National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2773

B100 Biodiesel (Animal-Based)

This Standard Reference Material (SRM) is a commercial 100 % biodiesel produced from animal feedstocks. SRM 2773 is intended for use in evaluating analytical methods for the determination of selected chemical and physical properties in pure biodiesel (B100). A unit of SRM 2773 consists of five 10-mL ampoules, each containing approximately 10 mL of biodiesel.

The development of SRM 2773 was a collaboration between the National Institute of Standards and Technology (NIST), USA and the National Institute of Metrology, Standardization, and Industrial Quality (INMETRO), Brazil.

Certified Values: Certified mass fraction values for thirteen fatty acid methyl esters, water, and sulfur are provided in Tables 1, 2, and 3, respectively. A certified value for density at 20 °C and kinematic viscosity at 20 °C, 30 °C, and 40 °C are provided in Table 4. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [1]. The certified values are based on the agreement of results obtained at NIST using one or more analytical techniques and additional results from INMETRO and Cannon Instrument Company (State College, PA) using different analytical techniques.

Reference Values: Reference mass fraction values for five fatty acid methyl esters are provided in Table 5. Reference values for additional chemical and physical properties are provided in Tables 6 and 7. Reference values are noncertified values that are estimates of the true value; however, the values do not meet the NIST criteria for certification and are provided with associated uncertainties that may reflect only measurement precision, may not include all sources of uncertainty, or may reflect a lack of sufficient statistical agreement among multiple analytical methods [1].

Information Values: Information mass fraction values for trace elements, glycerides, and ethanol are provided in Table 8. Information values for a number of physical and chemical properties of the material measured as part of an ASTM Biodiesel Crosscheck Program are provided in Appendix A. An information value is considered to be a value that will be of interest to the SRM user, but insufficient information is available to assess the uncertainty associated with the value or only a limited number of analyses were performed [1].

Expiration of Certification: The certification of **SRM 2773** is valid, within the measurement uncertainty specified, until **28 February 2016**, provided the SRM is handled in accordance with instructions given in this certificate (see "Instructions for Handling, Use, and Storage"). The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

The overall direction and coordination of technical measurements leading to certification were performed by M.M. Schantz, S.A. Wise, and W.E. May of the NIST Material Measurement Laboratory.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division. The acquisition and ASTM testing of the biodiesel material used for this SRM were coordinated by B.S. MacDonald of the NIST Measurement Services Division.

Statistical consultation for this SRM was provided by S.D. Leigh of the NIST Statistical Engineering Division.

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Certificate Issue Date: 28 September 2011

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Analytical measurements at NIST were performed by W.R. Kelly, J.L. Mann, L. Samuel (guest researcher from Measurements Standards Laboratory of New Zealand), M.M. Schantz, L.J. Wood, and R.D. Vocke, Jr. of the NIST Analytical Chemistry Division; B.E. Lang of the NIST Biochemical Science Division; and T. Fortin and A. Laesecke of the NIST Thermophysical Properties Division. Analytical measurements at INMETRO were performed by M.A. Gonçalves, S.P. Sobral, J.J.P. dos Santos, Jr., C.R.C. Rodrigues, F.B. Gonzaga, J.M. Rodrigues, G.F. da Cruz, and L.V.F. Gonçalves, and the measurements were coordinated by V.S. Cunha and R.J. Daroda. Cannon Instrument Company provided data for the kinematic viscosity at 40 °C.

INSTRUCTIONS FOR HANDLING, STORAGE, AND USE

Handling: This material should be handled with care. Use proper disposal methods.

Storage: Sealed ampoules, as received, should be stored in the dark at temperatures lower than 30 °C.

Use: Sample aliquots for analysis should be withdrawn at 20 °C to 25 °C **immediately** after opening the ampoules and should be processed without delay for the certified values to be valid within the stated uncertainties. Transfer of material from the ampoule should be performed with maximum care so as not to contaminate the SRM.

PREPARATION AND ANALYSIS[1]

Source of Material: The animal-based biodiesel for SRM 2773 was obtained from Smithfield BioEnergy LLC, Cleburne, TX. This biodiesel consists of approximately 85 % animal fat (70 % choice white grease and 15 % edible pork lard) and 15 % soy oil. The animal fat sources are approximately 50 % to 60 % pork, 20 % beef, and 10 % to 20 % poultry.

