



PFI Standard Specification for Residential/Commercial Densified Fuel 18-June-2008

Pellet Fuel Institute (PFI) Standard Specification for Residential/Commercial Densified Fuel

1. Scope

- 1.1 This specification is applicable for the determination of fuel quality grade for Residential or Commercial Densified Fuel as shown in Table 1.
- 1.2 Fuel properties included in the specification are fines, bulk density, diameter, length, chloride, ash fusion properties, moisture content, heating value, pellet durability index and inorganic ash content. Bag weight is measured but is not part of the determination of fuel quality grade.
- 1.3 This specification is for the use of purchasers and users of Residential/Commercial Densified Fuel in selection of the grade most suitable to their needs.
- 1.4 Commercial users include commercial facilities that utilize densified fuel burning appliances or equipment that have the same fuel requirements as residential appliances. Commercial applications should not be confused with industrial applications, which can utilize a much wider array of materials and have vastly different fuel requirements.
- 1.5 The values stated in inch-pound units are to be regarded as the standard. Any values given in parentheses are mathematical conversions to the International System of Units (SI units), which are provided for information only and are not considered standard.
- 1.6 This standard specification does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard specification to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:

ASTM E 873-82 (2006) *Standard Test Method for Bulk Density of Densified Particulate Biomass Fuels.*

ASTM E 871-82 (2006) *Standard Test Method for Moisture Analysis of Particulate Wood Fuels*

D 1102-84 (2001) *Standard Test Method for Ash in Wood*

ASTM E 791-90 (2004) *Standard Test Method for Calculating Refuse-Derived Fuel Analysis Data from As-Determined to Different Bases*

ASTM E 776-87 (2004) *Standard Test Method for Forms of Chlorine in Refuse-Derived Fuel*

ASTM D 4208-02e1 *Standard Test Method for Total Chlorine in Coal by the Oxygen Bomb Combustion/Ion Selective Electrode Method*

ASTM D 6721-01 (2006) *Standard Test Method for Determination of Chlorine in Coal by Oxidative Hydrolysis Microcoulometry*

ASTM E 711-87 (2004) *Standard Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter*

ASTM E29-06b *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM C702-98(2003) *Standard Practice for Reducing Samples of Aggregate to Testing Size*

ASTM D1857-04 *Standard Test Method for Fusibility of Coal and Coke Ash*

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2.2 Other Referenced Documents:

Kansas State University - *Mechanical Durability of Feed Pellets*, Call Number: LD2668 .T4
1962 Y68

PFI *Quality Assurance/Quality Control (QA/QC) Program for Residential/Commercial Densified Fuels*

3. Terminology

3.1 Definitions: General

- 3.1.1 Bulk Density – the fuel mass per cubic foot of the fuel sample as determined by ASTM E873-82 (2006).
- 3.1.2 Bag Weight – the weight of the fuel plus the bag, determined by weighing a standard bag of fuel.
- 3.1.3 Diameter – the average diameter of the fuel pellets in the fuel sample.
- 3.1.4 Pellet Durability Index (PDI) – a parameter for specifying the ability of the fuel pellets to resist degradation caused by shipping and handling.
- 3.1.5 Fines – the percentage of fuel material in the fuel sample passing through a 1/8 inch screen when the fuel is sampled after completion of production and bagging and before transportation, unloading, distribution, use, etc.
- 3.1.6 Inorganic Ash – the percent inorganic material in the fuel sample as determined by ASTM D1102-84 (2001).
- 3.1.7 Length – the weight percent of pellets exceeding 1.5 inches in length in the fuel sample.
- 3.1.8 Moisture – the moisture content of the as-received fuel sample as determined by ASTM E871-82 (2006).
- 3.1.9 Heating Value – The higher heating value of the fuel sample as determined by ASTM E711-87 (2004).
- 3.1.10 Additives – Any substance other than virgin cellulosic material that has been intentionally introduced into the fuel feed stock prior to pellet extrusion (except steam/water). Trace amounts of grease or other lubricants that are introduced into the fuel processing stream as part of normal mill operations are not considered as additives.
- 3.1.11 Chemically Treated Materials – Any feed stock material (cellulosic or otherwise) that has at any time been processed, formed, treated or contaminated with any bonding agent, resin, preservative, surface coating or other finish, or any other chemical compound. Trace amounts of grease or other lubricants that are introduced into the fuel processing stream as part of the normal mill operations are not considered as chemically treated materials.
- 3.1.12 NIST - The National Institute of Standards and Technology is a federal technology agency that develops and promotes measurement, standards, and technology.

