Citywide Administrative Services

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To: Sally Renfro, Chief of Staff

From: Keith T. Kerman, Deputy Commissioner

Date: November 23, 2015

RE: Use of Biodiesel for City buildings, Local Law 107 of 2013

Attached is a report on City facility use of biodiesel as required by Local Law 107 of 2013. This report discusses the City's compliance with the use of biodiesel (B5) and also the pilot use of higher blends of biodiesel (B10 and B20).

The Local Law also calls for DCAS and the Mayor's Office of Sustainability to submit a feasibility report regarding the use of B5 for all buildings. This report was submitted in June 2015.

Thank you.

Cc: Suzanne Lynn, DCAS Counsel
Ozgem Ornektekin, Deputy Commissioner, Energy
Sherry Lee, Chief of Staff, Fleet

DCAS: REPORT ON THE USE OF BIODIESEL IN CITY BUILDINGS, LOCAL LAW 107 OF 2013

1) Summary

2) Use of Biodiesel (B5) in City Buildings

3) Pilot of Biodiesel (B10 and B20) in City Buildings

Attachments:

ASTM D396; Standard Specifications for Fuel Oils, revised in 2015

Department of Energy Fact Sheet on Biodiesel

Biodiesel use in City buildings, FY13 through FY15

1) Summary

NYC has successfully used biodiesel in fleet operations for over ten years, starting at the City Parks department and now moving to all agencies. The City uses blends of B5 and B20 and has legislated use of biodiesel in fleet units. NYC was recognized for its leadership in biodiesel implementation in fleet by the National Biodiesel Board in 2011.

Since FY13, NYC has expanded the use of biodiesel to City owned buildings and facilities. This use is often referred to as 'bio-heat'. NYC has used over 102 million gallons of biodiesel blended heating oil for buildings as of June 2015. The main fuel used has been B5, a 5% blend of biodiesel with traditional heating oil, mostly D2. B5 has been used across 1,700 fuel accounts and through difficult winter seasons. The City has experienced no operational or technical concerns. The cost difference for D2 blended biodiesel B5 was 2% or approximately 8 cents per gallon.

The City has also tested bio-heat blends of B10 and B20 over the last five years. This implementation has been led at the City Parks Department. Parks has used 1.5 million gallons of B10 and B20 since FY13. A number of other agencies have also tested B10 including Education, Environmental Protection, and Sanitation. In general, this implementation has been successful. The cost difference for D2 blended biodiesel with B10 is 8% or 13 cents per gallon and with B20 is 9% or 15 cents per gallon. Fuel costs including for biodiesel blends can vary greatly. In general, fuel costs have decreased dramatically overall since the bio-heat efforts began in FY14.

There are a few specific areas that must be monitored for higher use of bio-heat of B10 or B20. These include:

- If B10 or B20 is used with emergency generators or with tanks that are backups at natural gas sites (interruptible sites), there must be a clear maintenance program for turning over the fuel. This fuel should not sit unused for long periods.

- Biodiesel is a solvent and can dissolve debris, grime, and build up in tanks and fuel lines. Over time, this can be very positive for system functioning. However, if this type of dissolving takes place too quickly, it can cause clogged lines and maintenance problems. A transition to higher blends of biodiesel should take place over a number of years to prevent these issues.

The Federal EPA and the California Air Resources Board (CARB) both report that biodiesel achieves 50% to 80% reduction in greenhouse gases, depending on source. CARB re-asserted these findings in their Low Carbon Fuels Standard, published this September 2015.

Biodiesel qualifies as an Advanced Biofuel as part of EPA's Renewable Fuel Standard (RFS). Biodiesel must conform to ASTM 6751 and does not contain sulfur and its use reduced particulate matter, hydrocarbons, and carbon monoxide.

In early 2015, the American Society for Testing and Materials (ASTM) established performance standards for B5 through B20 in heating oil blended with D2. B5 to B20 blends with D2 heating oil are now covered by ASTM standard D396. This ASTM establishes the technical requirements for the blending of biodiesel and regular ultra-low sulfur diesel (ULSD).

2) Use of Biodiesel (B5) in City Buildings

Local Law 43 of 2010 requires all City buildings, public and private, to use at least biodiesel blends of B2 by October 1, 2012. Local Law 107 of 2013 requires all heating oil purchased by the City of New York for City owned facilities by October 1, 2014 to be at minimum biodiesel B5. B5 refers to a 5% blend of biodiesel mixed with Heating Oil Diesel #2, #4, or #6 as otherwise required by each facility.

The City is in full compliance with the Local Law 107 mandate for B5 use and achieved compliance well before the legislated timetables.

To monitor compliance, DCAS Fleet, which administers the City's Local Law requirements for biodiesel in fleet vehicles, assisted with citywide oversight of the biodiesel implementation for buildings. Among many steps taken:

- Fleet reached out to the City's vendor, Castle (now purchased by Sprague) to discuss and coordinate fuel delivery options;
- Fleet developed a contact list for fuel deliveries for all agencies;
- Fleet developed a first tracking report for heating oil deliveries by type of fuel by agency across all user agencies. See attached reports "Heating Oil Usage FY13 through FY15".

City vendors through DCAS contracts currently deliver fuel across over 1,700 separate facility and location accounts. The sites include diverse locations such as:

- Downtown office buildings
- Schools and universities
- Jails
- Recreation Centers
- Garages
- Power plants
- Hospitals
- Shelters
- Fire houses and Police precincts
- Park buildings and historic houses

These facilities have a wide variety of heating oil tanks and furnaces in terms of models and ages. The City does not currently have a citywide inventory of makes and years but creating such an inventory is one of our recommendations below.

DCAS bids the City's fuel supply contracts. The contract requires the supplier to achieve BQ9000 certification. BQ9000 is a voluntary accreditation program that tests and certifies for ASTM compliance in fuel management and provision. More information on BQ9000 certification can be found at *bq-9000.org*.

For most of the period addressed in this report, the Castle Fuel Company was the City's contracted biodiesel supplier. Recently, the Sprague Company procured the Castle Fuel Company and has assumed the City's contract for heating oil.

DCAS worked to achieve compliance on the biodiesel mandate well prior to the timetables established in Local Law 10 of 2013. The City began the transition to Biodiesel (B5) in FY13 which covers July 1, 2012 to June 30, 2013.

In FY13, over 86% of the City's heating fuel was biodiesel (B5) or higher. The City used 28.2 million gallons of biodiesel (B5) or higher across 16 main agencies that operate facilities.

In FY14, the City had phased out all non-biodiesel blended heating oil. In FY14, the City used 35.5 million gallons of biodiesel (B5) or higher.

In FY15, the City used 35.6 million gallons of B5 blends or higher.

Through June 2015, the City successfully used over 99.2 million gallons of B5 or higher blends of biodiesel for its diverse stock of City owned buildings. The use o f B5 for heating oil has been problem-free.

In FY14, the City's total heating oil breakdown by type of diesel purchased was as follows:

- B5/20, D2: 43%
- B5, D4: 49%
- B5, D6: 8%

After FY13, the City stopped bidding non-biodiesel heating oil. Because of this, we only have the ability to compare City actual contract costs for biodiesel and non-biodiesel for FY13.

- B5, Diesel 2: The City paid $3.17 per gallon on average for non-biodiesel D2 in FY2013 and $3.25 for B5. The average difference is 8 cents or 2.4 percent.

- B5, Diesel 4: The City paid $3.00 per gallon on average for non-biodiesel D4 in FY2013 and $3.06 for B5. The average difference is 6 cents or 2 percent.

- B5, Diesel 6: The City paid $2.74 per gallon on average for non-biodiesel D4 in FY2013 and $2.90 for B5. The average difference is 16 cents or 6 percent.

All of these costs are from FY 2013 and do not take into account any potential biodiesel credits.

