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Standard Specification for Natural Gasoline as a Blendstock in Ethanol Fuel Blends or as a Denaturant for Fuel Ethanol¹

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1. Scope*

1.1 This specification covers natural gasoline to be used as a hydrocarbon blendstock in ethanol fuel blends for flexible-automotive spark-ignition engines (Specification D5798). In the United States, these blends are referred to commercially as Ethanol Flex Fuel.

1.2 This specification also covers natural gasoline to be used as a denaturant in denatured fuel ethanol for blending with gasolines for use as automotive spark-ignition engine fuel (Specification D4806).

1.3 Specific regulatory requirements for the intended uses from various jurisdictions are given in appendices for information.

1.4 This specification is not intended to provide a market specification nor a regulatory reference for natural gasoline for any use other than as a hydrocarbon blendstock in ethanol fuel blends or as a denaturant in denatured fuel ethanol.

1.5 The values stated in SI units are to be regarded as standard.

1.5.1 *Exception*—Values given in parentheses are provided for information only.

2. Referenced Documents

2.1 ASTM Standards:²

- D86 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure
- D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)
- D381 Test Method for Gum Content in Fuels by Jet Evaporation
- D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)

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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.

- 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
- 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 Products, Liquid Fuels, and Lubricants
- D4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
- 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
- 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
- D5482 Test Method for Vapor Pressure of Petroleum Products (Mini Method—Atmospheric)
- D5580 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 Chromatography
- D5798 Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines
- D5842 Practice for Sampling and Handling of Fuels for Volatility Measurement
- D5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products

*A Summary of Changes section appears at the end of this standard

- D6378** Test Method for Determination of Vapor Pressure (VP_x) of Petroleum Products, Hydrocarbons, and Hydrocarbon-Oxygenate Mixtures (Triple Expansion Method)
- D6469** Guide for Microbial Contamination in Fuels and Fuel Systems
- D6550** Test Method for Determination of Olefin Content of Gasolines by Supercritical-Fluid Chromatography
- D6730** Test Method for Determination of Individual Components in Spark Ignition Engine Fuels by 100–Metre Capillary (with Precolumn) High-Resolution Gas Chromatography
- D6920** Test Method for Total Sulfur in Naphthas, Distillates, Reformulated Gasolines, Diesels, Biodiesels, and Motor Fuels by Oxidative Combustion and Electrochemical Detection
- 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
- D7096** Test Method for Determination of the Boiling Range Distribution of Gasoline by Wide-Bore Capillary Gas Chromatography
- D7220** Test Method for Sulfur in Automotive, Heating, and Jet Fuels by Monochromatic Energy Dispersive X-ray Fluorescence Spectrometry
- D7347** Test Method for Determination of Olefin Content in Denatured Ethanol by Supercritical Fluid Chromatography
- D7576** Test Method for Determination of Benzene and Total Aromatics in Denatured Fuel Ethanol by Gas Chromatography
- 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
- 2.2 *Canadian National Standards:*³
- CAN/CGSB-3.512** Automotive Ethanol Fuel (E50-E85)
- CAN/CGSB 3.516** Denatured Fuel Ethanol for Use in Automotive Spark Ignition Fuels
- CAN/CGSB 3.0 No. 60.32** Standard Test Method for the Determination of Corrosiveness to Silver of Gasoline, Middle Distillate Fuels and Oxygenated Fuels using Silver Wool: Rapid Ultrasonic Method
- 2.3 *Government Regulations:*
- CFR Title 40, Part 79** Registration of Fuels and Fuel Additives⁴

- CFR Title 40, Part 80** Regulation of Fuels and Fuel Additives⁴
- CFR Title 27, Part 19** Distilled Spirits Plants⁴
- CFR Title 27, Part 20** Distribution and Use of Denatured Alcohol and Rum⁴
- CFR Title 27, Part 21** Formulas for Denatured Alcohol and Rum⁴
- CCR Title 13 § 2260-§2298**, California Code of Regulations⁵

3. Terminology

3.1 For general terminology, refer to Terminology **D4175**.

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. **Appendix X7** contains additional information for a number of these terms.