Preparation of Material: The 55- gallon drum of material remained sealed until the material was ampouled. A 10 mL aliquot of the animal-based biodiesel was dispensed into each 10 mL amber ampoule, which had been evacuated with argon and was then flame-sealed.

Analytical Methods Used at NIST:

Fatty Acid Methyl Esters: Fatty acid methyl esters were measured by using combinations of two gas chromatographic (GC) methods with flame ionization detection (FID) or mass spectrometric (MS) detection. Two aliquots (0.5 mL, exact mass known) from each of twelve ampoules of SRM 2773 were chosen using a stratified random sampling scheme. These test portions were combined with approximately 75 mL iso-octane in 150 mL amber bottles with Teflon-lined caps. To each bottle, 1 mL of the internal standard solution, consisting of tridecanoic acid methyl ester and octacosanoic acid methyl ester in chloroform, was gravimetrically added using a gas-tight syringe. GC-FID analysis was performed using a 0.25 mm × 100 m SP2560 (nonbonded; biscyanopropyl polysiloxane) fused silica capillary column (Supelco, Bellefonte, PA), 0.25 µm film thickness. GC/MS was performed using a 0.25 mm × 60 m DB-23 (50 % cyanopropyl + 50 % phenylpolysiloxane, mole fraction) fused silica capillary column (Agilent Technologies, Wilmington, DE), 0.25 µm film thickness. The MS was operated in the scan mode (from 70 u to 400 u). Average response factors relative to the internal standards were calculated from independently prepared calibration solutions.

Water: Water was determined using a volumetric Karl Fischer technique. Just prior to analysis, the sample ampoules were opened, and immediately 2 mL to 3 mL of the biodiesel was aliquoted into dry 6 mL glass headspace vials. The solvent for the analysis was anhydrous methanol, and the Karl Fischer reagent was one-part Hydranal Composite 2. The samples vials were inserted into the Karl Fischer oven that was maintained at 140 °C to release the moisture from the samples. The resulting water vapor was transferred into the Karl Fischer titration cell using dry nitrogen as the carrier gas, flowing at a rate of 40 mL/min. All titrations were run for a set length of time rather than by electrochemical potential of the cell alone (generally 30 min for the calibration runs and 50 min for the samples run in the oven).

Density, Viscosity, and Speed of Sound: A density and sound speed analyzer was used to measure these two properties in the temperature range from 70 °C to 10 °C, and a viscodensimeter was used for the viscosity measurements and additional density measurements in the range from 100 °C to 10 °C.

[1] Certain commercial equipment, instruments, or materials are identified in this report to specify adequately the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Methanol and Ethanol: For analysis, 2.5 g (exact mass known) of the calibrant or biodiesel sample was mixed with 2.5 g of the internal standard solution, containing methanol-d_4 in water, in a 10 mL amber vial sealed with an open cap and Teflon-lined septum. The samples were heated at 70 °C for 5 min. A 5 min headspace solid-phase microextraction (SPME) sampling was performed by exposing the 100 µm polydimethylsiloxane fiber near the surface of the solution. GC/MS analysis was performed using a 0.32 mm × 15 m HP-Plot Q fused silica capillary column (Agilent Technologies), 20 µm film thickness. The SPME fiber was exposed in the injection port (220 °C) for 1 min. The split valve was closed for this 1 min and then opened to 20 mL/min. Ions 31 u, 35 u, and 45 u were monitored. Average response factors relative to the internal standards were calculated from independently prepared calibration solutions.

