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Standard Specification for Methanol Fuel Blends (M51–M85) for Methanol-Capable Automotive Spark-Ignition Engines[1]

This standard is issued under the fixed designation D5797; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers the requirements for automotive fuel blends of methanol and gasoline for use in ground vehicles equipped with methanol-capable flexible-fuel, and dedicated methanol spark-ignition engines. Fuel produced to this specification contains 51 % to 85 % by volume methanol. This fuel is sometimes referred to at retail as "M85." Appendix X1 discusses the significance of the properties specified. Appendix X2 presents the current status in the development of a luminosity test procedure (flame visibility) for methanol fuel blends (M51–M85).

1.2 The vapor pressure of methanol fuel blends is varied for seasonal climatic changes. Vapor pressure is increased at lower temperatures to ensure adequate vehicle operability and safety. Methanol content and selection of gasoline blendstocks are adjusted by the blender to meet these vapor pressure requirements.

1.3 The United States government has established various programs for alternative fuels. Many of the definitions of alternative fuel used by these programs can be more or less restrictive than the requirements of this specification. See Annex A1 for additional information on alternative fuels containing methanol.

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

1.4.1 *Exception*—Non-SI units are provided for information only. In most cases, U.S. federal regulations specify non-SI units.

1.5 The following precautionary caveat pertains only to the test method portions–Appendix X2 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:*[2,3]

D86 Test Method for Distillation of Petroleum Products and Liquid Fuels 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

D525 Test Method for Oxidation Stability of Gasoline (Induction Period Method)

D1193 Specification for Reagent Water

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

D3231 Test Method for Phosphorus in Gasoline

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, 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

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)

D5059 Test Methods for Lead in Gasoline by X-Ray Spectroscopy

D5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is under the direct responsibility of Subcommittee D02.A0.02 on Oxygenated Fuels and Components.

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[2] Reference to the following documents is to be the latest issue unless otherwise specified.

[3] 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**

D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D5798 Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines
D5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
D7328 Test Method for Determination of Existent and Potential Inorganic Sulfate and Total Inorganic Chloride in Fuel Ethanol by Ion Chromatography Using Aqueous Sample Injection
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
D7920 Test Method for Determination of Fuel Methanol (M99) and Methanol Fuel Blends (M10 to M99) by Gas Chromatography
E203 Test Method for Water Using Volumetric Karl Fischer Titration

3. Terminology

3.1 For general terminology, refer to Terminology D4175.

3.2 *Definitions:*

3.2.1 *aliphatic ether, n*—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 *denatured fuel ethanol, n*—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. **D4806**

3.2.3 *ethanol, n*—ethyl alcohol, the chemical compound C_2H_5OH. **D4806**

3.2.4 *finished fuel, n*—a homogeneous mixture of blendstocks and fuel additives meeting all specification and regulatory requirements for its intended use at the location where sold.

3.2.5 *fuel methanol (M99), n*—methanol with small/trace alcohol and hydrocarbon impurities.

3.2.6 *gasoline, n*—volatile mixture of liquid hydrocarbons, generally containing small amounts of additives, suitable for use as a fuel in spark-ignition, internal combustion engines. **D4814**

3.2.7 *gasoline blendstock, n*—a liquid hydrocarbon component suitable for use in spark-ignition engine fuels.

3.2.7.1 *Discussion*—Examples of gasoline blendstock include natural gasoline, raffinate, reformate, naphtha, conventional gasoline blendstock for oxygenated blending (CBOB), and reformulated gasoline blendstock for oxygenate blending (RBOB).

3.2.8 *higher alcohols*—aliphatic alcohols of the general formula $C_nH_{2\ n+1}OH$ with *n* being 2 to 8.

3.2.9 *hydrocarbon*—a compound composed solely of hydrogen and carbon.

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

3.2.11 *methanol fuel blend (M51–M85), n*—a blend of methanol and hydrocarbons of which the methanol portion is nominally 51 % to 85 % by volume.

3.2.11.1 *Discussion*—In the abbreviation, MXX, the XX represents the volume percentage of methanol in the fuel blend.

4. Ordering Information

4.1 The purchasing agency shall:

4.1.1 Indicate the season and locality in which the fuel is to be used,

4.1.2 If requested, ensure that the methanol concentration meets the requirements for an alternative fuel for United States federal fleets.

4.1.3 For further information, see Annex A1 of this specification.

5. Methanol Fuel Blends Performance Requirements

5.1 Methanol fuel blends shall conform to the requirements in Table 1.

NOTE 1—Most of the requirements cited in Table 1 are based on the best technical information currently available. As greater experience is gained from field use of methanol-capable vehicles, some of these requirements will change.

5.1.1 The components used to produce methanol fuel blends are limited to methanol and gasoline blendstock as defined in 5.2.

5.1.2 The intentional addition of lead or phosphorus compounds to methanol fuel blends is not permitted.

5.2 Gasoline blendstocks used shall meet the requirements of Table 2. The gasoline blendstock may contain aliphatic ethers as blending components that are used in automotive fuels in some countries outside of North America.

5.3 Vapor pressure is varied for seasonal and climatic changes by providing three vapor pressure classes for methanol fuel blends as follows:

(1) Class 1 encompasses geographical areas with 6 h tenth-percentile minimum ambient temperature of greater than 5 °C (41 °F).