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TABLE 1 PFI Fuel Grade Requirements

Fuel Property	Residential/Commercial Densified Fuel Standards - See Notes 1 - 9			
	PFI Super Premium	PFI Premium	PFI Standard	PFI Utility
Bulk Density, lb./cubic foot	40.0 - 46.0	40.0 - 46.0	38.0 - 46.0	38.0 - 46.0
Diameter, inches	0.250 - 0.285	0.250 - 0.285	0.250 - 0.285	0.250 - 0.285
Diameter, mm	6.35 - 7.25	6.35 - 7.25	6.35 - 7.25	6.35 - 7.25
Pellet Durability Index	≥ 97.5	≥ 97.5	≥ 95.0	≥ 95.0
Fines, % (at the mill gate)	≤ 0.50	≤ 0.50	≤ 0.50	≤ 0.50
Inorganic Ash, % - See Note 1	≤ 0.50	≤ 1.0	≤ 2.0	≤ 6.0
Length, % greater than 1.50 inches	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
Moisture, %	≤ 6.0	≤ 8.0	≤ 8.0	≤ 10.0
Chloride, ppm	≤ 300	≤ 300	≤ 300	≤ 300
Ash Fusion - See Note 8	NA	NA	NA	NA
Heating Value - See Note 1	As-Rec. ± 2SD	As-Rec. ± 2SD	As-Rec. ± 2SD	As-Rec. ± 2SD

Table 1 Notes:

1. There is no required value or range for Heating Value. It is required to print the mean higher heating value in BTU per pound as well as the ash content on the fuel bag label using a bar scale to represent the mean value ± 2 Std. Dev. See note 9.
2. The bag must be labeled indicating which PFI grade of material is in the bag. See note 9.
3. The bag label must also disclose the type of materials as well as all additives used. For purposes of this standard specification, additives are defined in 3.1.10. See note 9.
4. It is required that manufacturers include on their bags the PFI logo and in a printed block the guaranteed analysis of the fuel. See note 9.
5. PFI prohibits the use of any chemically treated materials. For purposes of this standard specification, chemically treated materials are defined in 3.1.11.
6. The following applies to all limits in this table: For purposes of determining the fuel grade, all properties must fall at or within the specified limits listed for a particular grade. Observed or calculated values obtained from analysis shall be rounded to the nearest unit in the last right-hand place of the figures used in expressing the limit in accordance with ASTM E 29-06b *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.
7. It is the intent of these fuel grade requirements that failure to meet any fuel property requirement of a given grade does not automatically place a fuel in the next lower grade unless it meets all requirements of the lower grade.

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8. It is required to report ash fusion properties at a frequency as specified in the PFI *Quality Assurance/Quality Control (QA/QC) Program for Residential/Commercial Densified Fuels*.
9. Refer to PFI *Quality Assurance/Quality Control (QA/QC) Program for Residential/Commercial Densified Fuels* for specific labeling requirements for fuel properties and other information.

4. Detailed Requirements

- 4.1 The various grades of densified fuel shall conform to the limiting requirements shown in Table 1.

5. Sampling and Sample Handling

- 5.1 The reader is strongly advised to review all intended test methods and sampling requirements prior to sampling in order to understand the importance and effects of sampling technique and special handling required for each method. Representative samples shall be taken for testing in accordance with the PFI *Quality Assurance/Quality Control (QA/QC) Program for Residential/Commercial Densified Fuels*.

6. Test Methods

- 6.1 The requirements enumerated in this specification shall be determined in accordance with the referenced ASTM test methods or other referenced methods except where modifications are noted or in accordance with the test procedures specified.
 - 6.1.1 Bulk Density – Test Method E 873-82 (2006) except this method shall be revised to utilize a 1/4 cubic foot container that is tapped 25 times from 1 inch. In order to insure that an adequate sample quantity is available for this revised method, a minimum sample size of 12 pounds (5.44 kilograms) is recommended.
 - 6.1.2 Bag Weight – Record and report the sample bag weight using the balance or scale specified in 8.1. All weights shall be measured and recorded to the nearest gram.
 - 6.1.3 Diameter - Select 5 pellets randomly out of the pellet sample being evaluated and measure the diameter of each pellet with the caliper specified in 8.2. Each measured pellet diameter shall be recorded to the nearest 0.001 inch. The average pellet diameter as well as the range of all pellet diameters measured shall be calculated and reported to the nearest 0.001 inch .
 - 6.1.4 Pellet Durability Index (PDI) - Durability shall be determined by using the Kansas State method with one modification. The screen size used in determining durability shall be a 1/8-inch (3.17 mm) wire screen sieve. A summarization of the Kansas State method with the specified modification is provided in Annex A.1. All weight measurements shall be conducted using the analytical balance specified in 8.3 and recorded to the nearest 0.1 grams. It should be noted that the pellets remaining after performing the fines determination as specified in 6.1.5 can be used without further preparation to conduct the durability test.
 - 6.1.5 Fines – Determined using the following procedure that incorporates the use of a 1/8-inch (3.17 mm) wire screen sieve. All weight measurements shall be recorded to the nearest 0.1 gram.
 - 6.1.5.1 Secure a representative fuel sample.