3.2 Definitions:

3.2.1 *dry vapor pressure equivalent (DVPE)*, *n*—value calculated by a defined correlation equation that is expected to be comparable to the vapor pressure value obtained by Test Method **D4953**, Procedure A. **D4953**

3.2.2 *natural gasoline*, *n*—a hydrocarbon blend composed predominately of molecules with 5 to 8 carbon atoms and typically separated from the production flows from natural gas wells or crude oil wells.

3.2.2.1 *Discussion*—These hydrocarbon blends may be processed to further remove lighter or heavier hydrocarbons or reduce sulfur content. Other names for this blend include naphtha and field naphtha.

3.2.2.2 *Discussion*—Different government regulations may define “natural gasoline” in different ways. Refer to specific regulations.

3.3 Abbreviations:

- 3.3.1 CARB—California Air Resources Board
- 3.3.2 CFR—U.S. Code of Federal Regulations
- 3.3.3 CGSB—Canadian General Standards Board
- 3.3.4 DVPE—Dry Vapor Pressure Equivalent
- 3.3.5 EFB—Ethanol Fuel Blend
- 3.3.6 EPA—The U.S. Environmental Protection Agency
- 3.3.7 TTB—Alcohol and Tobacco Tax and Trade Bureau of the U.S. Department of Treasury
- 3.3.8 U.S.—United States of America

4. Performance Requirements

4.1 See **Table 1**.

5. Regulatory Requirements

5.1 Natural gasoline shall meet the performance requirements in **Table 1**. It will also need to meet additional limits related to the regulatory requirements of the authority having jurisdiction for regulating denaturants and hydrocarbon blendstocks. The hydrocarbons used as denaturants to produce

³ Canadian fuel standards are available from Canadian General Standards Board: CGSB Sales Centre Gatineau, Canada K1A 1G6; web site: <http://www.techstreet.com/cgsb/subgroups/13684>.

⁴ 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>.

⁵ California regulations are available online at <http://government.westlaw.com>.

TABLE 1 Performance Requirements

Properties/Use of Natural Gasoline	Denaturant for Denatured Fuel Ethanol ^{A,B}	Hydrocarbon Blendstock for Ethanol Fuel Blends ^C	Test Methods
Density, kg/m ³ at 15 °C, or API gravity	Report	Report	D4052 D287
Dry Vapor Pressure Equivalent, at 37.8 °C (100 °F), kPa (psi)	Report	Report ^{D,E}	D4953, D5191, D5482, D6378
Distillation Temperature, End point (or Final Boiling Point), °C (°F), max	225 (437)	225 (437)	D86, ^F D7096
Silver corrosion, max		No. 1	D7667, D7671, CAN/CGSB 3.0 No. 60.32 ^G
Sulfur, mg/kg	Report	Report	D1266, D2622, D3120, D5453, D6920, D7039, or D7220
Unwashed Gum, mg/100 mL	Report	Report	D381
Solvent washed gum, max, mg/100 mL	Report	5	D381

^A Natural gasoline intended for use as a denaturant in denatured fuel ethanol meeting the requirements in Specification D4806. See Section 5 for regulatory requirements related to natural gasoline used to produce denatured fuel ethanol.

^B See U.S. EPA 40 CFR 80.47 for Performance-Based Analytical Test Method Approach requirements for analytical reporting and validation.

^C Natural gasoline intended for use as a hydrocarbon blendstock in ethanol fuel blends meeting the requirements in Specification D5798. See Section 5 for regulatory requirements related to natural gasoline used to produce ethanol fuel blends.

^D The vapor pressure of the natural gasoline used as the hydrocarbon blendstock to produce ethanol fuel blends shall be such that seasonal and geographical limits as outlined in Tables 1 and 3 of Specification D5798 are met. Specification D5798 fuel blend vapor pressure ranges from 38 kPa (5.5 psi) to 103 kPa (15.0 psi). The vapor pressure of the blend is a function of the vapor pressure of the hydrocarbon blendstock and the content of ethanol in the blend which can range from 51 % to 83 % by volume.

^E Users of natural gasoline may have limits on dry vapor pressure equivalent related to the storage tanks used and environmental permitting of the storage tanks.

^F Test Method D86 does not include natural gasoline in its scope and can provide highly variable results for low boiling point materials. Test Method D86 is considered appropriate for determination of the final boiling point of natural gasoline. Test Method D7096 will work for lower boiling point materials but an ASTM standard correlation between Test Method D86 and Test Method D7096 has not been developed, see 7.1.1.1.