(2) Class 2 encompasses geographical areas with 6 h tenth-percentile minimum temperatures of greater than –5 °C (23 °F) but less than or equal to 5 °C (41 °F).

(3) Class 3 encompasses geographical areas with 6 h tenth-percentile minimum ambient temperature less than or equal to –5 °C (23 °F).

5.3.1 There is a 10 % probability that the highest temperature of the six coldest consecutive hourly temperature readings

TABLE 1 Requirements for Methanol Fuel Blends (M51–M85)

Properties	Class 1[A]	Class 2	Class 3	Test Methods Annex A1 D4953 or D5191
Vapor pressure, kPa[B] (psi)	48–62 (7.0–9.0)	62–83 (9.0–12.0)	83–103 (12.0–15.0)	
		All Classes[C]		
Methanol Content, % by volume, min		51–85		D7920
Lead, mg/L, max		2.6		D5059[D]
Phosphorus, mg/L, max		0.2		D3231
Sulfur, mg/kg, max		80		D5453
Acidity, as acetic acid, mg/kg, max		50		D1613
Unwashed gum content, mg/100 mL, max		20		D381
Solvent washed gum content, mg/100 mL, max		5		D381
Total Inorganic Sulfate, mg/kg, max		4		D7328
Water, % by mass, max		0.5		E203
Total Inorganic Chloride, mg/kg, max		1		D7328

[A] See 5.3 for volatility class criteria.
[B] The vapor pressure overlap is intentional to cover changes associated with seasonal changes.
[C] Methanol content and selection of gasoline blendstock are adjusted by the blender to meet vapor pressure requirements. See X1.3.3 for additional information and guidance for blending.
[D] With Test Methods D5059, prepare the calibration standards using methanol (reagent grade) as the solvent to prevent errors caused by large differences in carbon-hydrogen ratios.

TABLE 2 Requirements for Gasoline Blendstock

Properties		Test Methods
Distillation, end point, °C(°F), max	225 (437)	D86
Oxidation stability, minutes, min	240	D525
Copper strip corrosion, max	No. 1	D130
Silver strip corrosion, max	No. 1	D7667, D7671
Vapor pressure, kPa	Report[A]	D4953, D5191

[A] While not a requirement of this specification, the blender will need to know the vapor pressure of the gasoline blendstock in order to choose a suitable blend ratio for the components to meet the vapor pressure requirement of a particular volatility class.

of a 24 h day will be colder than the 6 h tenth percentile minimum ambient temperature.

5.3.2 See 5.4.2 for seasonal and geographical distributions in the United States.

5.4 *Regulatory and Other Requirements in the United States:*

5.4.1 Methanol content and other requirements for methanol alternative fuel blends in the United States can be found in Annex A1 of this standard.

5.4.2 The United States seasonal and geographical distribution for the three vapor pressure classes is shown in Annex A1, Table A1.1.

5.5 *Regulatory and Other Requirements Outside the United States:*

5.5.1 Users of this specification are advised to consult with the applicable regulatory agency for specific requirements for their jurisdictions.

5.5.2 Users of the specification in geographical areas outside the United States need to determine the 6 h tenth percentile minimum ambient temperatures for their geographic areas and times of year in order to select the appropriate classes of fuel.

5.6 Use of unprotected aluminum in methanol fuel blend distribution and dispensing equipment will introduce insoluble aluminum compounds into the fuel causing plugged vehicle fuel filters. Furthermore, this effect can be exaggerated even with protected aluminum by elevated fuel conductivity caused by contact with a nitrile rubber dispensing hose. Therefore, unprotected aluminum and an unlined nitrile rubber dispensing hose should be avoided in methanol fuel blend distribution and dispensing systems.[4,5]

6. Workmanship

6.1 The finished fuel blend shall be visually free of sediment, suspended, or undissolved matter. It shall be clear and bright at the fuel temperature at the point of custody transfer or at a lower temperature agreed upon by the purchaser and seller.

NOTE 2—Finished fuel should be resistant to phase separation or undissolved matter at the lowest temperatures to which it is likely to be subjected, dependent on the time and place of its intended use. See Specification D4814, Table X7.1 for guidance.

NOTE 3—Solubility is temperature dependent. As this fuel cools, some high molecular weight additives can become insoluble.

6.2 The specification defines only a basic purity for methanol fuel blend (M51–M85). The product shall be free of any adulterant or contaminant that can render the material unacceptable for its commonly used applications.

6.2.1 Manufacturers and blenders of methanol fuel blend (M51–M85) shall avoid methanol (for example, improperly recycled methanol), or hydrocarbon blend components contaminated by silicon-containing materials, or both. 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 that might be applicable to methanol fuel blend (M51–M85). No specification limits have been established for silicon.

[4] California Energy Commission, "Fifteen Years of Fuel Methanol Distribution," http://www.methanol.org/Energy/Resources/Alternative-Fuel/CEC- 1996-ISAF-Fuel-Meoh-Paper.aspx

[5] California Air Resources Board, Methanol Fuel Additive Demonstration, http://arb.ca.gov/research/apr/past/a832-123a