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- 6.1.5.2 Reduce the sample size down to a minimum of 2.5 pounds (1,133 grams) using a sample splitter with 3.5-inch (89 mm) slots. Larger sample sizes may be used.
- 6.1.5.3 Using the analytical balance specified in 8.3, weigh the sample and record as the initial sample weight.
- 6.1.5.4 Weigh the receiving pan and record the weight.
- 6.1.5.5 Attach a 1/8-inch (3.17 mm) screen to the receiving pan and place the pellet sample on the screen using care not to overload the screen. The maximum load on the screen should not exceed 1 pound (453 grams) of pellets per 100 square inches (654 square centimeters) of screen surface area. Smaller screens may require the sample to be screened in increments.
- 6.1.5.6 Screen the sample by tilting the screen side to side 10 times.
- 6.1.5.7 If the sample is being screened in increments, after the first portion has been screened remove the 1/8-inch (3.17 mm) screen from the base pan, and empty the pellets off the screen.
- 6.1.5.8 Repeat 6.1.5.5 through 6.1.5.7 until the entire sample has been screened.
- 6.1.5.9 Remove the 1/8-inch (3.17 mm) screen and weigh and record the weight of the base pan with the fines.
- 6.1.5.10 Calculate and report the percent of fines to the nearest 0.01% as follows:

$$\% \text{ Fines} = \frac{[(\text{Weight of Base Pan} + \text{Fines}) - (\text{Weight of Base Pan})]}{\text{Initial Sample Weight}} \times 100$$

- 6.1.6 Inorganic Ash - ASTM D 1102-84 (2001)
- 6.1.7 Length - Starting with 2.5 pounds (1.13 kilograms) of pellets randomly selected from the sample being evaluated, hand sort to identify pellets over 1.50 inches in length. Use the caliper specified in 8.2 or a certified measuring block as specified in 8.4 to confirm that a pellet exceeds the specified length. The weight percent of all pellets exceeding the specified length shall be reported. In addition, of the pellets exceeding the specified length, the longest pellet shall be identified, measured with the caliper specified in 8.2, and the length reported as the maximum pellet length.
- 6.1.8 Moisture - ASTM E 871-82 (2006)
- 6.1.9 Higher Heating Value - ASTM E 711-87 (2004)
- 6.1.10 Chloride - ASTM E 776-87 (2004) or ASTM D 4208-02e1 or ASTM D 6721-01 (2006)
- 6.1.11 Ash Fusion - ASTM D1857-04

7. Sample Preparation

- 7.1 A sample preparation schematic is shown in Annex B.1 to illustrate how a 40 lb bag of pelletized material should be subdivided to perform the analysis procedures. All sample subdividing shall be conducted utilizing a sample splitter with a slot width of 3.5 inches (89 mm) and meeting the requirements specified in ASTM C702-98 (2003).

8. Equipment and Supplies

- 8.1 Scale – A scale capable of weighing the sample bag of fuel to within 0.1 lb (0.05 kg). Must meet the calibration requirements specified in 9.1.

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- 8.2 Caliper – A vernier caliper capable of measuring fuel diameter and length to within 0.001 in. (0.025 mm). Must meet the calibration requirements specified in 9.2.
- 8.3 Analytical Balance – A balance with a resolution of 0.1 g or better. Must meet the calibration requirements specified in 9.3.
- 8.4 Measuring Block – A 1.50 inch long gauge block used for screening fuel pieces for length. Must meet the requirements specified in 9.4.

9. Calibration and Standardization

- 9.1 Scale - Perform a multi-point calibration (at least five points spanning the operational range) of the scale before its initial use. The scale manufacturer's calibration results are sufficient for this purpose. Before each certification test, audit the scale by weighing at least one calibration weight (ASTM Class F) that corresponds to between 80 percent and 120 percent of the expected fuel bag weight. If the scale cannot reproduce the value of the calibration weight within 0.1 lb (0.05 kg) or 1 percent of the expected fuel bag weight, whichever is greater, recalibrate the scale before use with at least five calibration weights spanning the operational range of the scale.
- 9.2 Caliper – Before each test, audit the caliper by measuring one NIST traceable gauge block that corresponds to between 80 percent and 120 percent of the anticipated fuel diameter and by measuring the length of the measuring block specified in 8.4. If the caliper can not reproduce the calibration gauge dimensions within 1%, the caliper may not be used.
- 9.3 Analytical Balance - Perform a multipoint NIST traceable calibration (at least five points spanning the operational range) of the analytical balance before the first test and semiannually, thereafter. Before each test, audit the balance by weighing at least one calibration weight (ASTM Class 1) that corresponds to 50 to 150 percent of the weight of the fuel sample to be measured. If the scale cannot reproduce the value of the calibration weight to within 0.1 g, recalibrate the balance before use with at least five calibration weights spanning the operational range of the balance.
- 9.4 Measuring Block – The length of the block must be traceable to NIST and demonstrate accuracy of ± 0.01 in. from length specified in 8.4. The block manufacturer's certification documents are sufficient for this purpose.