Although overall market trends in fuel costs have likely had more impact overall than the use of biodiesel blends in particular, the fact is the overall costs for heating oil have decreased substantially since the biodiesel initiative began. In FY13, the City paid $3.25 per gallon on average for D2 B5 heating oil fuel and $3.35 on average for D2 B20.

On October 19, 2015, the City price for B5 D2 was $1.58 per gallon; the City price for B10 D2 was $1.74 per gallon, and the price for B20 D2 was $1.76 per gallon.

3) Testing of B10 and B20 for City buildings

Local Law 107 of 2013 requires DCAS to implement pilot use of B10 blends of biodiesel at 5% of City facilities starting October 1, 2014 to October 1, 2015 and to report on the findings.

Effective October 1, 2014 DCAS has initiated a B10 pilot impacting 69 facility accounts at Parks, DEP, DSNY, DCAS and DOE.

In addition, NYC Parks has used biodiesel (B20) blends for a majority (over 75%) of its 115 facility accounts from FY10 through FY14. Parks used over 490,000 gallons of B20 D2 biodiesel in FY11. This amount increased to over 560,000 gallons of B20 D2 in FY14.

Overall, the biodiesel (B10 and B20) initiatives have been successful to date.

Issues that have been reported with B10 or B20 blends in heating oil include:

- Instances of maintenance issues with heating oil tanks or boilers relating especially to the potential solvent properties of biodiesel. In most cases, these were clogs of fuel lines and quickly addressed.

- Concerns regarding degradation of biodiesel fuel of high (B20) blends when used at sites in conjunction with emergency generators or with interruptible sites where natural gas is the main heating fuel and the oil tank is used as a backup. By ASTM standard, biodiesel is expected to have a minimum shelf life of 6 months. In our experience, stored biodiesel lasts much longer. . However, biodiesel used for buildings generators or interruptible sites may sit for far longer than six months.

The City should look at a number of steps as it works to further implement biodiesel in higher blends such as B10 or B20 for heating oil. These include:

- Better inventorying the heating oil and boiler systems used citywide and assessing if there are any compatibility issues with higher level blends of biodiesel and, if so, developing a plan to address these. Compatibility issues should examine questions involve interaction with pumps, seals, and metal components.

- Restricting use of higher blends of biodiesel for emergency generator or interruptible sites unless there are operational procedures employed that will ensure biodiesel does not sit unused for long periods.

- Developing a Citywide system to report on maintenance issues to heating oil systems.

Designation: D396 – 15a

Standard Specification for Fuel Oils[1]

This standard is issued under the fixed designation D396; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification (see Note 1) covers grades of fuel oil intended for use in various types of fuel-oil-burning equipment under various climatic and operating conditions. These grades are described as follows:

1.1.1 Grades No. 1 S5000, No. 1 S500, No. 2 S5000, and No. 2 S500 are middle distillate fuels for use in domestic and small industrial burners. Grades No. 1 S5000 and No. 1 S500 are particularly adapted to vaporizing type burners or where storage conditions require low pour point fuel.

1.1.2 Grades B6–B20 S500 and B6–B20 S5000 are middle distillate fuel/biodiesel blends for use in domestic and small industrial burners.

1.1.3 Grades No. 4 (Light) and No. 4 are heavy distillate fuels or middle distillate/residual fuel blends used in commercial/industrial burners equipped for this viscosity range.

1.1.4 Grades No. 5 (Light), No. 5 (Heavy), and No. 6 are residual fuels of increasing viscosity and boiling range, used in industrial burners. Preheating is usually required for handling and proper atomization.

NOTE 1—For information on the significance of the terminology and test methods used in this specification, see Appendix X1.

NOTE 2—A more detailed description of the grades of fuel oils is given in X1.3.

1.2 This specification is for the use of purchasing agencies in formulating specifications to be included in contracts for purchases of fuel oils and for the guidance of consumers of fuel oils in the selection of the grades most suitable for their needs.

1.3 Nothing in this specification shall preclude observance of federal, state, or local regulations which can be more restrictive.

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

NOTE 3—The generation and dissipation of static electricity can create problems in the handling of distillate burner fuel oils. For more information on the subject, see Guide D4865.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D56 Test Method for Flash Point by Tag Closed Cup Tester
D86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure
D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D97 Test Method for Pour Point of Petroleum Products
D129 Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device Method)
D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
D473 Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method
D482 Test Method for Ash from Petroleum Products
D524 Test Method for Ramsbottom Carbon Residue of Petroleum Products
D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration
D975 Specification for Diesel Fuel Oils
D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
D1552 Test Method for Sulfur in Petroleum Products (High-Temperature Method)
D2500 Test Method for Cloud Point of Petroleum Products
D2622 Test Method for Sulfur in Petroleum Products by

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.E0 on Burner, Diesel, Non-Aviation Gas Turbine, and Marine Fuels.

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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**

TABLE 1 Detailed Requirements for Fuel Oils[A,B]

Property	ASTM Test Method[C]	No. 1 S500[C]	No. 1 S5000[C]	No. 2 S500[C]	No. 2 S5000[C]	B6–B20 S500[C]	B6–B20 S5000[C]	No. 4 (Light)[C]	No. 4	No. 5 (Light)	No. 5 (Heavy)	No. 6
Flash Point, °C, min	D93 – Proc. A	38	38	38	38	38	38	38	...	...	...	...
	D93 – Proc. B	...	...	...	...			...	55	55	55	60
Water and sediment, percent by volume, max	D2709	0.05	0.05	0.05	0.05	0.05	0.05	...	...	...	...	...
	D95 + D473	...	...	...	...			(0.50)[D]	(0.50)[D]	(1.00)[D]	(1.00)[D]	(2.00)[D]
Distillation Temperature, °C	D86											
10 % volume recovered, max		215	215	...	...	...	...					
90 % volume recovered, min		...	...	282	282	282	282					
90 % volume recovered, max		288	288	338	338	343	343					
Kinematic viscosity at 40 °C, mm^2/s	D445											
min		1.3	1.3	1.9	1.9	1.3	1.3	1.9	>5.5	...	...	...
max		2.4	2.4	4.1	4.1	4.1	4.1	5.5	24.0[E]			
Kinematic viscosity at 100 °C, mm^2/s	D445											
min		...	...	...	...			...	...	5.0	9.0	15.0
max		...	...	...	...			...	...	8.9[E]	14.9[E]	50.0[E]
Ramsbottom carbon residue on 10 % distillation residue percent by mass, max	D524	0.15	0.15	0.35	0.35	0.35	0.35	...	...	...	...	...
Ash, percent by mass, max	D482	...	...	...	...			0.05	0.10	0.15	0.15	...
Sulfur, percent by mass max[F]	D2622	0.05	0.5	0.05	0.5	0.05	0.5					
Copper strip corrosion rating, max, 3 h at a minimum control temperature of 50 °C	D130	No. 3	No. 3	No. 3	No. 3	No. 3	No. 3	...	...	...	...	...
Density at 15 °C, kg/m^3	D1298											
min		...	...	...	...			>876[G]	...	...	...	...
max		850	850	876	876	876	876	...	...	...	...	...
Pour Point °C, max[H]	D97	−18	−18	−6	−6	−6	−6	−6	−6	...	...	[I]
Oxidation Stability, hours, min	EN 15751	...	...	...	...	6	6					
Acid Number, mg KOH/g, max	D664	...	...	...	...	0.3	0.3					
Biodiesel Content, percent (V/V)[J]	D7371	...	...	...	...	6. – 20.	6. – 20.	...				

