practice E300 for manual method sampling and in Practice D4177 for automatic method 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 for tests sensitive to trace contamination. Refer to Practice D5854 for procedures on container selection and sample mixing and handling. All sampling and storage containers should be evaluated for durability, compatibility, and contamination of denatured fuel ethanol prior to use. If samples must be collected in metal containers, do not use soldered metal containers. Soldering flux in the containers and the lead in the solder can contaminate the sample.

7.4 **Sample Size**—A minimum of about 1 L is recommended. If specific gravity is to be determined by a hydrometer method, additional volume may be required. This depends on the size of the hydrometer.

7.5 **Lot Size**—A lot shall normally consist of the amount contained in a tanker compartment or other bulk container in which it is delivered. If this definition does not apply, the definition of a lot must be agreed upon between the supplier and purchaser.

**NOTE 6**—See 4—See Sections 5, 6, and 7 on Significance, Safety, and Statistical Considerations, respectively, of Practice E300 for a detailed discussion of the statistics of sampling.

## 8. Test Methods

8.1 The scope of some of the test methods specified in 8.2-8.10 listed below do not include denatured fuel ethanol. The precisions of those test methods may can differ from the reported precisions when testing denatured fuel ethanol.

8.2 **Water Content**—Test Methods E203 or E1064.



8.3 *Solvent-Washed Gum Content*—Test Method D381, air jet apparatus.

8.4 *Acidity*—Test Method D1613.

8.5 *pHe*—Test Method D6423.

8.6 *Appearance*—The product shall be visibly free of suspended or precipitated contaminants (clear and bright). This shall be determined at indoor ambient temperature unless otherwise agreed upon between the supplier and the purchaser.

8.7 *Specific Gravity*—Test Methods D891, Procedure B or Test Method D4052. For Test Methods D891, Procedure B (hydrometer), no formal precision statement is available, but practical experience indicates that precision is no better than 0.0005. Test Methods D891 Procedure C (pycnometer), with an interlaboratory precision (reproducibility) of 0.0002, should be used as a referee method.

8.8 *Inorganic Chloride Content*—Test Methods D7319 and D7328 Inorganic Chloride—Test Methods D7319 or D7328.

8.9 *Copper Content*—Modification of Test Methods D1688, Test Method A.

8.9.1 The modifications of Test Methods

8.7 *Copper*—Modification of Test Methods 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 or diluent for the preparation of reagents and standard solutions. However, this must not be done to prepare the stock copper solution described in the section on Copper Solution, Stock in Test Method, Test Method A.

8.7.1 The modifications of Test Methods D1688. Because a violent reaction may 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.

8.9.2 The precision of this modified method has not been determined, but it is expected to be similar to the precision of Test Method, Test Method A (atomic absorption, direct) consists of mixing reagent-grade ethanol (which can be denatured in accordance with TTB Formula 3A or 30) in place of water as the solvent or diluent for the preparation of reagents and standard solutions. However, this must 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.

8.7.2 The precision of this modified method has not been determined, but it is expected to be similar to the precision of Test Method D1688, Test Method A.

8.10 *Ethanol and Methanol Contents*

8.8 *Ethanol and Methanol*—Test Method D5501.

8.11 *Sulfur Content*—Test Methods D2622, D3120, or D5453. California specifies that compliance with the California sulfur standard for denatured ethanol shall be determined using Test Method D5453-93. EPA allows Test Methods

8.9 *Sulfur*—Test Methods D2622, D3120, D5453, or D7039. California specifies that compliance with the California sulfur standard for denatured ethanol shall be determined using Test Method D5453 for measuring sulfur in gasoline as long as these alternative test method results are correlated to the EPA designated Test Method D2622 when determining compliance with Federal EPA sulfur standards.

8.12 *Total Sulfate Content*—93. EPA allows Test Methods D3120-06<sup>e1</sup>, D5453-08a, or D7039-07 for measuring sulfur in gasoline as long as these alternative test method results are correlated to the EPA designated Test Method D2622-05 when determining compliance with Federal EPA sulfur standards.

8.10 *Total Sulfate*—Test Methods D7318, D7319, and/or D7328.

8.13 *Denaturant Content*—Denaturant is added in the specified range to comply with federal regulations. The content is set by volumetric addition during the denaturing process. There is no standardized test procedure to directly determine the denaturant content in fuel ethanol. Current analytical procedures only provide a calculated estimate of the denaturant content, which is not sufficiently accurate for determining compliance.

8.11 *Denaturant*—The denaturant content is determined by the ratio of (metered denaturant) to (metered denaturant and ethanol volumes) at the time of denaturing. There is no standardized test procedure or calculation to directly or indirectly determine the denaturant content in denatured fuel ethanol.

## 9. Keywords

9. acidity; automotive spark-ignition engine fuel; base gasoline; chloride ion content; copper content; corrosion inhibitors; denaturants; denatured fuel ethanol; ethanol; ethanol content; ethanol purity; fuel; fuel ethanol; gasoline; gasoline-ethanol blend; impurities; oxygenate; solvent-washed gum; sulfate ion content; sulfur content; water content

9.1 acidity; automotive spark-ignition engine fuel; base gasoline; chloride ion; copper; corrosion inhibitors; denaturants; denatured fuel ethanol; ethanol; fuel; fuel ethanol; gasoline; gasoline-ethanol blend; oxygenate; solvent-washed gum content; sulfate ion; sulfur; water

## APPENDIXES