^G See 7.1.2 for equivalent limits using CAN/CGSB-3.0 No. 60.32.

denatured fuel ethanol and as hydrocarbon blendstock used to produce ethanol fuel blends are covered by regulations specific to a jurisdiction or by multiple regulations due to overlapping jurisdictions. Appendixes have been developed to provide information for several jurisdictions describing the requirements for products and activities within the designated jurisdiction:

5.1.1 **Appendix X2:** Regulatory Requirements for Canada.

5.1.2 **Appendix X3:** Regulatory Requirements for the United States.

5.1.3 **Appendix X4:** Regulatory Requirements for California. (See **Appendix X3** and **Appendix X4**.)

5.1.4 **Table X1.1** provides the limits established by relevant regulatory agencies for Canada, the United States and the State of California at the time of publication of this standard. **Table X1.2** provides limits for parameters based on the regulatory requirements of U.S. and California regulatory agencies and possible usage scenarios in the marketplace.

5.2 Consult the appropriate regulatory agencies to confirm if hydrocarbons other than natural gasoline may be mixed with the natural gasoline to be used as a denaturant for denatured fuel ethanol or as a hydrocarbon blendstock for blending with denatured fuel ethanol to produce ethanol fuel blends. The use of hydrocarbons other than natural gasoline can result in parameter limits other than the values in these tables to maintain compliance with the jurisdictional regulations.

5.3 Other agencies or jurisdictions not listed may also establish additional requirements for natural gasoline used as the denaturant in denatured fuel ethanol or as the hydrocarbon blendstock in ethanol fuel blends. The user of this standard is responsible for consulting the jurisdiction where the denatured

fuel ethanol and ethanol fuel blends will be produced and used to determine specific regulatory compliance requirements.

6. Workmanship

6.1 At the point of custody transfer, natural gasoline shall be visually free of sediment, undissolved water, and suspended matter. It shall be clear and bright at the fuel temperature at the point of custody transfer or at an alternative temperature agreed upon by the purchaser and seller. The product shall be free of any adulterant or contaminant that can render the material unacceptable for its commonly used applications.

NOTE 2—Test Method D4176 can be helpful for evaluating the product.

6.2 The specification defines only the basic requirements for natural gasoline. Buyers and sellers may agree upon more stringent requirements.

6.2.1 Producers and blenders of natural gasoline shall avoid natural gasoline contaminated by silicon-containing materials. Silicon contamination of gasoline, denatured ethanol, and their blends has led to fouled vehicle components (for example, spark plugs, exhaust oxygen sensors, catalytic converters) requiring parts replacement and repairs. Test Method D7757 is a procedure for determining silicon content that might be applicable to natural gasoline. No specification limits have been established for silicon.

6.2.2 Producers and blenders of natural gasoline shall avoid natural gasoline contaminated by any materials not composed of carbon, hydrogen, oxygen, nitrogen and sulfur (non-CHONS). There is concern that the limited processing received by some natural gasoline (in comparison to the processing received by gasoline blending components in conventional refining) could result in trace contaminants (for example,

phosphorus, mercury, cyanides, and a long list of metallic elements) being present in natural gasoline that could deactivate catalytic converters on vehicles, resulting in undesirable emissions. Work is underway to identify possible non-CHONS contaminants in natural gasoline, and to determine if a suitable test method and limit can be developed.

6.2.3 The natural gasoline used as a denaturant in denatured fuel ethanol and as a hydrocarbon blendstock for ethanol fuel blends shall not contain materials which can separate from solution at the expected temperatures of blending, storage and use. If drag reducing agent (additive) (DRA) is used in the natural gasoline distribution system, it cannot be present in the product delivered to be used as a denaturant at a concentration or sheer condition which can separate from the denatured fuel ethanol under those conditions.

7. Test Methods

7.1 The requirements of this specification shall be determined in accordance with the methods listed below. Refer to the listed test methods to determine applicability or required modifications for use with natural gasoline. The scopes of some of the test methods below do not specifically include natural gasoline. The precision of these test methods can differ from the reported precisions when testing natural gasoline.