[A] It is the intent of these classifications that failure to meet any requirement of a given grade does not automatically place an oil in the next lower grade unless in fact it meets all requirements of the lower grade. However, to meet special operating conditions, modifications of individual limiting requirements may be agreed upon among the purchaser, seller, and manufacturer.
[B] Refer to 7.1.2.1 for Low Temperature guidance for <1000 gal outside or unheated storage containers for the United States.
[C] Under United States regulations, Grades No. 1 S5000, No. 1 S500, No. 2 S5000, No. 2 S500, and No. 4 (Light) are required by 40 CFR Part 80 to contain a sufficient amount of the dye Solvent Red 164 so its presence is visually apparent. At or beyond terminal storage tanks, they are required by 26 CFR Part 48 to contain the dye Solvent Red 164 at a concentration spectrally equivalent to at least 3.9 lb of the solid dye standard Solvent Red 164 per thousand barrels of fuel oil.
[D] The amount of water by distillation by Test Method D95 plus the sediment by extraction by Test Method D473 shall not exceed the value shown in the table. For Grade No. 6 fuel oil, the amount of sediment by extraction shall not exceed 0.50 % by mass, and a deduction in quantity shall be made for all water and sediment in excess of 1.0 % by mass.
[E] Where low sulfur fuel oil is required, fuel oil falling in the viscosity range of a lower numbered grade down to and including No. 4 can be supplied by agreement between the purchaser and supplier. The viscosity range of the initial shipment shall be identified and advance notice shall be required when changing from one viscosity range to another. This notice shall be in sufficient time to permit the user to make the necessary adjustments.
[F] Other sulfur limits may apply in selected areas in the United States and in other countries.
[G] This limit ensures a minimum heating value and also prevents misrepresentation and misapplication of this product as Grade No. 2.
[H] Lower or higher pour points can be specified whenever required by conditions of storage or use. When a pour point less than −18 °C is specified, the minimum viscosity at 40 °C for grade No. 2 shall be 1.7 mm^2/s and the minimum 90 % recovered temperature shall be waived.
[I] Where low sulfur fuel oil is required, Grade No. 6 fuel oil will be classified as Low Pour (+15 °C max) or High Pour (no max). Low Pour fuel oil should be used unless tanks and lines are heated.
[J] See subsection 4.3.3 on biodiesel content for grades other than B6–B20.

4.3.1 *Biodiesel for Blending*—If biodiesel is a component of any fuel oil, the biodiesel shall meet the requirements of Specification D6751.

4.3.2 The remainder of the fuel oil shall be fuel oil conforming to Specification D396 Grades No. 1 or No. 2 of any sulfur level specified, with the exception that fuel oil whose sulfur level falls outside of Specification D396 may be blended with biodiesel meeting Specification D6751, provided the finished mixture meets this specification.

4.3.3 Fuel oil containing up to 5 percent by volume biodiesel shall meet the requirements for the appropriate grade No. 1 or No. 2 fuel as listed in Table 1.

4.3.4 Fuel oil containing 6. to 20. percent by volume biodiesel shall meet the requirements for the appropriate grade B6 to B20 as listed in Table 1.

4.3.5 Test Method D7371 shall be used for determination of the percent by volume biodiesel in a biodiesel blend. Test Method EN 14078 may also be used. In cases of dispute, Test Method D7371 shall be the referee test method. See Practice E29 for guidance on significant digits.

4.3.6 Fuel oils containing more than 20. percent by volume biodiesel component are not included in this specification.

4.3.7 Biodiesel blends with Grades 4, 5, or 6 are not covered by this specification.

5. Detailed Requirements

5.1 The various grades of fuel oil shall conform to the limiting requirements shown in Table 1. A representative sample shall be taken for testing in accordance with Practice D4057.

5.2 Modifications of limiting requirements to meet special operating conditions agreed upon between the purchaser, the seller, and the supplier shall fall within limits specified for each grade, except as stated in supplementary footnotes for Table 1.

6. Sampling, Containers, and Sample Handling

6.1 The reader is strongly advised to review all intended test methods prior to sampling in order 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 obtaining a sample representative of the fuel oil to be tested. Refer to X1.4 for recommendations. The recommended procedures or practices provide techniques useful in the proper sampling or handling of fuels oils.

7. Test Methods

7.1 The requirements enumerated in this specification shall be determined in accordance with the following ASTM test methods,[5] except as may be required under 7.1.1.

7.1.1 *Flash Point*—Test Method D93 (Procedure A) for Grades No. 1 S5000, No. 1 S500, No. 2 S5000, No. 2 S500, and No. 4 (Light), and Test Method D93 (Procedure B) for Grades No. 4, No. 5 (Light), No. 5 (Heavy), and No. 6, except where other methods are prescribed by law. For Grades No. 1 S5000, No. 1 S500, No. 2 S5000, No. 2 S500, and No. 4 (Light), Test Methods D3828 and D7094 may be used as an alternative with the same limits. For Grades No. 1, No. 1 Low Sulfur, No. 2, and No. 2 Low Sulfur, Test Method D56 may be used as an alternative with the same limits, provided the flash point is below 93 °C and the viscosity is below 5.5 mm^2 /s at 40 °C. This test method will give slightly lower values. In cases of dispute, Test Method D93, with the appropriate procedure, shall be used as the referee method.

7.1.2 *Pour Point*—Test Method D97. For all grades, the automatic Test Methods D5949, D5950, D5985, D6749, and D6892 can be used as alternates with the same limits. In case of dispute, Test Method D97 shall be used as the referee method. Alternative test methods that indicate flow point properties can be used for low sulfur residual fuels by agreement between purchaser and supplier.

7.1.2.1 The maximum Pour Point limits specified in Table 1 should be adequate under most circumstances for shipment and use of Fuel Oil from April through September and in operations year round where larger storage tanks (>1000 gal) are in use and appropriate consideration has been given to operating conditions as described in X2.1.2.

7.1.2.2 Table 2 lists 10th percentile ambient temperatures as guidance for smaller Fuel Oil storage conditions (<1000 gal in outside or unheated storage) in the United States (see X2.1.3, Current Practices). Appropriate low temperature operability properties should be agreed upon between the fuel supplier and purchaser for the intended use and expected ambient temperatures. The 10th percentile ambient temperatures are divided by month (October through March) and by state or by specific portion of a state. Smaller storage containers are commonly used and stored outside in home heating oil applications (275 gal and 550 gal outside storage tanks are typical).

7.1.2.3 The low temperature recommendations discussed in X2.1.3 may be met by Test Method D2500 Cloud Point (or an approved alternate test method) or by Test Method D97 Pour Point (or an approved alternate test method). If Pour Point is used then the difference between the Cloud Point and the Low Temperature guidance found in Table 2 should not exceed 10 °C.

7.1.3 *Water and Sediment*—The water and sediment in Grade No. 1 S500, No. 1 S5000, No. 2 S500, and No. 2 S5000 shall be determined in accordance with Test Method D2709 and in Grade Nos. 4, 5, and 6 by Test Method D95 and Test Method D473. A density of 1.0 kg/L shall be used for the Test Method D95 water.

7.1.4 *Carbon Residue*—Test Method D524.

7.1.5 *Ash*—Test Method D482.

7.1.6 *Distillation*—Distillation of Grade No. 1 and No. 2 oils shall be determined in accordance with Test Methods D86 or D2887.[6] Results from Test Method D2887 shall be reported as "Predicted D86" results by application of the correlation in Appendix X5 Test Method D2887 to convert the values. In case of dispute, Test Method D86 shall be used as the referee test method.

7.1.7 *Viscosity*—Viscosity shall be determined in accordance with Test Method D445. Bias-corrected values from Test Method D7042 may be used as alternative results for Test Method D445 on Grades No. 1 and No. 2 with the same limits. Section 15 of Test Method D7042 contains bias-correction information. In case of dispute, Test Method D445 shall be used as the referee method.

7.1.8 *Density*—Test Method D1298. Test Method D4052 can be used as an alternate with the same limits. In case of dispute, Test Method D1298 shall be used as the referee method.

