



PFI Standard Specification for Residential/Commercial Densified Fuel

Proposed Revisions as of June 23, 2010

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 Normative fuel properties included in the specification are fines, bulk density, diameter, length, chloride, moisture content, pellet durability index and inorganic ash content. Determination of these properties is mandatory for determining fuel quality grade. Informative fuel properties include ash fusion and heating value. Determination of these properties is not mandatory for determining fuel quality grade.
- 1.3 This specification is for the use of densified fuel producers to establish grade requirements for the certification of North American Residential/Commercial densified fuel. It is also for the use of pellet fuel appliance manufacturers for the purpose of designing appliances that meet air emission regulations that cite this standard specification and for users of residential/commercial densified fuel in selection of the grade most suitable to their appliance.
- 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. If values are stated in SI units only, they are to be regarded as the 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 Standards¹:

ASTM E 873 *Standard Test Method for Bulk Density of Densified Particulate Biomass Fuels.*

ASTM E 871 *Standard Test Method for Moisture Analysis of Particulate Wood Fuels*

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

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

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

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

ASTM D 6721 *Standard Test Method for Determination of Chlorine in Coal by Oxidative Hydrolysis Microcoulometry*

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

1. For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org.

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ASTM E 29 *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM C 702 *Standard Practice for Reducing Samples of Aggregate to Testing Size*

ASTM D 1857 *Standard Test Method for Fusibility of Coal and Coke Ash*

2.2 Other Referenced Documents:

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

3. Terminology

3.1 Definitions: General

- 3.1.1 *bulk density* – the fuel mass per cubic foot of the fuel sample
- 3.1.2 *diameter* – the average diameter of the fuel pellets in the fuel sample.
- 3.1.3 *Pellet Durability Index (PDI)* – a standardized parameter for specifying the ability of the fuel pellets to resist degradation caused by shipping and handling.
- 3.1.4 *finest* – the percentage of fuel material in the fuel sample passing through a 1/8 inch screen when the fuel is sampled in accordance with the requirements in 6.1.4.
- 3.1.5 *inorganic ash* – the percent inorganic material in the fuel sample.
- 3.1.6 *length* – the weight percent of pellets exceeding 1.5 inches in length in the fuel sample.
- 3.1.7 *Moisture* – the moisture content of the as-received fuel sample.
- 3.1.8 *heating value* – The higher heating value of the fuel sample.
- 3.1.9 *NIST* - The National Institute of Standards and Technology is a federal technology agency that develops and promotes measurement, standards, and technology.

TABLE 1 PFI Fuel Grade Requirements

Fuel Property	Residential/Commercial Densified Fuel Standards - See Notes 1 & 2			
	PFI Super Premium	PFI Premium	PFI Standard	PFI Utility
Normative Information - Mandatory				
Bulk Density, lb./cubic foot	40.0 - 46.0	40.0 - 46.0	38.0 - 46.0	38.0 - 46.0
Diameter, inches	0.230 - 0.285	0.230 - 0.285	0.230 - 0.285	0.230 - 0.285
Diameter, mm	5.84 - 7.25	5.84 - 7.25	5.84 - 7.25	5.84 - 7.25
Pellet Durability Index	≥ 96.5	≥ 96.5	≥ 95.0	≥ 95.0
Fines, % (at the mill gate)	≤ 0.50	≤ 0.50	≤ 1.0	≤ 1.0
Inorganic Ash, %	≤ 0.50	≤ 1.0	≤ 2.0	≤ 6.0
Length, % greater than 1.50 inches	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
Moisture, %	≤ 8.0	≤ 8.0	≤ 10.0	≤ 10.0
Chloride, ppm	≤ 300	≤ 300	≤ 300	≤ 300
Informative Only - Not Mandatory				
Ash Fusion	NA	NA	NA	NA
Heating Value	NA	NA	NA	NA

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Table 1 Notes:

1. 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 *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.
2. 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.

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.

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 – Determine in accordance with ASTM E 873 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 Diameter - Select 5 pellets randomly out of the pellet sample being evaluated and measure the diameter of each pellet with the caliper specified in 8.1. 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.
 - 6.1.3 Pellet Durability Index (PDI) – Pellet durability shall be determined by using the method specified in Annex A.1. It should be noted that the pellets remaining after performing the fines determination as specified in 6.1.4 can be used without further preparation to conduct the durability test.
 - 6.1.4 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.
 - 6.1.4.1 Secure a representative fuel sample.
 - 6.1.4.2 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.
 - 6.1.4.3 Using the analytical balance specified in 8.2, weigh the sample and record as the initial sample weight to the nearest 0.1 grams.
 - 6.1.4.4 Weigh the receiving pan and record the weight to the nearest 0.1 grams.