7.1.1 *Distillation*—Test Methods **D86** and **D7096**.

7.1.1.1 Test Method **D86** – 12 does not cover natural gasoline in the scope. Versions prior to Test Method **D86** – 07 included natural gasoline in the scope. Natural gasoline normally contains very light hydrocarbons which can evaporate before the initial stages of the distillation and be lost, thus there would be a need for cold samples and careful apparatus preparation. By the time the distillation reaches ten percent evaporation, the distillation should be similar to the distillation of a typical gasoline sample. Test Method **D86** should be applicable for the distillation points referenced in this specification after it is corrected for the front end loss. Test Method **D7096** is a gas chromatographic test method that detects and measures low boiling point hydrocarbons, however an ASTM correlation between Test Methods **D86** and **D7096** has not been developed. Before converting Test Method **D7096** results to predicted Test Method **D86** values, a correlation shall be developed and agreed to by the seller, buyer, and appropriate regulatory agencies.

7.1.2 *Corrosion, for Silver*—Test Methods **D7667**, **D7671**, or CAN/CGSB-3.0 No. 60.32. A silver wool rating of ‘B’ maximum by CAN/CGSB-3.0 No. 60.32 would be equivalent to a silver strip rating of ‘No. 1’ maximum by Test Methods **D7667** or **D7671**. Since silver is more susceptible to corrosion by aggressive sulfur species than copper, a passing result in a silver corrosion test is indicative that the sample would also pass a copper strip corrosion test.

7.1.3 *Sulfur*—Test Methods **D1266**, **D2622**, **D3120**, **D5453**, **D6920**, **D7039**, or **D7220**. With Test Method **D3120**, fuels with sulfur content greater than 100 mg/kg (0.0100 % by mass) shall be diluted with isooctane. The dilution of the sample can result in a loss of precision.

7.1.4 *Vapor Pressure (Dry Vapor Pressure Equivalent)*—Test Methods **D4953**, **D5191**, **D5842**, or **D6378**.

7.1.4.1 When using Test Method **D6378**, determine VP_4 at 37.8 °C (100 °F) using a sample from a 1 L container and convert to DVPE (Test Method **D5191** equivalence) using the following equation:

$$\text{Predicted DVPE} = VP_{4, 37.8\text{ }^\circ\text{C}} - 1.005 \text{ kPa} \quad (1)$$

$$(\text{Predicted DVPE} = VP_{4, 100\text{ }^\circ\text{F}} - 0.15 \text{ psi}) \quad (2)$$

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

7.1.6 *Benzene*—Test Methods **D5580**, **D6730**.

8. Sampling, Containers, and Sample Handling

8.1 The reader 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.

8.2 Correct sampling procedures are critical to obtain a sample representative of the lot intended to be tested. Use appropriate procedures in Practice **D4057** for manual method sampling and in Practice **D4177** for automatic method sampling, as applicable, and note the guidance of Practice **D5842** for sampling natural gasoline because of its high volatility.

8.3 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. For octane number determination, protection from light is important. Collect and store sample fuels in an opaque container, such as a dark brown glass bottle, metal can, or minimally reactive plastic container to minimize exposure to UV emissions from sources such as sunlight or fluorescent lamps.

8.4 For volatility determination of a sample, refer to Practice **D5842** for special precautions recommended for representative sampling and handling techniques.

9. Keywords

9.1 denaturant; denatured fuel ethanol; ethanol fuel blend; gasoline; natural gasoline

APPENDIXES
(Nonmandatory Information)
X1. REGULATORY AND RELATED REQUIREMENTS

X1.1 **Appendix X1** contains both regulatory requirements and calculated values based on regulatory requirements for natural gasoline to be used as a denaturant in denatured fuel ethanol and as the hydrocarbon blendstock in ethanol fuel blends. While the following requirements are believed to be accurate at the time of publication, users should consult the relevant authority to confirm the current regulations and requirements. The information provided about the regulations is for information only. In case of conflict, the text of current regulations takes precedence.

X1.1.1 **Table X1.1** contains information about relevant

regulatory requirements for Canada, the United States, and the State of California at the time of publication of this standard.