7.1.9 *Corrosion*—Test Method D130, 3-h test at a minimum control temperature of 50°C.

7.1.10 *Sulfur*—Test Method D2622. See Table 3 for alternate test methods for sulfur, the range over which each applies, and the corresponding fuel grades.

8. Keywords

8.1 biodiesel; biodiesel blend; burner fuels; fuel oils; furnace oils; petroleum and petroleum products

[5] For information on the precision of the ASTM test methods for fuel oils refer to "An Evaluation of Methods for Determination of Sulfur in Fuel Oils" by A. R. Crawford, Esso Mathematics and Systems Inc. and G. V. Dyroff, Esso Research and Engineering Co., 1969. This document is available from the Publications Section, API Library, American Petroleum Institute, 1220 L St., NW, Washington, DC 20005.

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1553.

TABLE 2 Tenth Percentile Minimum Ambient Air Temperatures in °C for the United States (except Hawaii)

State		Oct.	Nov.	Dec.	Jan.	Feb.	March
Alabama		4	−3	−6	−7	−3	−2
Alaska							
	Northern	−25	−37	−45	−49	−47	−43
	Southern	−11	−13	−18	−32	−32	−29
	South East	−4	−11	−16	−19	−13	−12
Arizona							
	North 34° latitude	−4	−12	−14	−17	−16	−12
	South 34° latitude	7	0	−2	−4	−3	−1
Arkansas		2	−4	−7	−11	−7	−3
California							
	North Coast	3	0	−2	−2	−1	−1
	Interior	2	−3	−4	−7	−6	−6
	South Coast	6	2	0	−1	0	2
	Southeast	1	−6	−8	−11	−7	−5
Colorado							
	East 105° long	−2	−12	−14	−19	−15	−12
	West 105° long	−8	−18	−25	−30	−24	−16
Connecticut		−1	−7	−16	−17	−16	−9
Delaware		2	−3	−10	−11	−10	−6
Florida							
	North 29° latitude	7	1	−2	−3	−1	2
	South 29° latitude	14	7	3	3	5	7
Georgia		3	−2	−6	−7	−6	−2
Idaho		−4	−13	−18	−21	−18	−13
Illinois							
	North 40° latitude	−1	−9	−19	−21	−18	−11
	South 40° latitude	1	−7	−16	−17	−15	−8
Indiana		−1	−7	−16	−18	−16	−9
Iowa		−2	−13	−23	−26	−22	−16
Kansas		−2	−11	−15	−19	−14	−13
Kentucky		1	−6	−13	−14	−11	−6
Louisiana		5	−1	−3	−4	−2	1
Maine		−3	−10	−23	−26	−26	−18
Maryland		2	−3	−10	−12	−10	−4
Massachusetts		−2	−7	−16	−18	−17	−10
Michigan		−2	−11	−20	−23	−23	−18
Minnesota		−4	−18	−30	−34	−31	−24
Mississippi		3	−3	−6	−6	−4	−1
Missouri		1	−7	−14	−16	−13	−8
Montana		−7	−18	−24	−30	−24	−21
Nebraska		−3	−13	−18	−22	−19	−13
Nevada							
	North 38° latitude	−7	−14	−18	−22	−18	−13
	South 38° latitude	8	0	−3	−4	−2	1
New Hampshire		−3	−8	−18	−21	−21	−12
New Jersey		2	−3	−11	−12	−11	−6
New Mexico							
	North 34° latitude	−2	−11	−14	−17	−14	−11
	South 34° latitude	4	−4	−8	−11	−7	−3
New York							
	North 42° latitude	−3	−8	−21	−24	−24	−16
	South 42° latitude	−1	−5	−14	−16	−15	−9
North Carolina		−1	−7	−10	−11	−9	−5
North Dakota		−4	−20	−27	−31	−29	−22
Ohio		−1	−7	−16	−17	−15	−9
Oklahoma		1	−8	−12	−13	−8	−7
Oregon							
	East 122° long	−6	−11	−14	−19	−14	−9
	West 122° long	0	−4	−5	−7	−4	−3
Pennsylvania							
	North 41° latitude	−3	−8	−19	−20	−21	−15
	South 41° latitude	0	−6	−13	−14	−14	−8
Rhode Island		1	−3	−12	−13	−13	−7
South Carolina		5	−1	−5	−5	−3	−2
South Dakota		−4	−14	−24	−27	−24	−18
Tennessee		1	−5	−9	−11	−9	−4
Texas							
	North 31° latitude	3	−6	−9	−13	−9	−7
	South 31° latitude	9	2	−2	−3	−1	2
Utah		−2	−11	−14	−18	−14	−8
Vermont		−3	−8	−20	−23	−24	−15
Virginia		2	−3	−9	−11	−9	−4
Washington							
	East 122° long	−2	−8	−11	−18	−11	−8
	West 122° long	0	−3	−3	−7	−4	−3

TABLE 2 *Continued*

State	Oct.	Nov.	Dec.	Jan.	Feb.	March
West Virginia	–3	–8	–15	–16	–14	–9
Wisconsin	–3	–14	–24	–28	–24	–18
Wyoming	–4	–15	–18	–26	–19	–16

TABLE 3 Sulfur Test Methods

Sulfur Test Method	Grades
D2622 (referee for all grades)	All Grades
D129	No. 1 S5000, No. 2 S5000, No. 4 (Light), No. 5 (Heavy), No. 6
D1266	No. 1 S500, No. 2 S500
D1552	No. 1 S5000, No. 2 S5000, No. 4 (Light), No. 4, No. 5 (Light), No. 5 (Heavy), No. 6
D4294	All Grades
D5453	All Grades
D7039	S500 grades, S5000 grades only if the sulfur result is 2822 mg/kg or less
D7220	S500 grades

APPENDIXES

(Nonmandatory Information)

X1. SIGNIFICANCE OF ASTM SPECIFICATION FOR FUEL OILS

X1.1 Scope

X1.1.1 This specification divides fuel oils into grades based upon the types of burners for which they are suitable. It places limiting values on several of the properties of the oils in each grade. The properties selected for limitation are those that are believed to be of the greatest significance in determining the performance characteristics of the oils in the types of burners in which they are most commonly used.

X1.2 Classes

X1.2.1 Because of the methods employed in their production, fuel oils fall into two broad classifications: distillates and residuals. The distillates consist of overhead or distilled fractions. The residuals are bottoms remaining from the distillation, or blends of these bottoms with distillates. In this specification, Grades No. 1 and No. 2 are distillates and the grades from No. 4 to No. 6 are usually residual, although some heavy distillates can be sold as Grade No. 4.

X1.3 Grades

X1.3.1 *Grades No. 1 S5000 and No. 1 S500* are middle distillates intended for use in burners of the vaporizing type in which the oil is converted to a vapor by contact with a heated surface or by radiation. High volatility is necessary to ensure that evaporation proceeds with a minimum of residue. The low sulfur grade S500 may be specified by federal, state, or local regulations and can result in reduced deposits on ferrous heat exchanger surfaces compared to Grade No. 1 S5000 when burned under similar conditions.

X1.3.2 *Grades No. 2 S5000 and No. 2 S500* are middle distillates somewhat heavier than grades No. 1 S5000 and No. 1 S500. They are intended for use in atomizing type burners which spray the oil into a combustion chamber where the tiny droplets burn while in suspension. These grades of oil are used in most domestic burners and in many medium capacity commercial-industrial burners where ease of handling and ready availability sometimes justify higher cost over the residual fuels. The low sulfur grade S500 may be specified by federal, state, or local regulations and can result in reduced deposits on ferrous heat exchanger surfaces compared to Grade No. 2 S5000 when burned under similar conditions.