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- 6.1.4.5 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.
- 6.1.4.6 Screen the sample by tilting the screen side to side 10 times.
- 6.1.4.7 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.
- 6.1.4.8 Repeat 6.1.4.5 through 6.1.4.7 until the entire sample has been screened.
- 6.1.4.9 Remove the 1/8-inch (3.17 mm) screen and weigh and record the weight of the base pan with the fines to the nearest 0.1 grams.
- 6.1.4.10 Calculate and report the percent of fines to the nearest 0.01% as follows:

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

- 6.1.5 An alternative fines determination procedure is provided in Annex C.1.
- 6.1.6 Inorganic Ash – Determine in accordance with ASTM D 1102.
- 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 8.1 or a certified measuring block as specified in 8.3 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 8.1, and the length reported as the maximum pellet length.
- 6.1.8 Moisture – Determine in accordance with ASTM E 871.
- 6.1.9 Chloride – Determine in accordance with ASTM E 776 or ASTM D 4208 or ASTM D 6721.
- 6.1.10 Ash Fusion - Determine in accordance with ASTM D1857.
- 6.1.11 Heating Value – Determine in accordance with ASTM E 711.

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 C 702.

8. Equipment and Supplies

- 8.1 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 9.1.
- 8.2 Analytical Balance – A balance with a resolution of 0.1 g or better. Must meet the calibration requirements specified in 9.2.
- 8.3 Measuring Block – A 1.50 inch long gauge block used for screening fuel pieces for length. Must meet the requirements specified in 9.3.

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9. Calibration and Standardization

- 9.1 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 8.3. If the caliper can not reproduce the calibration gauge dimensions within 1%, the caliper may not be used.
- 9.2 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.
- 9.3 Measuring Block – The length of the block must be traceable to NIST and demonstrate accuracy of ± 0.01 in. from length specified in 8.3. 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 (See Kansas State University - *Mechanical Durability of Feed Pellets*, Call Number: LD2668 .T4 1962 Y68) for assessing the durability of residential/commercial densified pellet fuel products, with the exception that the screen size used in determining durability has been modified to be a 1/8-inch (3.17 mm) wire screen sieve.

The durability tester consists of a dust tight box. The box shall be made of a rigid material with smooth and flat surfaces (e.g., stainless steel plate). The inner dimensions of the box shall be 305 ± 3 mm long by 140 ± 3 mm wide by 305 ± 3 mm deep. It shall rotate about an axis which is perpendicular to and centered in the nominal 305 mm by 305 mm sides. A 230 ± 3 mm long baffle is affixed symmetrically to a diagonal of one nominal 305 mm by 305 mm side of the box. The baffle extends 50 ± 1 mm into the box and is securely fastened to the back of the box. The edges of the baffle shall not be sharp, but rounded to avoid any cutting effect. A door may be placed on any side of the box. Projections, such as rivets and screws, shall be kept to a minimum and well rounded (alternatively, flat head screws may be used. An illustration of the tester is shown in Fig 1.

The procedure is outlined as follows:

1. Secure a representative pellet fuel sample. The minimum recommended representative sample weight is 1100 grams.
2. Screen the representative sample with a 1/8-inch wire screen sieve to remove fines. Obtain the initial test sample from the portion of the representative sample retained on the screen.
3. Using the analytical balance specified in 8.3, weigh 500 ± 10 grams of the initial test sample and record as the initial weight to the nearest 0.1 grams (IW).
4. Tumble the pre-weighed initial test sample in the durability tester at 50 ± 2 rotations per minute for a total of 500 rotations.
5. Re-screen the tumbled test sample weigh the portion retained on the 1/8-inch sieve and record as the whole pellet sample weight to the nearest 0.1 grams (WPW).

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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 fuel sample.