X1.1.2 **Table X1.2** provides limits for parameters based on the regulatory requirements of U.S. and California regulatory agencies and possible usage scenarios in the marketplace. These calculated values assume that only natural gasoline is being used as the denaturant or as the hydrocarbon blendstock. If other hydrocarbons are included, the values may no longer be appropriate.

TABLE X1.1 Regulatory Requirements Pertaining to Natural Gasoline Used as a Denaturant and Hydrocarbon Blendstock for Ethanol Fuel Blends

Properties	Denaturant		Hydrocarbon Blendstock for Ethanol Fuel Blends				Test Methods
	For use in Canada	For use in the U.S. ^A	For use in California	For use in Canada	For use in the U.S.	For use in California	
Reference	See X2.2	See X3.2	See X3.2 and X4.2	See X2.3	See X3.3	See X3.3 and X4.3	
Distillation Temperatures, °C, (°F), at % Evaporated							D86, D7096
10 % by volume, min	35 (95) ^B	36 (97) ^B					
50 % by volume, max		69 (156) ^B				100 (213) ^C	
90 % by volume, max		98 (209) ^B				152 (305) ^C	
Sulfur, mg/kg, max		330 ^D					D1266, D2622, D3120, D5453, D6920, D7039, or D7220
Benzene, % by volume, max			ASTM D8011 1.1 ^{E7}			1.10 ^F	D5580
Olefins, % by volume, max			10.0 ^E			10.0 ^F	D6550
Aromatics, % by volume, max			35.0 ^E			35.0 ^F	D5580

^A See U.S. EPA 40 CFR 80.47 for Performance-Based Analytical Test Method Approach requirements for analytical reporting and validation.

^B No specific test method is referenced in the Alcohol and Tobacco Tax and Trade Bureau (TTB) of the U.S. Treasury Department and Revenue Canada regulations. At the time the TTB and Revenue Canada limits were created, Test Method **D86** was the standard test method for these parameters.

^C Limits set by the California Air Resources Board (CARB) utilize Test Method **D86** – 99.

^D The U.S. EPA, effective January 1, 2017, establishes a limit of 330 ppm sulfur in denaturant. See **X3.4.2**.

^E California regulations (Title 13 CCR 2262.9) establish limits of 1.10 % by volume benzene, 10.0 % by volume olefins, and 35.0 % by volume aromatics for the denaturant used to produce denatured fuel ethanol. The regulatory limits assume the maximum denaturant content of 5.00 % by volume is contained in the denatured fuel alcohol. The regulations allow the limits to be adjusted if lower denaturant concentrations are used.

^F California regulations (Title 13 CCR 2292.4) sets a maximum content of benzene, olefins, and aromatics for the hydrocarbon blendstock used to produce ethanol fuel blends.

TABLE X1.2 Calculated Requirements Pertaining to Natural Gasoline Based on U.S. and California Regulations

Properties Applicability	Denaturant for Denatured Fuel Ethanol		Hydrocarbon Blendstock for Ethanol Fuel Blends (EFB)			Test Methods
	For use in the U.S. outside of California (U.S. grade) ^A	For use in California (CARB grade)	For use in the U.S. outside of California	For use in U.S. outside of California	For use in California	
Grade of Denatured Fuel Ethanol			U.S.	CARB	CARB	
Grade of Natural Gasoline	D1	D2	EFB1	EFB2	EFB3	
Assumption	Denaturant content, 2.5 % by volume, max	Denaturant content, 2.5 % by volume, max				
Sulfur, mg/kg, max	330 ^B	400 ^C	30 ^D	53 ^E	86 ^F	D1266, D2622, D3120, D5453, D6920, D7039, or D7220 D5580 or D6730
Benzene, % by volume, max	24.8 ^G	2.2 ^H	0.62 ^I	1.2 ^J		D5580 or D6730
Olefins, % by volume, max		20.0 ^H				D6550 or D6730
Aromatics, % by volume, max		70.0 ^H				D5580 or D6730

^A See U.S. EPA 40 CFR 80.47 for Performance-Based Analytical Test Method Approach requirements for analytical reporting and validation.

^B Effective January 1, 2017 the maximum sulfur content of certified denaturant will be 330 mg/kg (see X3.4.2).