X1.3.3 *Grade No. 4 (Light)* is a heavy distillate fuel or distillate/residual fuel blend meeting the specification viscosity range. It is intended for use both in pressure-atomizing commercial-industrial burners not requiring higher cost distillates and in burners equipped to atomize oils of higher viscosity. Its permissible viscosity range allows it to be pumped and atomized at relatively low-storage temperatures.

X1.3.4 *Grade No. 4* is usually a heavy distillate/residual fuel blend but can be a heavy distillate fuel meeting the specification viscosity range. It is intended for use in burners equipped with devices that atomize oils of higher viscosity than domestic burners can handle. Its permissible viscosity range allows it to be pumped and atomized at relatively low storage temperatures. Thus, in all but extremely cold weather it requires no preheating for handling.

X1.3.5 *Grade No. 5 (Light)* is residual fuel of intermediate viscosity for burners capable of handling fuel more viscous than grade No. 4 without preheating. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.6 *Grade No. 5 (Heavy)* is a residual fuel more viscous than Grade No. 5 (Light) and is intended for use in similar service. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.7 *Grade No. 6,* sometimes referred to as Bunker C, is a high-viscosity oil used mostly in commercial and industrial

heating. It requires preheating in the storage tank to permit pumping, and additional preheating at the burner to permit atomizing. The extra equipment and maintenance required to handle this fuel usually preclude its use in small installations.

X1.3.8 Residual fuel oil supplied to meet regulations requiring low sulfur content can differ from the grade previously supplied. It may be lower in viscosity (and fall into a different grade number). If it must be fluid at a given temperature, Test Method D97 need not accurately reflect the pour point which can be expected after a period of storage. It is suggested that the purchaser and supplier discuss the proper handling and operating techniques for a given low-sulfur residual fuel oil in the installation where it is to be used.

X1.4 Sampling, Containers, and Sample Handling

X1.4.1 *Introduction*—This appendix section provides guidance on methods and techniques for the proper sampling of fuel oils. As fuel oil specifications become more stringent, and contaminants and impurities become more tightly controlled, even greater care needs to be taken in collecting and storing samples for quality assessment.

X1.4.2 *Sampling, Containers, and Sample Handling Recommendations:*

X1.4.2.1 Appropriate manual method sampling procedures found in Practice D4057, and automatic method sampling is covered in Practice D4177.

X1.4.2.2 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.

X1.4.2.3 For volatility determination of a sample, refer to Practice D5842 for special precautions recommended for representative sampling and handling instructions.

X1.5 Significance of Test Methods

X1.5.1 The significance of the properties of fuel oil on which limitations are placed by the specification is as follows:

X1.5.1.1 *Flash Point*—The flash point of a fuel oil is an indication of the maximum temperature at which it can be stored and handled without serious fire hazard. The minimum permissible flash point is usually regulated by federal, state, or municipal laws and is based on accepted practice in handling and use.

X1.5.1.2 *Reduced Temperature Properties*—The fuel's cloud and pour points are good measures for determining low temperature operability with a batch of fuel oil. It is especially important to consider these fuel properties if the heating oil will be subjected to low ambient temperatures at time of use. Fuel temperatures can fluctuate markedly in small, residential, outdoor, above ground tanks compared with indoor, basement tanks, or underground tanks. A decrease or stoppage of fuel flow can occur in small transfer lines used for residential heating applications because the fuel line temperature will fluctuate with ambient temperature faster than will bulk tank contents. Fuel oils purchased during the summer, but not used until the cold heating season arrives, can be a serious source of problems. This is because when these fuels are produced they are intended for use during the warm season and thus typically have higher cloud and pour points than fuels produced for use during the cold season. Fuels can be produced for use at low temperatures with lower cloud and pour points by blending with low paraffin fuels, such as kerosine or No. 1 fuel, and additives, or a combination thereof, to improve low temperature operability. The key to effective treatment is routine monitoring of incoming and stored fuels, and testing of the treated fuels. Although this specification only sets maximum limits for the pour point, the recommendations for cloud point of distillate fuels in Specification D975 may be applied to heating fuels under extreme cold conditions. Some pipeline companies or local specifications have included requirements for both cloud and pour points for certain grades of fuel oil.

(1) Pour Point—The pour point is an indication of the lowest temperature at which a fuel oil is capable of flowing under very low forces. The pour point is prescribed in accordance with the conditions of storage and use. Higher pour point fuels are permissible where heated storage and adequate piping facilities are provided. An increase in pour point can occur when residual fuel oils are subjected to cyclic temperature variations that can occur in the course of storage or when the fuel is preheated and returned to storage tanks.

(2) Cloud Point (Test Method D2500)—The cloud point defines the temperature at which a cloud or haze of wax crystals appears in the oil under prescribed test conditions which generally relates to the temperature at which wax crystals begin to precipitate from the oil in use. It is generally observed that cloud point temperature of a fuel oil is higher than its pour point by several degrees Celsius. Fuel oils stored at, or below, their cloud point temperature can have suspended wax crystals that may cause operability problems due to plugging. Examples are when fuels are pumped through small openings or passageways, that is, oil-line filters, burner nozzles, and pump strainers. The plugging is reversible when the fuel is warmed.

X1.5.1.3 *Water and Sediment*—Appreciable amounts of water and sediment in a fuel oil tend to cause fouling of facilities for handling it, and to give trouble in burner mechanisms. Sediment may accumulate in storage tanks and on filter screens or burner parts, resulting in obstruction to flow of oil from the tank to the burner. Water in distillate fuels can cause corrosion of tanks and equipment and it can cause emulsions in residual fuels.

X1.5.1.4 *Carbon Residue*—The carbon residue of a fuel is a measure of the carbonaceous material left after all the volatile components are vaporized in the absence of air. It is a rough approximation of the tendency of a fuel to form deposits in vaporizing burners, such as pot-type and sleeve-type burners, where the fuel is vaporized in an air-deficient atmosphere.

X1.5.1.4.1 To obtain measurable values of carbon residue in the lighter distillate fuel oils, it is necessary to distill the oil to remove 90 % of it in accordance with Section 9 of Test Method D524, and then determine the carbon residue concentrated in the remaining 10 % bottoms.

X1.5.1.5 *Ash*—The amount of ash is the quantity of noncombustible material in an oil. Excessive amounts can indicate

the presence of materials that cause high wear of burner pumps and valves, and contribute to deposits on boiler heating surfaces.

X1.5.1.6 *Distillation*—The distillation test shows the volatility of a fuel and the ease with which it can be vaporized. The test is of greater significance for oils that are to be burned in vaporizing type burners than for the atomizing type. For example, the maximum 10 % and 90 % distilled temperatures are specified for grade No. 1 fuel. The limiting 10 % value ensures easy starting in vaporizing type burners and the 90 % limit excludes heavier fractions that would be difficult to vaporize.

(1) The limits specified for grade No. 2 heating oil define a product that is acceptable for burners of the atomizing type in household heating installations. Distillation limits are not specified for fuel oils of grades Nos. 4, 5, and 6.

X1.5.1.7 *Viscosity Limits for Grades Nos. 1 and 2*—The viscosity of an oil is a measure of its resistance to flow. In fuel oil it is highly significant since it indicates both the relative ease with which the oil will flow or can be pumped, and the ease of atomization.

(1) Viscosity limits for No. 1 and No. 2 grades are specified to help maintain uniform fuel flow in appliances with gravity flow, and to provide satisfactory atomization and constant flow rate through the small nozzles of household burners. For the heavier grades of industrial and bunker fuel oils, viscosity is of major importance, so that adequate preheating facilities can be provided to permit them to be pumped to the burner and to provide good atomization. However, it is equally important that the maximum viscosity under the existing conditions be such that the oil can be pumped satisfactorily from the storage tank to the preheater.

