Notification on Specifications and Quality Standards of Wood Pellets

Enacted on May 21, 2009. National Forest Research Institute, Notification No. 2009-2
Amended on June 28, 2013. National Forest Research Institute, Notification No. 2013-5

Article 1 (Purposes)
This Standard establishes the specifications and quality standards for domestically produced and imported wood pellets in order to enhance the quality of wood pellets, one of the solid biofuels specified in Article 20 Paragraph 1 of the "Act on the Sustainable Use of Timbers" (No. 11429), and to establish an order related to logistics and delivery.

Article 2 (Definitions)
The definitions of terms used in this Standard shall be as follows:

(1) The term "wood pellet" means a standardized wood-based solid biofuel of cylindrical shape produced by compression molding of wooden materials uncontaminated by hazardous materials.
(2) The expression "wooden materials uncontaminated by hazardous materials" means all wooden materials, excluding wood treated with chemicals such as preservatives and paints, wood recovered from furniture and buildings, and wood of unclear origin.
(3) The term "compression molding" means the process of molding pellets into a regular shape and diameter by passing raw materials through a molding frame under high pressure.
(4) The term "bulk density" means the ratio of the wood pellet mass to the container volume. It is an index useful for transportation and other practical purposes.
(5) The term "moisture content" means the percentage of the water mass in wood pellets on a wet mass basis.
(6) The term "ash content" means the percentage of residual minerals left after burning wood pellets under specific conditions in relation to the total dry mass.
(7) The term "fine content" means the percentage of particles generated during wood pellet production that are smaller than a certain specified size and included in the package at the time of delivery, on a wet mass basis.
(8) The term "durability" means the percentage of the mass of unformed pellets that remains after the tumbler test, in relation to the total wet mass. It is an index indicating the strength of wood pellets.
(9) The term "calorific value" means the calorific value generated by burning wood pellets and is expressed as the calories per the oven-dried mass.
(10) The term "additives" means all materials other than wood that are added to facilitate wood pellet molding.

Article 3 (Raw Materials)
Raw materials include softwood and hardwood sawdust or chips. The following items cannot be used for the production of wood pellets:

(1) Wood treated with preservatives
(2) Wood exposed to chemical treatments, such as binding, painting, or immersion
(3) Wood recovered from building demolition
(4) Wood of unclear origin

Article 4 (Classification of Wood Pellets)
Wood pellets are classified into white-wood pellets, bark pellets, and common pellets.

(1) White-wood pellets: wood pellets with bark content of 5% or less
(2) Bark pellets: wood pellets with bark content of 50% or more
(3) Common pellets: wood pellets with bark content ranging between 5% and 50%

Article 5 (Quality Standards for Wood Pellets and Testing Methods)
Quality standards for wood pellets and testing methods shall be specified as follows.

(1) Quality Standards

1. The quality standards for wood pellets shall be specified in Appended Table 1.
2. The quality grade for wood pellets shall be as follows:
   1) Grade 1
   2) Grade 2
   3) Grade 3
   4) Grade 4

(2) Testing Methods

1. Sampling

1) Wood pellet producers or importers should prepare samples of their fabricated or imported wood pellets when they are ready for delivery.
   Wood pellet sampling for testing purposes should be done as per the following specifications.

Retail packaging of wood pellets		Bulk packaging of wood pellets	
Package mass (kg)	Sample mass (kg)	Population mass (t)	Number of samples per bulk
< 20	2	< 1	4–6
20–49	2–3	1–2	6–8
50–99	5–8	2–5	8–10
100–449	8–10	5–10	10–15
≥ 500	10–15	≥ 10	15–20

2) From the pellets taken from a package, some or all shall be evenly spread over a clean plate. Sampling can be done using the splitter method or cone-and-quarter method as follows.
   a. Splitter method: Extracted pellets are poured evenly into a splitter and one of the two heaps is randomly chosen. The process continues with the chosen half at each repetition until the intended testing amount is obtained. The sample thus collected is put into a glass bottle or plastic pouch and sealed.
   b. Cone-and-quarter method: Extracted pellets are heaped to a cone shape, which is then flattened perpendicularly from the vertex. After one or two repetitions of this process, the flattened sample is evenly divided into four equal fan-shaped sectors, and one diagonal pair is randomly chosen. The whole process can be repeated until a suitable amount for testing is obtained. The sample thus collected is put into a glass bottle or plastic pouch and sealed.

2. Size

1) Of the sampled pellets, 25 are randomly collected and the length and diameter of each pellet is measured with a vernier caliper to 0.1 mm precision and rounded to the nearest mm for recording.