^C The California regulations set a sulfur limit of 10 mg/kg in the denatured fuel ethanol (Title 13 CCR 2262.9). Assume all sulfur originates with the denaturant, at a maximum denaturant content of 2.5 % by volume the limit for sulfur content in the denaturant would be 400 mg/kg.

^D To compensate for the denaturant content in the denatured fuel ethanol, assume 53 % by volume denatured fuel ethanol is needed to obtain 51 % by volume ethanol. The ethanol fuel blend would contain a maximum of 47 % by volume natural gasoline. The current U.S. EPA annual average sulfur limit in spark-ignition engine fuels defined in Specification D4814 is 30 mg/kg. The current limit in Specification D4806 is 30 mg/kg (ppm by mass). The maximum sulfur content of the natural gasoline used as the hydrocarbon blendstock to produce ethanol fuel blends would be 30 mg/kg. (see X3.5.2.)

^E To compensate for the denaturant content in the denatured fuel ethanol, assume 53 % by volume denatured fuel ethanol is needed to obtain 51 % by volume ethanol (Specification D5798). The ethanol fuel blend would contain a maximum of 47 % by volume natural gasoline. The sulfur limit in California compliant denatured fuel ethanol is 10 mg/kg (Title 13 CCR 2262.9). The current U.S. EPA annual average sulfur limit in spark-ignitions engine fuels defined by Specification D4814 is 30 mg/kg. The sulfur limit of the natural gasoline used as the hydrocarbon blendstock to produce ethanol fuel blends (Specification D5798 outside of California) would be 53 mg/kg. (see X3.5.2)

^F California regulations (Title 13 CCR 2292.4) require 79 % by volume minimum ethanol content and a maximum sulfur content of 0.004 % by mass in ethanol fuel blends. To compensate for the denaturant content in the denatured fuel ethanol, assume 82 % by volume denatured fuel ethanol is needed to obtain 79 % by volume ethanol. The ethanol fuel blend would contain a maximum of 18 % by volume natural gasoline. The sulfur limit in California compliant denatured fuel ethanol is 10 mg/kg (Title 13 CCR 2262.9). The maximum sulfur content of the natural gasoline used as the hydrocarbon blendstock to produce California compliant ethanol fuel blends would be 86 mg/kg. (see X3.5.2)

^G The U.S. EPA regulations (40 CFR 80.1230(a)(1)) set a maximum annual average benzene content of gasoline. Denaturant with a maximum benzene content of 24.8 % by volume when used at a maximum denaturant content of 2.5% by volume would produce a denatured fuel ethanol with a maximum benzene content of 0.62 % by volume.

^H The California regulatory limits for denaturant are based on a maximum denaturant content of 5.00 % by volume in the denatured fuel alcohol. The regulations allow the limits to be adjusted if lower denaturant concentrations are used. See Table X4.2 for appropriate test methods.

^I The U.S. EPA regulations limit the annual average benzene content in gasoline to a maximum of 0.62 % by volume. This limit for the natural gasoline used as the hydrocarbon blendstock to produce ethanol fuel blends assumes the denatured fuel ethanol in the blend will have a maximum benzene content equal to the maximum average annual benzene content for gasoline.

^J California regulations (Title 13 CCR 2262.9) limit the benzene content in denatured fuel ethanol to 0.06 % by volume. Natural gasoline used as the hydrocarbon blendstock with a maximum benzene content of 1.2 % by volume would produce an ethanol fuel blend with a maximum benzene content equal to the annual average benzene standard for gasoline of 0.62 % by volume (40 CFR 80.1230(a)(1)).

X2. REGULATORY REQUIREMENTS FOR CANADA

X2.1 Applicable Jurisdiction

X2.1.1 The requirements of Appendix X2 apply to natural gasoline used as a denaturant if denatured fuel ethanol or as the hydrocarbon blendstock in ethanol fuel blends that are produced, imported or used in Canada.

X2.2 Information Related to Denaturants in Canada

X2.2.1 In Canada, denaturants and denaturant formulas are approved by Revenue Canada. See CAN/CGSB 3.516 for a discussion of denaturant requirements in Canada.

X2.3 Information Related to Hydrocarbon Blendstock in Ethanol Fuel Blends in Canada

X2.3.1 The Canadian regulations related to ethanol fuel blends are found in CGSB specification CAN/ CGSB-3.512.