X1.5.1.8 *Density*—Density alone is of little significance as an indication of the burning characteristics of fuel oil. However, when used in conjunction with other properties, it is of value in mass-volume relationships and in calculating the specific energy (heating value) of an oil.

X1.5.1.9 *Corrosion*—The corrosion test serves to indicate the presence or absence of materials that could corrode copper, brass, and bronze components of the fuel system. This property is specified only for Nos. 1 and 2 distillate fuel oils.

X1.5.1.10 Limited sulfur content of fuel oil can be required for special uses in connection with heat treatment, nonferrous metal, glass, and ceramic furnaces or to meet federal, state, or local legislation or regulations.

X1.5.1.11 *Nitrogen*—Nitrogen oxide emission regulations have been imposed on certain combustion facilities as a function of fuel nitrogen content. For purposes of these regulations, distillate fuels, low nitrogen residual fuels, and high nitrogen residual fuels have been defined by their nitrogen content. Installations are required to meet different emission standards according to the classification of the fuel being used. When regulations require such a distinction to be made, fuel nitrogen specifications can be needed in the contractual agreement between the purchaser and the supplier.

X1.6 Other

X1.6.1 *Microbial Contamination*—Refer to Guide D6469 for a discussion of this form of contamination.

X2. TENTH PERCENTILE MINIMUM AMBIENT AIR TEMPERATURES FOR THE UNITED STATES (EXCEPT HAWAII)

X2.1 Introduction

X2.1.1 The tenth percentile minimum ambient air temperatures shown in Table 2 were derived from an analysis of historical hourly temperature readings recorded over a period of 15 to 21 years from 345 weather stations in the United States. This study[7] as conducted by the U.S. Army Mobility Equipment Research and Development Center (USAMERDC), Coating and Chemical Laboratory, Aberdeen Proving Ground, MD 21005. The tenth percentile minimum ambient air temperature is defined as the lowest ambient air temperature which will not go lower on average more than 10 % of the time. In other words, the daily minimum ambient air temperature would on average not be expected to go below the monthly tenth percentile minimum ambient air temperature more than 3 days for a 30-day month. See Table 2.

X2.1.2 These data can be used to estimate low temperature operation and handling requirements for fuel oil/heating oil systems. In establishing low temperature requirements, consideration should be given to the following. These factors, or any combination, can make low temperature operations more or less severe than normal. Pour point is a directional indicator of low temperature mobility of fuel, but, due to the nature of the lab test, fuel stored at or above the Pour Point for extended periods can gel and prevent flow to the fuel oil burner with or without cold flow additives.

X2.1.2.1 Long term weather patterns. (Average winter low temperatures will be exceeded on occasion.)

X2.1.2.2 Short term local weather conditions. (Unusual cold periods do occur.)

X2.1.2.3 Elevation. (High locations are usually colder than surrounding lower areas.)

X2.1.2.4 Fuel delivery system design. (Fuel delivery line diameter, filter location, filter capacity, filter porosity, and so forth.)

X2.1.2.5 Fuel viscosity at low temperatures.

X2.1.2.6 Equipment add-ons (that is, fuel line and fuel filter heaters).

X2.1.2.7 Types of operation. (Fuel turn over rate, continuous operation, or unusual operation.)

X2.1.2.8 Low temperature flow improver additives in fuel.

X2.1.2.9 Geographic area for fuel use.

X2.1.2.10 General housekeeping. (Dirt or water, or both, in fuel or fuel supply system.)

[7] Doner, John P., "A Predictive Study for Defining Limiting Temperatures and Their Application in Petroleum Product Specifications," CCL Report No. 316.

X2.1.2.11 Consequences of failure to start or operate. (Critical vs. non-critical application.)

X2.1.2.12 Fuel tank location.

X2.1.3 *Current Practices*—It is recognized that fuel distributors, producers, and end users commonly use pour point to estimate low temperature operation and handling limits for fuel oil. No independent data has been published in recent years to determine test applicability for today's fuel oils. It is also well known that smaller volumes will cool down faster under outside storage conditions making the 275 gal and 550 gal storage tanks commonly used in home heating oil applications more susceptible to wax precipitation and fuel gelling. Colder than normal temperatures and extended periods of normal low temperatures significantly increase the chances for field problems even in the larger terminal and distributor tanks.

X2.1.4 *Pour Point and Cloud Point*—Cloud Point may be used to meet the low temperature recommendations, or Pour Point may be used as long as the Cloud Point was not more than 10 °C above the low temperature recommendation from Table 2. For example, if the low temperature guidance in January is −24 °C, then the Pour Point could be −24 °C or lower as long as the Cloud Point did not exceed −14 °C. The reason for this guidance is that at 10 °C below the Cloud Point of a fuel between 2 % and 3 % wax is out of solution in a typical United States fuel and it is quite manageable. 3 % wax out of solution appears to be a critical limit for most filterability tests. Higher levels of wax have been found to overwhelm filters and produce less reliable results in laboratory test results which is why general confidence limits of 10 °C below Cloud Point are placed upon those tests.

X3. GUIDANCE ON EVALUATION OF NEW MATERIALS FOR No. 1 AND No. 2 GRADES OF FUEL OILS

X3.1 The purpose of this appendix is to provide some general guidance from Subcommittee D02.E0 on evaluation of new materials or blends containing new materials intended to meet Specification D396, Grades No. 1 and No. 2 type fuel oils.

X3.2 ASTM International is an organization made up of volunteers and open to all stakeholders and interested entities including users of fuels, producers of fuels, and general interests, including members of the public, and governmental and nongovernmental organizations. Technical committees and subcommittees of ASTM International do not certify, approve, reject, or endorse specific fuels. Rather, ASTM International Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and its Subcommittee D02.E0 on Burner, Diesel, Non-Aviation Gas Turbine, and Marine Fuels develop fuel specifications and with other subcommittees, test methods for diesel fuels. These fuel specifications and test methods provide minimum requirements for properties of fuels covered by these documents in commerce and address the concerns of stakeholders, including that fuels perform appropriately in the specified application.

X3.3 Historically, fuel oil has been hydrocarbon molecules refined from petroleum. As a result, Specification D396 has evolved to define performance requirements (and tests to determine if those requirements were met) for fuel oils composed of conventional hydrocarbon oils refined from petroleum. Because the specification evolved to describe this type of fuel, some of the properties necessary for use in conventional burners which are inherent in petroleum derived oils may not be addressed in Specification D396.

X3.4 Specification D396, however, does not require that fuels be derived from petroleum. Subection 4.1 reads, "The grades of fuel oil herein specified shall be hydrocarbon oils, except as provided in 4.3, free from inorganic acid, and free from excessive amounts of solid or fibrous foreign matter. The inclusion of additives to enhance performance properties, if required, is allowed." Subsection 4.3 provides a path to include other fuels and blendstocks found by the Subcommittee to be appropriate for inclusion in Specification D396. To date, this path has been used by biodiesel, which is not refined from petroleum and is not hydrocarbon oil.

X3.5 It should be noted that fuel specifications other than Specification D396 have been and are being developed for fuel oils used in burners. Specification D6751 sets specifications for alkyl esters of fatty acids (B100) to be used as a blend stock. Other new specifications are currently under development. Some new materials may require new standard specifications if they are significantly different than current fuel oils and require different parameters to be controlled or different test methods to properly measure required parameters.

X3.6 Because the composition and properties of new fuels may vary, the particular path to a specification for a new fuel may vary. Some current alternative fuels are similar to traditional petroleum-refined diesel fuel while others are chemically and physically different. Future fuels may vary even more.

X3.7 Three areas for consideration when reviewing new fuels' alignment with existing standards or developing new standards are: test methods, chemical and physical limitations of fuels in existing specifications, and chemical and physical limitations appropriate for new fuels. The test methods that have been developed for existing burner fuels may or may not be appropriate for a new fuel. Guidance on materials used to develop a test method, and its applicability, can generally be found in a test method's scope and precision statements. The test method may also work for other materials.