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Annex A.1

**Pellet Fuels Institute
Standard Operating Procedure for:
Durability Testing – Residential/Commercial Pellet Fuels**

Produced by: PFI Standards Committee

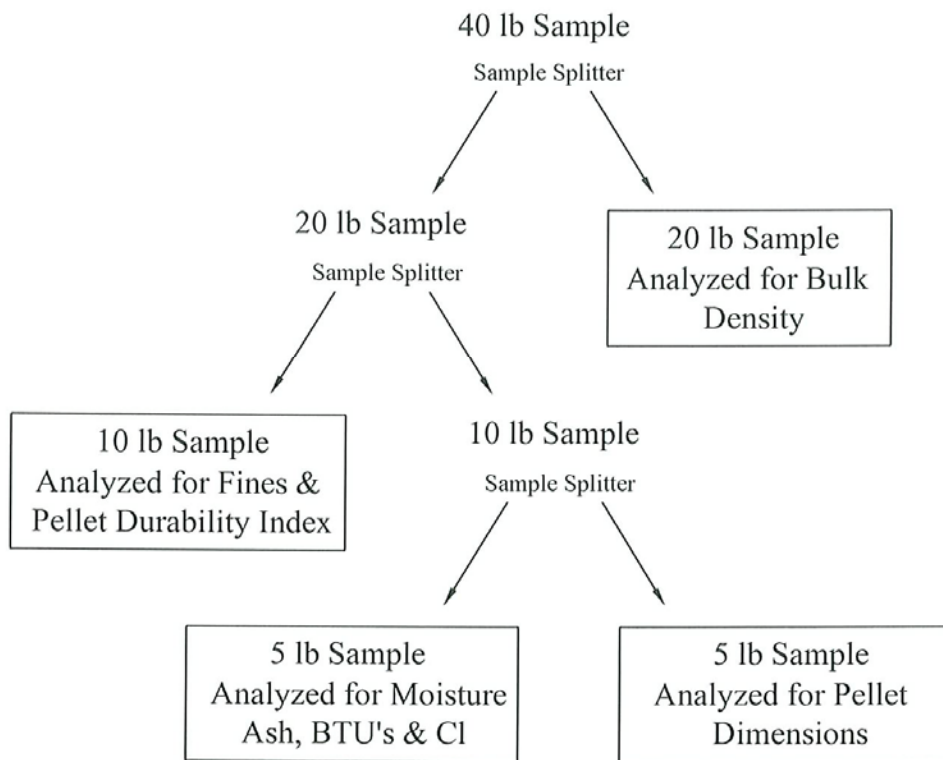
The Pellet Fuels Institute has adopted the test procedure outlined by Kansas State University in assessing the durability of residential grade pelletized fuel products, with the exception that the screen size used in determining durability is to be a 1/8-inch (3.17 mm) wire screen sieve. The durability tester is to be of the metal tumbler type with chamber dimensions of 12 inches long (305 mm) x 5.5 inches wide (140 mm) x 12 inches deep (305 mm). The results of the test are interpreted as a standard measure of quality, which is referred to as the Pellet Durability Index (P.D.I). All durability tests should be conducted in duplicate and the average of the two tests reported. The procedure is outlined as follows:

1. Secure a representative sample.
2. Screen the representative sample with a 1/8-inch wire screen sieve to remove fines. Obtain the initial sample from the portion retained on the screen.
3. Weigh approximately 500 grams of screened sample and record as the initial weight (IW).
4. Tumble the pre-weighed sample of screened pellets in the durability tester for 10 minutes at 50 rotations per minute.
5. Re-screen the sample and weigh the portion retained on the 1/8-inch sieve. Record as the whole pellet sample weight (WPW).
6. Compute Pellet Durability Index (PDI) by dividing the whole pellet sample weight (WPW) by the initial weight (IW) of the sample and multiply by 100. Report to one decimal place.

$$PDI = 100 \times \frac{WPW}{IW}$$

7. Repeat steps 2-6 on a second portion of the representative sample.

Annex B.1 Sample Preparation and Analysis Flow Chart



* Sample Splitters should have a slot width of 3.5 inches (89 mm)

* Additional sample splitting may be necessary to analyze some parameters