Glycerides: The derivatization procedure used for the glycerides in SRM 2773 was similar to that reported by Plank and Lorbeer [2]. One aliquot (0.2 g, exact mass known) was taken from each of six ampoules of SRM 2773 that were chosen using a stratified random sampling scheme. These test portions were combined with approximately 1 mL pyridine in 22 mL amber vials with Teflon-lined caps. To each vial, 0.25 mL of the internal standard solution, consisting of butanetriol and tricaprin in pyridine, was gravimetrically added using a gas-tight syringe. N-methyl-N-(trimethylsilyl)trifluoroacetamide (250 µL) was then added to each vial followed by vortexing. The solutions were allowed to sit at room temperature for 30 min and then 10 mL of heptane was added prior to GC-FID analysis. GC-FID analysis was performed using a 0.32 mm ID × 10 m MXT-Biodiesel TG capillary column with a 2 m × 0.53 mm ID guard column (Restek Corporation, Bellefonte, PA). All injections were performed on-column (1 µL) with helium as a carrier gas. Average response factors relative to the internal standards were calculated from independently prepared calibration solutions.

Sulfur: The certified mass fraction value for sulfur is based on a single NIST primary method, isotope dilution thermal ionization mass spectrometry (ID-TIMS) [3]. Approximately 300 mg samples were added to Carius tubes followed by the addition of an accurate quantity of ^{34}S spike. High-purity nitric acid was used for the digestion. High-purity hydrochloric acid was used for conversion to the chloride form. All samples were processed through a reduction procedure within 24 h of preparation. Mass spectrometric analyses were performed using a NIST-designed thermal ionization mass spectrometer.

Additional Trace Elements: Trace elements other than sulfur were determined using inductively coupled plasma optical emission spectrometry (ICP-OES). Aliquots of 2 g were taken from each of x ampoules and placed in tall quartz beakers with HNO_3. Indium was added to each sample solution as an internal standard to improve the precision of the instrumental measurements. The samples were heated on a hot plate with surface temperature of 100 °C and swirled continuously until an exothermic reaction occurred. At this point 4 mL of $HClO_4$ was added, and the samples were covered and heated overnight on a hot plate with surface temperature of 150 °C. The temperature was increased to 210 °C. Frequent additions of HNO_3 were needed to complete the digestion. Samples were eventually reduced to near dryness. Approximately 10 mL of 1.5 % HNO_3 (volume fraction) was added to each beaker, and the solutions were heated until clear. After complete digestion, the samples were removed from the hot plate, cooled, and then transferred to polyethylene bottles. The solutions were diluted to 25 g with 1.5 % HNO_3. To determine calcium, iron, magnesium, and sodium, two 10 g aliquots were taken from the original solutions and transferred to weighed 30 mL polyethylene bottles. A spike containing calcium, iron, magnesium, and sodium was added to one of the aliquots for each sample. Analyte concentrations were calculated by the method of standard additions to compensate for any matrix effects. To determine copper, phosphorous and potassium, a calibration curve was used to calibrate the instrument.

Analytical Methods Used at INMETRO:

Fatty Acid Methyl Esters: Fatty acids methyl ester concentrations were determined by GC/MS using a 0.32 mm × 30 m, 0.25 µm film thickness, CP WAX 52 CB fused silica capillary column (chemically bonded polyethylene glycol, Varian, Walnut Creek, CA). The MS was operated in the scan mode (from 50 u to 400 u). This GC/MS method permits the determination of fatty acid methyl esters with carbon chains from C8 to C24. An aliquot of 250 mg of ampouled animal-based biodiesel was dissolved in 5 mL of *n*-heptane for analysis.

Water: Water was determined using a coulometric Karl Fischer technique with Hydranal Coulomat AG as the reagent. The ampoules of animal-based biodiesel were opened and 2 g was aliquoted into a glass tube which was sealed immediately for analysis. The sealed vials were inserted into a Karl Fischer oven maintained at 170 °C. Dry nitrogen at 150 mL/min was used as the carrier gas. The time for water extraction was fixed at 300 s with measurements every 2 s.

Glycerides: The glycerides were determined using GC-FID in accordance with ASTM D6584-07 [4]. The results were used for confirmation of the assigned values.

Trace Elements: Sodium and potassium were determined using flame atomic absorption spectroscopy, and calcium, magnesium, and phosphorous were determined using ICP-OES.