X3.8 Applicability of the test method to materials outside its scope may be established by the subcommittee responsible for the method. Also, Subcommittee D02.E0, during the specification development process, may determine that a test method is applicable for specification purposes, even if the material is not in the test method's scope. Chemical and physical limits set in existing standards may or may not be appropriate to the new fuel or components. The new material may also require

chemical or physical limits that are not appropriate to fuels in existing standards. These along with other considerations may indicate the need for separate new specifications. Although each case will require a separate evaluation, logic suggests that the fewer chemical and physical differences there are between the new fuel and traditional petroleum-based fuel oils, the fewer differences in test methods and chemical or physical limits will be needed.

X3.9 If the proponent of the new fuel desires to move forward via the consensus process as described by ASTM bylaws and as implemented in Committee D02, then the proponent or a task force including the fuel manufacturer or proponent will bring forward ballot revisions to Specification D396 or a new specification appropriate for use of the new fuel or blendstock. Because D02 specifications are established based on technical data, such data should exist before the specification process moves forward. If such data does not exist, it needs to be developed.

X3.10 This guidance is not all-encompassing and cannot replace the judgment and process of a task force and subcommittee charged with evaluating a new fuel or blendstock. However it may give some guidance to proponents or fuel manufacturers who are considering participation in ASTM Committee D02 and its subcommittees to promote the inclusion of their new fuel or blendstock in ASTM standards.

SUMMARY OF CHANGES

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D396 – 15) that may impact the use of this standard. (Approved March 1, 2015.)

(1) Added Test Method D664, Test Method D7371, and Practice E29 to Section 2.
(2) Added EN 15751 to subsection 2.2.
(3) Added new subsections 1.1.2, 4.3.2, and 4.3.4; revised subsections 4.3.5 and 4.3.6.
(4) Revised Table 1 to add B6–B20 S500 and B6–B20 S5000 columns.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D396 – 14a) that may impact the use of this standard. (Approved Jan. 1, 2015.)

(1) Added new Discussion to 3.1.3.
(2) Added new Appendix X3.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D396 – 14) that may impact the use of this standard. (Approved Oct. 1, 2014.)

(1) Revised Table 3 to remove Range and Units Used to Report Results columns; expanded grade applicability of Test Method D7039.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D396 – 13c) that may impact the use of this standard. (Approved May 15, 2014.)

(1) Added new definition 3.1.3, *hydrocarbon oil*.
(2) Revised 4.1 and added new Note 4.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D396 – 13b) that may impact the use of this standard. (Approved Dec. 1, 2013.)

(1) An alternative test method for viscosity (Test Method D7042) was added to Sections 2 and 7.1.7.

Biodiesel Blends

Biodiesel is a domestically produced, renewable fuel that can be manufactured from new and used vegetable oils, animal fats, and recycled restaurant grease. Biodiesel's physical properties are similar to those of petroleum diesel, but the fuel significantly reduces greenhouse gas emissions and toxic air pollutants. It is a biodegradable and cleaner-burning alternative to petroleum diesel.

Biodiesel can be blended and used in many different concentrations. They include B100 (pure biodiesel), B20 (20% biodiesel, 80% petroleum diesel), B5 (5% biodiesel, 95% petroleum diesel), and B2 (2% biodiesel, 98% petroleum diesel). The most common biodiesel blend is B20, which qualifies for fleet compliance under the Energy Policy Act (EPAct) of 1992.

Can I use B20 in my vehicle's diesel engine?

As long as the vehicle was manufactured after 1993, biodiesel can be used in diesel engines and fuel injection equipment with little impact on operating performance. If your vehicle is older than that, beware. The engine could be assembled with incompatible elastomers, which can break down with repetitive high-blend biodiesel usage.

Regardless of your vehicle's age, it's a good idea to check original engine manufacturer (OEM) recommendations before using biodiesel. Most OEMs approve blends up to B5 in their vehicles. Some approve blends up to B20 if the fuel meets certain specifications and standards. One even approves B100 in certain types of farm equipment.

If you can't find OEM recommendations, check your engine manufacturer's Web site or speak with a dealer to determine the biodiesel blend that's right for your vehicle. In addition, you can find general information on the National Biodiesel Board (NBB) Web site (*www.biodiesel.org/resources/fuelfactsheets/standards_and_warranties.shtm*). Manufacturer-specific information is also available.[1]

Is biodiesel readily available?

Biodiesel is available in all 50 states. NBB tallies show that 450 million gallons of biodiesel were sold in 2007, up substantially from 2 million gallons in 2000.[2] As of January 2008, the United States had an annual production capacity of more than 2.2 billion gallons.[3]

The number of retailers, petroleum distributors, and biodiesel distributors offering biodiesel blends continues to grow. According to the Alternative Fuels Station Locator tool on the Alternative Fuels and Advanced Vehicles Data Center (AFDC) Web site, there are more than 800 biodiesel fueling sites across the country. To look up biodiesel stations in your area, visit *http://afdcmap2.nrel.gov/locator.*

Will biodiesel perform as well as diesel?

Testing results of engines operating on B20 show similar fuel consumption, horsepower, and torque to those operating on conventional diesel. Biodiesel has some additional desirable characteristics, including a higher cetane number (a measure of the ignition value of diesel fuel) and higher lubricity (the capacity for reducing friction) than U.S. diesel fuel. B20 also has an energy content between those of #1 and #2 diesel fuels.

Will biodiesel perform well in cold weather?

Just like common #2 diesel, certain high-freezing-point compounds in biodiesel will crystalize in very cold temperatures. Pure biodiesel crystalizes in warmer temperatures than #2 diesel fuel, but B20 blends are administered with the same fuel management techniques as #2 diesel. As temperatures get colder, proper blending for B20 becomes more critical, and the fuel's sensitivity to process variations increases. Blends of 5% biodiesel and below have a small impact on cold-flow properties (measures of low temperature operability). For more information on cold-flow properties and biodiesel handling, download Biodiesel Handling and Use Guidelines from *www.nrel.gov/vehiclesandfuels/npbf/pdfs/40555.pdf.*

Will biodiesel plug my vehicle filters?

Biodiesel has a solvent effect proportionate to the amount of biodiesel in the fuel. For example, B100 has a higher solvent effect than B20. This will clean your vehicle's fuel system and could release deposits accumulated on tank walls and in pipes from previous diesel fuel usage.

[1] Source: *www.biodiesel.org/pdf_files/OEM%20Statements/oem_matrix.pdf*

[2] Source: *www.biodiesel.org/pdf_files/fuelfactsheets/Production_Graph_Slide.pdf*

[3] Source: *www.biodiesel.org/buyingbiodiesel/producers_marketers/ProducersMap-Existing.pdf*

The release of deposits in higher biodiesel blends may initially clog filters, so you should be proactive in checking for and replacing clogged fuel filters. Once the build-up is eliminated, return to your regular replacement schedule. This issue is less prevalent with B20 and lower blends. There is no evidence that lower-blend levels plug filters.

Will long-term biodiesel use affect my engine?

Studies of B20 and lower blends have not shown long-term effects for in-specification biodiesel. In general, B100 can soften and degrade certain types of elastomers and natural rubber compounds over time. Using higher-level blends (above B20) can impact fuel system components (primarily fuel hoses and fuel pump seals) that contain elastomer compounds incompatible with biodiesel. The effect is lessened as the biodiesel blend level is decreased. For more information, visit *www.biodiesel.org*.

Can I use vegetable oil in my diesel engine?