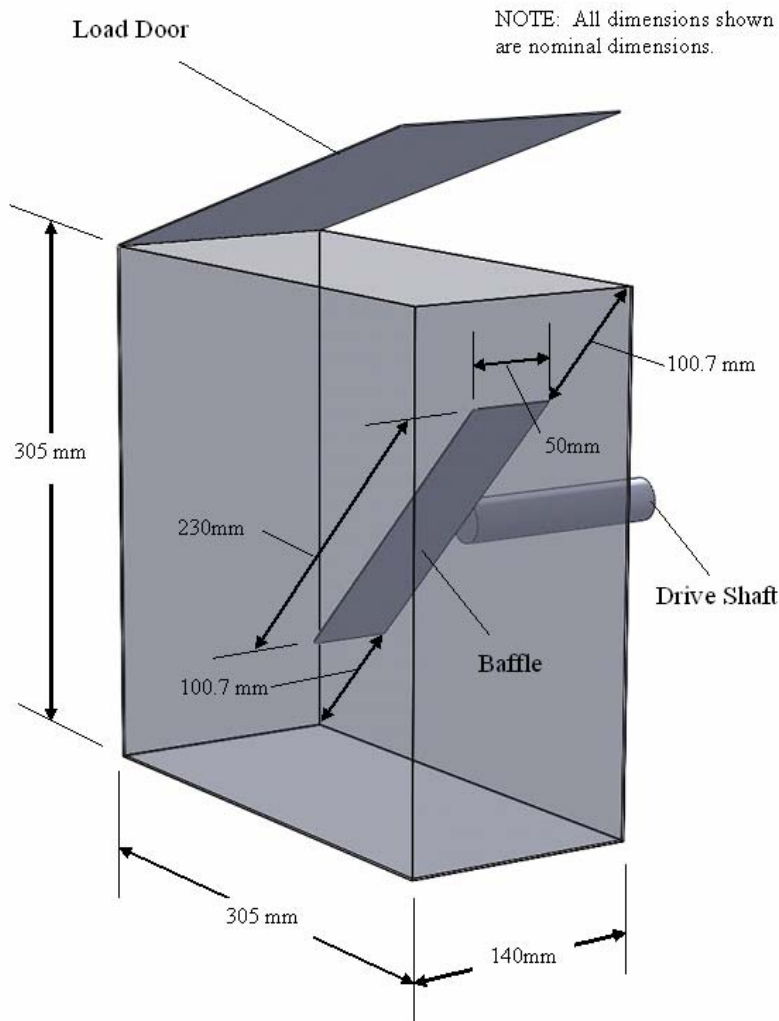
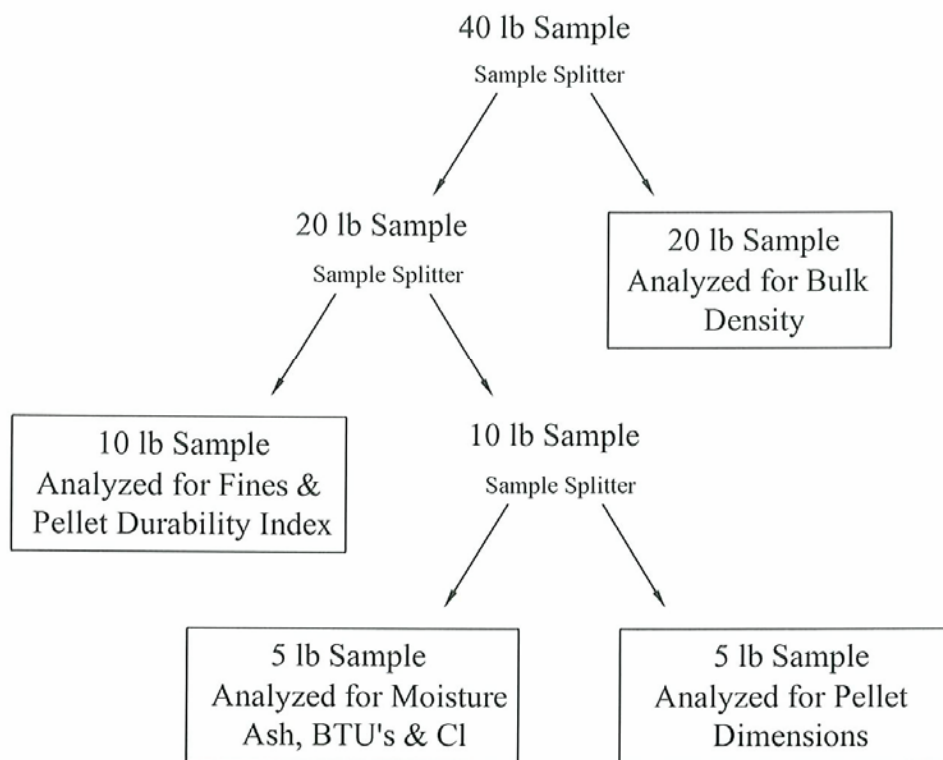


FIG 1. Pellet Durability Tester

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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

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Placeholder for Alternative Fines Testing Procedure