Acid Number: Potentiometric titration was used based on ASTM D664 [4] and ABNT NBR 14448 [5]. Because these methods are specific for petroleum products, the solvent was changed to anhydrous ethanol and the electrode was changed from LiCl to KCl. The biodiesel samples were dissolved in anhydrous ethanol (99.8 %) and were titrated, in duplicate, with an ethanolic solution of KOH at a concentration of 0.01 mol/L. A combined Ph electrode (Ag/AgCl) with KCl internal electrolyte was used to detect the end point. This method was validated by comparing the results with those obtained using the standard method ASTM D664 [4].

Density: Density was determined using methods ABNT NBR 14065 [5] and ASTM D4052 [4].

Oxidation Stability of Fatty Acid Methyl Esters at 110 ºC: EN14112 [6] was followed for the determination of the oxidation stability of the fatty acid methyl esters.

Viscosity: Viscosity was determined using methods ABNT NBR 10441 [5] and ASTM D446 (ISO 3105) [4].

Gross Heating Value: Gross heating value was determined using ASTM D4809-06 [4].

Methods Used at Cannon Instrument Company for Viscosity: ASTM D445 [4] was used for the viscosity measurements on two instruments, a Cannon-Ubbelohde glass capillary viscometer and a Cannon miniAV-X automated viscometer.

Additional Testing on the Same Lot of Biodiesel as Used to Prepare SRM 2773: Two drums of the same animal-based biodiesel as used to prepare SRM 2773 were used in an ASTM Biodiesel Crosscheck Program (ID BIOD0704) [7]. The crosscheck samples were distributed in one-gallon metal cans with screw caps. The data summarized in the ASTM report is attached as Appendix A. The ASTM and EN methods are listed in Appendix B. Because the material used for the cross check is from the same lot as that ampouled for SRM 2773, these data should be applicable to SRM 2773, except potentially for acid number and oxidation stability, which may change with storage conditions. These data are provided as information values only.

Homogeneity Assessment: The homogeneity of the fatty acid methyl esters was assessed at NIST by using GC-FID. An analysis of variance did not indicate inhomogeneity for a 0.5 g sample. Other analytes were treated as though they were homogeneously distributed in the material although homogeneity was not assessed.

Table 1. Certified Mass Fraction Values for Fatty Acid Methyl Esters in SRM 2773

	Mass Fraction (g/kg)
Dodecanoic Acid, Methyl Ester (C12:0) (Lauric Acid, Methyl Ester)	0.470 ± 0.017[a]
Tetradecanoic Acid, Methyl Ester (C14:0) (MyristicAcid, Methyl Ester)	9.20 ± 0.45[a]
Pentadecanoic Acid, Methyl Ester (C15:0)	0.305 ± 0.013[b]
Hexadecanoic Acid, Methyl Ester (C16:0) (Palmitic Acid, Methyl Ester)	184 ± 6[a]
(Z)-9-Hexadecenoic Acid, Methyl Ester (C16:1 n-7) (Palmitoleic Acid, Methyl Ester)	23.3 ± 0.9[b]
Octadecanoic Acid, Methyl Ester (C18:0) (Stearic Acid, Methyl Ester)	87.8 ± 4.2[b]
(Z)-9-Octadecenoic Acid, Methyl Ester (C18:1 n-9) (Oleic Acid, Methyl Ester)	343 ± 8[a]
(Z)-11-Octadecenoic Acid, Methyl Ester (C18:1 n-7) (Vaccenic Acid, Methyl Ester)	19.4 ± 0.7[b]
(Z,Z)-9,12-Octadecadienoic Acid, Methyl Ester (C18:2 n-6) (Linoleic Acid, Methyl Ester)	226 ± 5[b]
(Z,Z,Z)-9,12,15-Octadecatrienoic Acid, Methyl Ester (C18:3 n-3) (Linolenic Acid, Methyl Ester)	25.0 ± 1.0[b]
Eicosanoic Acid, Methyl Ester (C20:0) (Arachidic Acid, Methyl Ester)	2.28 ± 0.12[b]
(Z)-5,8,11,14-Eicosatetraenoic Acid, Methyl Ester (C20:4 n-6) (Arachidonic Acid, Methyl Ester)	2.53 ± 0.09[a]
Docosanoic Acid, Methyl Ester (C22:0) (Behenic Acid, Methyl Ester)	1.66 ± 0.06[a]

[a] Certified values are unweighted means of the results from three to four analytical methods at NIST with confirmatory data from INMETRO. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor $k = 2$, calculated by combining a between-method variance [8] with a pooled, within-method variance following the ISO Guide [9].