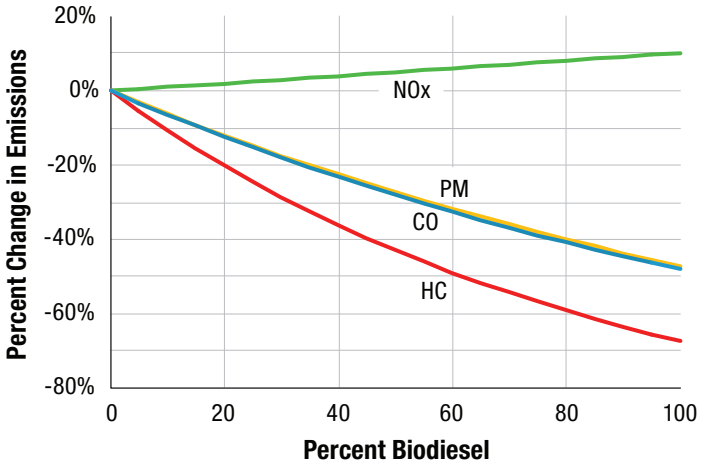
Straight vegetable oil is not the same as biodiesel and is generally not considered an acceptable fuel for large-scale or long-term use. It is not a legal motor fuel, it doesn't meet biodiesel fuel specifications and quality standards, and it is not registered with the U.S. Environmental Protection Agency (EPA). For more information, download "Straight Vegetable Oil as a Diesel Fuel," a fact sheet available on the AFDC at *www.eere.energy.gov/afdc/pdfs/39733.pdf*.

Is biodiesel cleaner burning than regular diesel?

The use of biodiesel in conventional diesel engines substantially reduces emissions of unburned hydrocarbons (HC), carbon monoxide (CO), sulfates, polycyclic aromatic HCs, nitrated polycyclic aromatic HCs, and particulate matter (PM). The reductions of these compounds increase as the amount of biodiesel blended into diesel fuel increases. B100 provides the best emission reductions, but lower-level blends also provide benefits. B20 has been shown to reduce PM emissions by 10%, CO by 11%, and unburned HCs by 21% (see Figure 1). Studies of oxides of nitrogen emissions have provided contradictory results, and additional testing and analysis is ongoing.

Biodiesel use also reduces greenhouse gas emissions because the carbon dioxide released in biodiesel combustion is offset by the carbon dioxide sequestered while growing the feedstock. B100 use reduces carbon dioxide emissions by more than 75% compared to diesel. Using B20 reduces carbon dioxide emissions by 15%.

Figure 1. Average Emission Impacts of Biodiesel for Heavy-Duty Highway Engines



Source: EPA, Draft Report EPA 420-P-02-001, Ocotober 2002

Does biodiesel need to meet any standards?

Biodiesel used in blends should meet specification D6751-07B, a standard set by ASTM International to ensure the quality of U.S. biodiesel used in blends. Biodiesel meeting this standard is legally registered as a fuel blendstock or additive with the EPA. As of January 2008, ASTM International was developing specifications explicitly for biodiesel blends.

Are incentives and credits available for biodiesel?

The American Jobs Creation Act of 2004 (Public Law 108-357) created tax incentives for biodiesel fuels, which are available to blenders and retailers. Section 1344 of EPAct 2005 extended the tax credit for biodiesel producers through 2008. The credits are $1 per gallon of agri-biodiesel and $.50 per gallon of waste-grease biodiesel. For more information, visit the State and Federal Incentives and Laws section of the AFDC at *www.eere.energy.gov/afdc/fuels/biodiesel_laws.html*.

Where can I find more information on biodiesel?

Visit the Biodiesel section of the AFDC at *www.eere.energy.gov/afdc/fuels/biodiesel.html*.

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Heating Oil Usage, FY13

Agency	#2 Fuel Oil	#4 Fuel Oil	#6 Fuel Oil	#2 B2 Fuel Oil	#4 B2 Fuel Oil	#2 B5 Fuel Oil	#4 B5 Fuel Oil	#6 B5 Fuel Oil	#2 B20 Fuel Oil	Total
Administration for Children's Services	603	0	0	0	0	14,490	0	0	0	**15,093**
Aging	0	0	0	0	0	3,002	0	0	0	**3,002**
Correction	2,501	0	0	0	0	162,584	0	0	0	**165,084**
DCAS	0	0	0	0	0	412,185	0	0	0	**412,185**
Education	89,546	324,728	254,104	0	0	7,759,300	10,387,813	6,349,972	0	**25,165,463**
Emergency Management	0	0	0	0	0	3,744	0	0	0	**3,744**
Environmental Protection	501	0	0	0	0	21,637	0	0	0	**22,138**
Fire	2,794	0	0	0	0	208,431	0	0	0	**211,225**
Health	0	0	0	0	0	26,651	0	0	0	**26,651**
Homeless Services	5,748	0	0	0	0	272,897	0	0	0	**278,644**
Housing Preservation and Development (city)	244,438	9,205	0	3,445,705	84,321	0	0	0	0	**3,783,669**
Human Resources Administration	4,000	2,844	0	0	0	72,630	72,767	0	0	**152,242**
Parks & Recreation	0	0	0	0	0	213,031	0	0	489,728	**702,759**
Police	6,804	0	0	0	0	551,286	0	0	0	**558,090**
Sanitation	0	0	0	0	0	1,074,914	0	47,210	0	**1,122,124**
Transportation	15,025	0	0	0	0	62,233	0	0	0	**77,259**
Citywide	**371,959**	**336,777**	**254,104**	**3,445,705**	**84,321**	**10,859,014**	**10,460,580**	**6,397,182**	**489,728**	**32,699,370**

Heating Oil Usage, FY14

Agency	#2 B5 Fuel Oil	#4 B5 Fuel Oil	#6 B5 Fuel Oil	#2 B20 Fuel Oil	Total
Administration for Children's Services	15,750	0	0	0	**15,750**
Aging	3,301	0	0	0	**3,301**
Correction	102,020	0	0	0	**102,020**
DCAS	767,410	0	0	0	**767,410**
Education	10,984,616	17,233,775	2,750,635	0	**30,969,026**
Environmental Protection	38,794	0	0	0	**38,794**
Fire	264,031	0	0	0	**264,031**
Health	20,226	0	0	0	**20,226**
Homeless Services	317,313	0	0	0	**317,313**
Human Resources Administration	79,275	13,728	0	0	**93,003**
Parks & Recreation	262,703	0	0	565,036	**827,739**
Police	644,243	0	0	0	**644,243**
Sanitation	1,139,462	0	123,837	0	**1,263,299**
Transportation	130,974	0	0	0	**130,974**
Citywide	**14,770,116**	**17,247,503**	**2,874,472**	**565,036**	**35,457,127**

Heating Oil Usage, FY15

Agency	#2 B5 Fuel Oil	#4 B5 Fuel Oil	#6 B5 Fuel Oil	#2 B10 Fuel Oil	#2 B20 Fuel Oil	Total
Administration for Children's Services	15,680	0	0	0	0	**15,680**
Aging	3,559	0	0	0	0	**3,559**
Correction	28,206	0	0	0	0	**28,206**
DCAS	832,357	0	0	0	0	**832,357**
Education	10,937,497	18,415,292	772,145	1,226,394	0	**31,351,328**
Environmental Protection	26,562	0	0	7,736	0	**34,299**
Fire	274,526	0	0	0	0	**274,526**
Homeless Services	321,281	0	0	0	0	**321,281**
Human Resources Administration	74,813	13,205	0	0	0	**88,018**
Parks & Recreation	200,871	0	0	472,412	12,868	**686,151**
Police	574,244	0	0	0	0	**574,244**
Sanitation	1,086,805	0	195,338	2,234	0	**1,284,378**
Transportation	60,558	0	0	0	0	**60,558**
Citywide	**14,436,960**	**18,428,497**	**967,483**	**1,708,777**	**12,868**	**35,554,585**