Designation: D7862 – 15a

Standard Specification for Butanol for Blending with Gasoline for Use as Automotive Spark-Ignition Engine Fuel[1]

This standard is issued under the fixed designation D7862; 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 butanol intended to be blended with gasoline at 1 % to 12.5 % by volume for use as an automotive spark-ignition engine fuel.

1.1.1 Butanol contains 22 % by mass oxygen. The mass percent of oxygen of a butanol blend with gasoline depends on the volume percent of butanol blended, the density of the butanol isomer, and the density of the base blendstock.

1.1.2 The maximum limit on blending is not a performance limit but a current regulatory limit in the United States.

1.2 This specification covers three butanol isomers:1-butanol, 2-butanol, and 2-methyl-1-propanol. This specification specifically excludes 2-methyl-2-propanol (that is, *tert*-butyl alcohol).

1.2.1 *Tert*-butyl alcohol has different physical properties (melting point, water miscibility) than the other three isomers.

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

1.4 *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]

D381 Test Method for Gum Content in Fuels by Jet Evaporation

D1298 Test Method for Density, Relative Density, 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

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, 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

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

D6299 Practice for Applying Statistical Quality Assurance and Control Charting Techniques to Evaluate Analytical Measurement System Performance

D7319 Test Method for Determination of Existent and Potential Sulfate and Inorganic Chloride in Fuel Ethanol and Butanol by Direct Injection Suppressed Ion Chromatography

D7875 Test Method for Determination of Butanol and Acetone Content of Butanol for Blending with Gasoline by Gas Chromatography

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

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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.

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

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.

3.2 *Definitions:*

3.2.1 *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**

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

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *butanol, n*—butanol or butyl alcohol refers to 1-butanol, 2-butanol, and 2-methyl 1-propanol, three isomeric alcohols with the molecular formula C_4H_9OH, either individually or as mixtures.

4. Performance Requirements

4.1 *Butanol*—Butanol shall conform to the requirements shown in Table 1 at the time of blending with a gasoline. (See Note 2.)

NOTE 2—Commercial processes used to manufacture butanol from biological feedstock typically yield some fusel oil or alcohols such as pentanol and other higher alcohols.

4.1.1 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 Table 1 and will not be observed in the remainder of this specification.

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. Workmanship

5.1 At the point of custody transfer, the butanol shall be visually free of sediment, suspended and 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 3—Fuel components 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 4—Solubility is temperature dependent. As this fuel component cools, water and some high molecular weight additives can become insoluble.

5.2 The product shall be free of any adulterant or contaminant that can render the material unacceptable for its commonly used applications.

5.2.1 Manufacturers and importers of butanol shall avoid butanol contaminated by silicon-containing materials. Silicon contamination of gasoline-oxygenate blends has led to fouled vehicle components (for example, spark plugs, exhaust oxygen sensors, catalytic converters) requiring parts replacement and repairs.

5.2.2 Manufacturers and importers of butanol shall avoid butanol contaminated by acetone. Acetone contamination of gasoline-oxygenate blends can degrade elastomers used in fuel system components as well as paint and/or clearcoat finishes used on vehicles.

6. Sampling, Containers, and Sample Handling

6.1 The 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.

6.2 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.

6.3 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

TABLE 1 Requirements

Property	Limit	Method
Butanol, % by volume, min	96.0	D7875
1-butanol, % by volume	Report	D7875
2-butanol, % by volume	Report	D7875
2-methyl 1-propanol, % by volume	Report	D7875
Methanol, % by volume, max	0.4	D7875
Water content, % by volume , max	1.0	E203 or E1064
Acidity (as acetic acid CH_3COOH), % by mass (mg/L), max	0.007 (56)	D1613
Inorganic Chloride, mg/kg (mg/L), max	8 (6)	D7319
Solvent-washed gum, mg/100 mL, max	5.0	D381
Sulfur, mg/kg, max	30.	D2622, D5453
Existent sulfate, mg/kg, max	4.	D7319

should be evaluated for durability and contamination of butanol prior to use. Butanol may be sampled in glass containers; however sodium leaching from glass containers has been shown to interfere with sulfate analysis. HDPE (high density polyethylene) containers may be used in place of glass to avoid sodium leaching. If samples must be collected in metal containers, do not use soldered metal containers. Soldering flux in the containers and lead in the solder can contaminate the sample.

6.4 *Sample Size*—A minimum of about 1 L or 1 U.S. qt is recommended.

6.5 *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 shall be agreed upon between the supplier and purchaser.

NOTE 5—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.

7. Test Methods

7.1 The scope of some of the test methods listed below do not include butanol. The precisions of those test methods can differ from the reported precisions when testing butanol.

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

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

7.4 *Acidity*—Test Method D1613.

7.5 *Sulfur Content*—In the United States, US EPA allows Test Methods D3120 or D5453 for measuring sulfur in gasoline as long as these alternative test method results are correlated to the US EPA designated Test Method D2622 when determining compliance with US Federal EPA sulfur standards.

7.6 *Inorganic Chloride*—Test Method D7319.

7.7 *Butanol (1-butanol, 2-butanol, 2-methyl 1-propanol)*—Test Method D7875.

7.8 *Methanol*—Test Method D7875.

7.9 *Total Sulfate*—Test Method D7319.