[b] Certified values are unweighted means of the results from three to four analytical methods at NIST with confirmatory data from INMETRO. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor $k = 3$, calculated by combining a between-method variance [8] with a pooled, within-method variance following the ISO Guide [9].

Table 2. Certified Mass Fraction Value for Water in SRM 2773

	Mass Fraction[a] (%)
Water	0.046 ± 0.002

[a] The certified value is the unweighted mean of the results from two analytical methods at NIST and INMETRO. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor $k = 2$, calculated by combining a between-method variance [8] with a pooled, within-method variance following the ISO Guide [9].

Table 3. Certified Mass Fraction Value for Sulfur in SRM 2773

	Mass Fraction[a] (mg/kg)
Sulfur	7.39 ± 0.39

[a] The certified value for sulfur is based on a single NIST primary method, isotope dilution thermal ionization mass spectrometry (ID-TIMS). The uncertainty in the certified value for sulfur is expressed as an expanded uncertainty with coverage factor $k = 2$ and is calculated according to the method described in the ISO Guide [9].

Table 4. Certified Value for Density at 20 °C and Kinematic Viscosity at 20 °C, 30 °C, and 40 °C of SRM 2773

	Value			
Density at 20 °C[(a)]	0.87628	±	0.00010	g/cm^3
Kinematic Viscosity at 20 °C[(b)]	7.147	±	0.021	mm^2/s
Kinematic Viscosity at 30 °C[(b)]	5.543	±	0.010	mm^2/s
Kinematic Viscosity at 40 °C[(c)]	4.428	±	0.009	mm^2/s

[(a)] The certified value is the unweighted mean of the results from three analytical methods, two at NIST and one at INMETRO. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor $k = 2$, calculated by combining a between-method variance [8] with a pooled, within-method variance following the ISO Guide [9].

[(b)] The certified value is the unweighted mean of the results from two analytical methods at NIST and INMETRO. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor $k = 2$, calculated by combining a between-method variance [8] with a pooled, within-method variance following the ISO Guide [9].

[(c)] The certified value is the unweighted mean of the results from three analytical methods at NIST, INMETRO, and Cannon Instrument Company. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor $k = 2$, calculated by combining a between-method variance [8] with a pooled, within-method variance following the ISO Guide [9].

Table 5. Reference Mass Fraction Values for Fatty Acid Methyl Esters in SRM 2773

	Mass Fraction[(a)] (g/kg)
Decanoic Acid, Methyl Ester (C10:0) (Capric Acid, Methyl Ester)	0.20 ± 0.03
(E)-11-Octadecenoic Acid, Methyl Ester (tC18:1 n-7) (*trans*-Vaccenic Acid, Methyl Ester)	0.78 ± 0.08
Nonadecanoic Acid, Methyl Ester (C19:0)	0.42 ± 0.05
Heneicosanoic Acid, Methyl Ester (C21:0)	0.077 ± 0.008
Tricosanoic Acid, Methyl Ester (C23:0)	0.13 ± 0.01

[(a)] The reference values are the means of results from one analytical technique at NIST. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution corresponding to the associated degrees of freedom (5) and a 95 % confidence level for each analyte.

Table 6. Reference Values for Additional Chemical and Physical Properties of SRM 2773

	Value[(a)]			Units	*t-value*
Acid Number[(b)]	0.201	±	0.007	mg/g	2.14
Diolein and Diolinolein[(c)]	1030	±	23	mg/kg	2.57
Free Glycerin[(c)]	12.1	±	0.6	mg/kg	2.57
Gross Heating Value[(b)]	39660	±	17	J/g	2.36
Methanol[(c)]	401	±	34	mg/kg	2.36
Monolein, Monolinolein, and Monolinolenin[(c)]	2668	±	14	mg/kg	2.57
Monopalmitin[(c)]	141	±	3	mg/kg	2.57
Oxidation Stability of Fatty Acid Methyl Esters at 110 °C[(b)]	4.46	±	0.04	h	2.36
Triolein[(c)]	495	±	38	mg/kg	2.57
Tripalmitin[(c)]	91.2	±	3.4	mg/kg	2.57

[(a)] The reference values are the means of results using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution corresponding to the associated degrees of freedom and a 95 % confidence level for each analyte.

