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Standard Test Method for Determination of the Fatty Acid Methyl Esters Content of Aviation Turbine Fuel Using Flow Analysis by Fourier Transform Infrared Spectroscopy—Rapid Screening Method^{1,2}

This standard is issued under the fixed designation D7797; 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 test method specifies a rapid screening method using flow analysis by Fourier transform infrared (FA-FTIR) spectroscopy with partial least squares (PLS-1) processing for the determination of the fatty acid methyl ester (FAME) content of aviation turbine fuel (AVTUR), in the range of 10 mg/kg to 150 mg/kg.

NOTE 1—Specifications falling within the scope of this test method are: Specification **D1655** and Defence Standard 91-91.

NOTE 2—This test method detects all FAME components, with peak IR absorbance at approximately 1749 cm⁻¹ and C₈ to C₂₂ molecules, as specified in standards such as Specification **D6751** and EN 14214. The accuracy of the method is based on the molecular weight of C₁₆ to C₁₈ FAME species; the presence of other FAME species with different molecular weights could affect the accuracy.

NOTE 3—Additives such as antistatic agents, antioxidants and corrosion inhibitors are measured with the FAME by the FTIR spectrometer. However the effects of these additives are removed by the flow analysis processing.

NOTE 4—FAME concentrations from 150 mg/kg to 500 mg/kg, and below 10 mg/kg can be measured but the precision could be affected.

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

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

¹ This test method is under the jurisdiction of ASTM International Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of ASTM Subcommittee D02.J0.05 on Fuel Cleanliness. The technically equivalent standard as referenced is under the jurisdiction of the Energy Institute Subcommittee SC-G-4.

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² This test method has been developed through the cooperative effort between ASTM and the Energy Institute, London. ASTM and IP standards were approved by ASTM and EI technical committees as being technically equivalent but that does not imply both standards are identical.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:³

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D1655 Specification for Aviation Turbine Fuels

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

D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products

D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products, Liquid Fuels, and Lubricants

D6751 Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels

E1655 Practices for Infrared Multivariate Quantitative Analysis

2.2 CEN Standards:⁴

EN 14214 Specification Automotive Fuels—Fatty Acid Methyl Esters (FAME) for Diesel Engines—Requirements and Test Methods

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.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

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

2.3 Energy Institute Standards:⁵

IP 583 Test Method for Determination of the Fatty Acid Methyl Esters Content of Aviation Turbine Fuel Using Flow Analysis by Fourier Transform Infrared Spectroscopy—Rapid Screening Method

2.4 Other Standards:⁶

Defence Standard 91-91 Issue 7 (DERD 2494) Turbine Fuel, Aviation Kerosine Type, Jet A1

2.5 ASTM Adjuncts:⁷

ADJD6300 (D2PP) Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this test method, refer to Terminology **D4175**.

3.1.2 **FAME**, *n*—Fatty acid methyl esters, also known as biodiesel.

3.1.2.1 *Discussion*—Used as a component in automotive diesel fuel and the potential source of contamination in aviation turbine fuel due to multi-fuel tankers and pipelines.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 **FA-FTIR**, *n*—flow analysis by Fourier Transform Infrared technique uses a flow-through measurement cell to make a number of measurements on a stream of test specimen.

3.2.1.1 *Discussion*—The test specimen is analyzed before and after passing through a sorbent that is designed to retard the FAME contamination to be measured. The results are compared to enable the amount of FAME present in the aviation fuel to be determined.

3.2.2 **sorbent cartridge**, *n*—a cartridge, through which the test specimen flows, containing a specific sorbent

3.2.2.1 *Discussion*—The sorbent cartridge is discarded after each test.

4. Summary of Test Method

4.1 A test specimen of aviation turbine (AVTUR) fuel is automatically analyzed, by an FTIR spectrometer, in a 2 mm effective path length flow-through cell, before and after flowing through a cartridge containing a sorbent designed to have a relatively long residence time for FAME. The spectroscopic absorbance differences of the IR spectra, between the measurements, are processed in conjunction with a PLS-1 model to determine the presence and amplitude of the carbonyl peak of FAME at approximately 1749 cm⁻¹. Test time is typically 20 min. The flow analysis by FTIR enables the FAME IR peak to be resolved from the bulk IR properties of the fuel.

5. Significance and Use

5.1 The present and growing international governmental requirements to add fatty acid methyl esters (FAME) to diesel fuel has had the unintended side-effect of leading to potential

FAME contamination of jet turbine fuel in multifuel transport facilities such as cargo tankers and pipelines, and industry wide concerns.

5.2 Analytical methods have been developed with the capability of measuring down to <5 mg/kg levels of FAME, however these are complex, and require specialized personnel and laboratory facilities. This Rapid Screening method has been developed for use in the supply chain by non specialized personnel to cover the range of 10 mg/kg to 150 mg/kg.

6. Interferences

6.1 Chemical compounds, which can arise during production, storage, distribution or sampling, containing carbonyl groups, whose spectral absorbances appear in the IR spectrum close to 1749 cm⁻¹, can affect the reading. Plasticizers: bis (2-ethyl hexyl) adipate; dibutyl-sebacate are known to increase measurement readings obtained by this test method.

NOTE 5—In a limited study, bis (2-ethyl hexyl) adipate at a concentration of 30 mg/kg in aviation fuel gave an increased reading of 15 mg/kg, and dibutyl-sebacate at 50 mg/L gave an increased reading of 20 mg/kg.

7. Apparatus

7.1 Automatically controlled, closely integrated, instrument comprising FTIR spectrometer with a 2 mm effective optical path length flow-through cell, computer controlled pump, sorbent cartridge holder, control and interface electronics, test specimen and waste containers, and solenoid valves.

7.2 The processing computer can be integrated into the instrument.

7.3 This apparatus and the required sorbent cartridge are described in more detail in **Annex A1**.

7.4 *Density Measuring Device (optional)*—According to Test Methods **D1298**, or **D4052**, or equivalent national standards, to determine the density of the aviation fuel test sample if required.

8. Reagents and Materials

8.1 *Cleaning Solvent*, heptane, reagent grade.

8.2 *Verification Fluids*:⁸

8.2.1 *100 mg/kg*, containing 100 mg/kg ± 10 mg/kg of FAME, with a certified value and uncertainty.

8.2.2 *30 mg/kg*, containing 30 mg/kg ± 5 mg/kg of FAME, with a certified value and uncertainty.

8.3 *Calibration Fluids*:⁸

8.3.1 *Set of Five Fluids*, containing amounts of FAME with certified values and uncertainty.

8.4 *Lint-free Cloth*, for cleaning and drying the sample input tube.

9. Sampling

9.1 Unless otherwise specified, take a sample of at least 60 mL in accordance with Practices **D4057** or **D4177** or in

⁵ Available from the Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K., <http://www.energyinst.org.uk>.

⁶ Available from Procurement Executive DF5 (air), Ministry of Defence, www.dstan.mod.uk.

⁷ ADJD6300 is no longer available from ASTM International Headquarters.

⁸ The following reagents and materials were used to develop the precision statements: Seta Verification and Calibration fluids for Seta FIJI, Stanhope-Seta, Chertsey, Surrey, KT16 8AP, UK. This is not an endorsement or certification by ASTM.