8. Keywords

8.1 acidity; automotive spark-ignition engine fuel; base gasoline; bio-butanol; butanol; chloride ion content; corrosion inhibitors; fuel; gasoline; gasoline-butanol blend; impurities; oxygenate; solvent-washed gum; sulfate ion content; sulfur content; water content

APPENDIX

(Nonmandatory Information)

X1. SIGNIFICANCE OF SPECIFIED PROPERTIES

X1.1 Butanol

X1.1.1 *Water Content*—Karl Fischer analysis is generally the only consistently reliable procedure for the determination of water in butanol. Test Method E203 describes the modifications required to run the test in the presence of alcohols. Blends of butanol and gasoline have a limited solvency for water. This solvency will vary with the butanol content, the temperature of the blend, and the aromatic content of the base gasoline. Because some degree of water contamination is practically unavoidable in transport and handling, the water content of the butanol should be limited to reduce the risk of phase separation.

X1.1.2 *Solvent-Washed Gum Content:*

X1.1.2.1 The test for solvent-washed gum content measures the amount of residue after evaporation of the fuel and following a heptane wash. The heptane wash removes the heptane-soluble, nonvolatile material such as additives, carrier oils used with additives, and diesel fuel. Solvent-washed gum consists of fuel-insoluble gum and fuel-soluble gum. The fuel-insoluble portion can clog fuel filters. Both can be deposited on surfaces when the fuel evaporates.

X1.1.2.2 Solvent-washed gum can contribute to deposits on the surfaces of carburetors, fuel injectors, and intake manifolds, ports, valves, and valve guides. The impact of solvent washed gum from pure alcohols such as ethanol or butanol on malfunctions of modern engines is not known. The test method is used essentially to detect the presence of high boiling, heptane insoluble impurities.

X1.1.2.3 Because the precision statements for Test Method D381 were developed using only data on hydrocarbons, they may not be applicable to butanol.

X1.1.3 *Acidity*—Very dilute aqueous solutions of low molecular weight organic acids such as acetic (CH_3COOH) are highly corrosive to many metals. It is therefore necessary to keep such acids at a very low concentration.

X1.1.4 *Appearance*—Turbidity or evidence of precipitation normally indicates contamination.

X1.1.4.1 Fuel components can encounter conditions in the bulk distribution system that could cause the material to fail a workmanship visual evaluation. Some fuel components can contain dirt or rust particles during distribution. Terminals or bulk plants can address these issues with proper operating procedures, for example, by allowing sufficient time for the dirt or particles to settle in the tank, by filtration, or by other means.

X1.1.5 *Butanol Purity*—The presence of even small quantities of some organic oxygen compounds other than butanol can adversely affect the properties of butanol-gasoline blends.

X1.1.6 *Sulfate Content*—The presence of small amounts of inorganic sulfates in butanol or denatured ethanol under the

right conditions can contribute to turbine meter deposits and the premature plugging of fuel dispensing pump filters in the fuel distribution system. The sulfates also have been shown to cause fuel injector sticking resulting in engine misfiring and poor drivability in automobiles.

X1.1.6.1 Because the precision statements for sulfate content were developed using only data on ethanol, they may not be applicable to butanol.

X1.1.7 *Sulfur Content*—The U.S. Federal Tier 2 Motor Vehicle and Emissions Standards and Gasoline Sulfur Control Requirements establish sulfur standards for U.S. refineries and importers producing reformulated gasoline, Reformulated Blendstock for Oxygenate Blending (RBOB), and conventional gasoline. EPA has established gasoline sulfur controls to support vehicle emission standards. Sulfur contaminates the catalytic converter necessary for reducing emissions of HC, CO, and NOx.

X1.2 Comparison of Butanol isomers (Reagent Grade)

X1.2.1 See Table X1.1.

TABLE X1.1 Comparison of Butanol Isomers[A]

Property	1-Butanol	2-Butanol	2-Methyl-1-propanol
CAS Number	71-36-3	78-92-2	78-83-1
Other (non IUPAC) Names	n-Butyl alcohol	sec-Butyl alcohol	Isobutyl alcohol
Density, (kg/m^3)	809.8	806.3	801.8
Research Octane Number (RON)	96	101	113
Motor Octane Number (MON)	78	82	94
Melting Point, (°C)	–89.5	–114.7	–108
Boiling Temperature, (°C)	117.7	99.5	108
Enthalpy of Vaporization at T_{boil}, (kJ/kg)	584	550	564
Flash Point	35°C (95°F)	24ºC (75ºF)	28°C (82ºF)
Autoignition Temperature	345°C (653°F)	406ºC (763ºF)	415ºC (779ºF)
Flammability Limits			
Lower Limit, (% by volume)	1.4	1.7	1.2
Upper Limit, (% by volume)	11.2	9.8	10.9

[A] References: International Chemical Safety Card; NIOSH Pocket Guide to Chemical Hazards; IPCS Environmental Health Criteria 65: Butanols: four isomers; IPCS Health and Safety Guide

SUMMARY OF CHANGES

Subcommittee D02.A0 has identified the location of selected changes to this standard since the last issue (D7862 – 15) that may impact the use of this standard. (Approved Oct. 1, 2015.)

(1) Revised subsection 5.1; added new Note 3 and Note 4. *(2)* Added new subsection X1.1.4.1.

Subcommittee D02.A0 has identified the location of selected changes to this standard since the last issue (D7862 – 13) that may impact the use of this standard. (Approved March 1, 2015.)

(1) Added Test Method D7875 to Referenced Documents.
(2) Deleted former Annex A1 and replaced all references to Annex A1 with references to Test Method D7875.