[(b)] Based on measurements at INMETRO (milligrams of KOH per gram).

[(c)] Based on measurements at NIST.

Table 7. Reference Values[a,b] as a Function of Temperature for Density, Kinematic Viscosity, and Speed of Sound of SRM 2773

Temperature (°C)	Density (g/cm^3)	Kinematic Viscosity (mm^2/s)	Speed of Sound (m/s)
10	0.8836 ± 0.0001	9.607 ± 0.005	1444.6 ± 0.3
15	0.8799 ± 0.0001	8.254 ± 0.004	1426.1 ± 0.3
20[c]			1407.8 ± 0.3
25	0.8726 ± 0.0001	6.281 ± 0.002	1389.7 ± 0.3
30[c]	0.8689 ± 0.0001		1371.8 ± 0.3
35	0.8653 ± 0.0001	4.946 ± 0.002	1354.1 ± 0.3
40[c]	0.8616 ± 0.0001		1336.6 ± 0.3
45	0.8580 ± 0.0001	4.007 ± 0.001	1319.2 ± 0.4
50	0.8543 ± 0.0001	3.639 ± 0.001	1302.0 ± 0.4
55	0.8507 ± 0.0001	3.323 ± 0.001	1285.0 ± 0.5
60	0.8471 ± 0.0001	3.048 ± 0.001	1268.1 ± 0.5
65	0.8434 ± 0.0001	2.809 ± 0.001	1251.4 ± 0.5
70	0.8398 ± 0.0001	2.598 ± 0.001	1234.8 ± 0.4
75	0.8362 ± 0.0001	2.412 ± 0.001	
80	0.8326 ± 0.0001	2.247 ± 0.001	
85	0.8289 ± 0.0001	2.098 ± 0.001	
90	0.8253 ± 0.0001	1.965 ± 0.001	
95	0.8216 ± 0.0001	1.845 ± 0.001	
100	0.8180 ± 0.0001	1.735 ± 0.001	

[a] The reference values are the means of results obtained using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution corresponding to the associated degrees of freedom and a 95 % confidence level for each analyte (t-*value* = 2.78).

[b] Based on measurements at NIST.

[c] See Table 4.

Table 8. Information Mass Fraction Values for Trace Elements, Glycerides, and Ethanol in SRM 2773

	Mass Fraction (mg/kg)
Calcium[a]	0.1
Copper[b]	<0.2[c]
Diglycerides[b]	2970
Ethanol[b]	<5[c]
Iron[b]	<0.2[c]
Magnesium[a]	0.05
Monoglycerides[b]	4110
Phosphorous[a,b]	<0.4[c]
Potassium[a,b]	<0.1[c]
Sodium[a]	0.9
Total Glycerin[b]	1660
Triglycerides[b]	1350

[a] Based on measurements at INMETRO.
[b] Based on measurements at NIST.
[c] The method detection limits were estimated by taking three times the standard deviation of the ten or more blanks that were run along with the samples.

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[3] Kelly, W.R.; Paulsen, P.J.; Murphy, K.E.; Vocke, R.D.; Chen, L.-T.; *Determination of Sulfur in Fossil Fuels by Isotope Dilution Thermal Ionization Mass Spectrometry*; Anal. Chem., Vol. 66, pp. 2505–2513 (1994).

[2] Plank, C.; Lorbeer, E.; *Simultaneous Determination of Glycerol, and Mono-, Di-, and Triglicerides in Vegetable Oil Methyl Esters by Capillary Gas Chromatography*; J. Chromatogr. A, Vol. 697, pp. 461–468 (1995).

[4] ASTM D6584 Standard Test Method for Determination of Free and Total Glycerin in B-100 Biodiesel Methyl Esters By Gas Chromatography; ASTM D664 Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration; ASTM D4052 Standard Test Method for Density and Relative Density of Liquids by Digital Density Meter; ASTM D446 Standard Specifications and Operating Instructions for Glass Capillary Kinematic Viscometers; ASTM D4809 Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method); ASTM D445 Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity), available at http://www.astm.org (accessed Sep 2011).

[5] ABNT NBR 14448 Acid Number; ABNT NBR 14065 Density; ABNT NBR 10441 Kinematic Viscosity, available at http://www.abnt.org.br (accessed Sep 2011).

[6] EN 14112 Fat and oil derivatives - Fatty Acid Methyl Esters (FAME) - Determination of oxidation stability (accelerated oxidation test), available at http://www.cen.eu/ (accessed Sep 2011).

[7] Information on the ASTM Crosscheck Program available at http://www.astm.org/ (accessed Sep 2011).

[8] Levenson, M.S.; Banks, D.L.; Eberhardt, K.R.; Gill, L.M.; Guthrie, W.F.; Liu, H.K.; Vangel, M.G.; Yen, J.H.; Zhang, N.F.; *An Approach to Combining Results from Multiple Methods Motivated by the ISO GUM*; J. Res. Natl. Inst. Stand. Technol., Vol. 105, pp. 571–579 (2000).

[9] JCGM 100:2008; *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement* (ISO GUM 1995 with Minor Corrections); Joint Committee for Guides in Metrology (2008); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf (accessed Sep 2011); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297; U.S. Government Printing Office: Washington, DC (1994); available at http://physics.nist.gov/Pubs/ (accessed Sep 2011).

Certificate Revision History: 28 September 2011 (Addition of *t-values*; editorial changes); **04 December 2009** (Original certificate issue date).

Users of this SRM should ensure that the Certificate of Analysis in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.

APPENDIX A

The following data are from the ASTM Committee D-2 Interlaboratory Crosscheck Program, Sample ID BIOD0704, April 2007. This sample was from the same lot of biodiesel as ampouled for SRM 2773. These data are provided to demonstrate user experience with this material using conventional methods and to better characterize the matrix. These results should be used for information only.

Method	Description	Robust mean	Robust Std Dev	No. of Labs
D1160 Automatic	Distillation – IBP	255 °C	30 °C	9
D1160 Manual	Distillation – IBP	262 °C	41 °C	15
D1160 Automatic	Distillation – 5 %	337 °C	5 °C	9
D1160 Manual	Distillation – 5 %	340 °C	9 °C	13
D1160 Automatic	Distillation – 10 %	342 °C	2 °C	9
D1160 Manual	Distillation – 10 %	346 °C	5 °C	11
D1160 Automatic	Distillation – 20 %	344 °C	2 °C	9
D1160 Manual	Distillation – 20 %	348 °C	4 °C	11
D1160 Automatic	Distillation – 30 %	345 °C	2 °C	9
D1160 Manual	Distillation – 30 %	350 °C	4 °C	11
D1160 Automatic	Distillation – 40 %	346 °C	2 °C	9
D1160 Manual	Distillation – 40 %	351 °C	4 °C	11
D1160 Automatic	Distillation – 50 %	347 °C	2 °C	9
D1160 Manual	Distillation – 50 %	353 °C	4 °C	11
D1160 Automatic	Distillation – 60 %	348 °C	2 °C	9
D1160 Manual	Distillation – 60 %	354 °C	4 °C	11
D1160 Automatic	Distillation – 70 %	350 °C	2 °C	9
D1160 Manual	Distillation – 70 %	355 °C	4 °C	11
D1160 Automatic	Distillation – 80 %	351 °C	2 °C	9
D1160 Manual	Distillation – 80 %	356 °C	4 °C	11
D1160 Automatic	Distillation – 90 %	353 °C	2 °C	9
D1160 Manual	Distillation – 90 %	358 °C	4 °C	11
D1160 Automatic	Distillation – 95 %	356 °C	3 °C	9
D1160 Manual	Distillation – 95 %	360 °C	7 °C	12
D1160 Automatic	Distillation - FBP	385 °C	31 °C	8
D1160 Manual	Distillation – FBP	378 °C	21 °C	13
D2500	Cloud Point	8.4 °C	1.7 °C	44
D5771	Cloud Point	8.06 °C	0.58 °C	6
D5773	Cloud Point	8.08 °C	0.99 °C	19
D3828 Procedure B	Flash Point	160 °C	3 °C	5
D93 Procedure B	Flash Point	154 °C	6 °C	57
D445 at 40 °C	Kinematic Viscosity	4.407 mm^2/s	0.042 mm^2/s	51
D4530[(a)]	Carbon Residue, Micro Method	0.010 %	0.010 mass %	31
D524[(a)]	Carbon Residue, Ramsbottom	0.113 %	0.114 mass %	6
D482[(b)]	Ash	0.0007 %	0.0007 mass %	24
D5453	Sulfur	7.53 mg/kg	1.63 mg/kg	44
D6079	Lubricity by HFRR	0.205 mm	0.040 mm	26
D6217	Total Particulate Contamination	9.23 mg/L	4.35 mg/L	16
D6304 Procedure A	Water by Karl Fischer	0.0557 %	0.0052 %	43
D6371	Cold Filter Plugging Point	4.3 °C	1.8 °C	26
D664 Automatic	Acid Number	0.173 mg/g	0.026 mg/g	43
D664 Manual	Acid Number	0.173 mg/g	0.024 mg/g	7
D974	Acid Number	0.186 mg/g	0.038 mg/g	20
D6584[(a)]	Free Glycerin	0.0052 %	0.0032 %	40
D6584[(a)]	Total Glycerin	0.146 %	0.040 %	47
D6468	Thermal Stability (90 min)	96.9	3.5	13
EN 14110[(a)]	FAME: Methanol Content A	0.014 %	0.011 %	7
EN 14110[(a)]	FAME: Methanol Content B	0.018 %	0.007 %	10
EN 14538	FAME: Ca, Mg by ICP/OES	0.34 mg/kg	0.27 mg/kg	23
EN 14538	FAME: Mg, K by ICP/OES	1.05 mg/kg	1.02 mg/kg	23
EN 14112	FAME: Oxidation Stability at 110 °C	3.77 h	0.47 h	30

[(a)] Mass percentage.
[(b)] Method D482 is applicable for mass fractions of ash in the range of 0.001% to 0.180 %.

APPENDIX B

List of ASTM and EN methods
(The ASTM standards can be ordered at www.astm.org while the EN methods are available at www.cen.eu/cenorm)

D1160	Test Method for Distillation of Petroleum Products at Reduced Pressure
D2500	Test Method for Cloud Point of Petroleum Products
D5771	Test Method for Cloud Point of Petroleum Products (Optical Detection Stepped Cooling Method)
D5773	Test Method for Cloud Point of Petroleum Products (Constant Cooling Rate Method)
D3828	Test Methods for Flash Point by Small Scale Closed Cup Tester
D93	Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D445	Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)
D4530	Test Method for Determination of Carbon Residue (Micro Method)
D524	Test Method for Ramsbottom Carbon Residue of Petroleum Products
D482	Test Method for Ash from Petroleum Products
D5453	Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D6079	Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR)
D6217	Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration
D6304	Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
D6371	Test Method for Cold Filter Plugging Point of Diesel and Heating Fuels
D664	Test Method for Acid Number of Petroleum Products by Potentiometric Titration
D974	Test Method for Acid and Base Number by Color-Indicator Titration
D6584	Test Method for Determination of Free and Total Glycerin in B-100 Biodiesel Methyl Esters by Gas Chromatography
D6468	Test Method for High Temperature Stability of Distillate Fuels
EN 14110	Fat and Oil Derivatives – Fatty Acid Methyl Esters (FAME) – Determination of Methanol Content
EN 14538	Fat and Oil Derivatives – Fatty Acid Methyl Esters (FAME) – Determination of Ca, K, Mg, and Na Content by Optical Emission Spectral Analysis with Inductively Coupled Plasma (ICP-OES)
EN 14112	Fat and Oil Derivatives – Fatty Acid Methyl Esters (FAME) – Determination of Oxidation Stability (Accelerated Oxidation Test)