3. Bulk Density

1) Measurement containers should be of a robust material and have a cylindrical form, with a height-to-diameter ratio ranging between 1.25 and 1.50. Both large and small containers are used depending on the pellet diameter. The small container is used for pellets with diameters up to 12 mm.
   a. The large measurement container can contain 50 L (0.05 m^3), with a permissible deviation of 1 L. A standard container has an inner diameter of 360 mm and inner height of 491 mm.
   b. The small measurement container can contain 5 L (0.005 m^3), with a permissible deviation of 0.1 L. A standard container has an inner diameter of 167 mm and inner height of 228 mm.
2) The exact volume of the large and small measurement containers should be measured to within 0.01 L (0.00001 m^3) and 0.001 L (0.000001 m^3), respectively, using water.
3) The sample is poured slowly into the container from a height of 200–300 mm from the container rim to form a conical heap. The heap is then compacted by dropping the container three times from a height of 150 mm onto a 15-mm-thick wooden plate placed on a flat, hard surface. Filling and compacting are repeated until the container is overflowing. Excess pellets are removed by sliding a 50-mm straight edge across the top of the container. The small and large containers are weighed to 1 g and 10 g precision, respectively. 4) Immediately after determining the bulk density, the moisture content should be determined.
5) Measurements should be made at least in duplicate. Bulk density should be calculated to the first digit using the following formula in units of kg/m^3. The mean values are rounded to the nearest 10 kg/m^3 for recording.

$$D_{ad}(at\ M_{ad}) = \frac{(M_2 - M_1)}{V}$$

D_{ad}: bulk density on a wet mass basis
M_{ad}: moisture content on a wet mass basis
m_1: mass of the empty container
m_2: mass of the container fully loaded with pellets
V: volume of the container

※ $D_{dm} = D_{ad} \times \frac{(100 - M_{ad})}{100}$

D_{dm} : bulk density of the oven-dried pellets

4. Moisture content

1) The measurement bottle with lid is dried at 105 ± 3℃ till the mass is constant and then cooled down to room temperature.
2) The mass of the empty bottle, including the lid, is measured and recorded to 0.01 g precision.
3) The measurement bottle is evenly filled with at least 20 g of pellets, and the loaded mass, including the lid, is measured.
4) After removing the lid, drying is continued at 105 ± 3℃ until no fluctuations are observed in the loaded mass of the bottle and sample. The lid is dried in the same oven.
5) The lid is again placed in the oven and the bottle is moved to a desiccator, where it is cooled to room temperature.

6) The loaded measurement bottle, including the lid, is measured to 0.01 g precision.
7)Measurements should be made at least in duplicate. Moisture content is calculated to 0.01% precision using the following formula, and the mean values are rounded to the nearest 0.1% for record.

$$M_{ad} = \frac{(m_2 - m_3)}{(m_2 - m_1)}$$

M_{ad}: moisture content of pellets on a wet mass basis
m_1: mass of the empty measurement bottle + lid
m_2: mass of bottle + lid + sample before drying
m_3: mass of bottle + lid + sample after oven-drying

5. Ash content

1) A crucible is preheated in a muffle furnace at 575 ± 25℃ for at least 60 min. After being taken out of the furnace, the crucible is cooled for 5–10 min and then placed in a desiccator without desiccant and cooled to room temperature. When the mass of the crucible reaches a constant level of 0.1 mg, the mass is recorded.
2) Pellets are crushed to sizes that can pass through a sieve with a 1-mm metal mesh and carefully mixed prior to weighing. At least 1 g of the crushed and sieved sample is evenly spread in the crucible. The net mass is determined and recorded at 0.1 mg precision. If the test sample has been oven-dried earlier, the loaded crucible should be dried again at 105 ± 3℃ to remove additional infiltrated moisture to ensure a precise measurement.
3) The loaded crucible is placed in the cooled muffle furnace and heated according to the following heating schedule:
   a. The furnace is heated to 250℃ at a rate of 4–5℃/min and left to cool for 60 min.
   b. The furnace is heated to 575 ± 25℃ at a rate of 5–6℃/min for 60 min and maintained at this temperature for at least 120 min.
4) The crucible is taken out of the furnace, left in ambient conditions for 5–10 min, and cooled in a desiccator without desiccants to room temperature. Measurements are made and recorded to 0.1 mg precision.
5) If incomplete combustion is suspected, for example by the evidence of soot,
   a. the sample is subjected to additional burning at 575 ± 25℃ for 30 min.
   b. the sample, with a few added drops of distilled water or ammonium nitrate, is subjected to additional burning at 575 ± 25℃ for 30 min, followed by weighing.
6) Measurements should be made at least in duplicate. Ash content is calculated on a dry mass basis to 0.01% precision using the following formula, and the mean values are rounded to the nearest 0.1% for recording.

$$A_{dm} = \frac{(m_3 - m_1)}{(m_2 - m_1)} \times 100 \times \frac{100}{100 - M_{ad}}$$

A_{dm}: ash content of oven-dried pellets on a dry mass basis
m_1: mass of the crucible
m_2: mass of the crucible + sample
m_3: mass of the crucible + ash
M_{ad}: moisture content of pellets on a wet mass basis

6. Fine content

1) At least 50 g of pellets are taken from a package and the mass is measured to 0.01 g precision.
2) Pellets are placed in a sieve with a diameter of 3.15 mm and an effective sieving area of 250 cm^2 or larger in accordance with ISO 3310-2, and are made to pass through the mesh

of a sieve mounted on a vibrating sorter until the sieving rate is reduced to 0.3%/min. The pellets remaining in the sieve are weighed.

3) Measurements should be made at least in duplicate. The percentage of the fines that pass through the meshes in relation to the total pellet mass is calculated (accuracy: 0.01%) using the following formula. The mean values are rounded to the nearest 0.1% for record.

$$F = \frac{(m_e - m_a)}{m_e} \times 100$$

F: amount of fines
m_e: mass of the sample before sieving
m_a: mass of sieved fines

7. Durability

1) Of the pellets already sieved using a 3.15-mm-diameter sieve in accordance with ISO 3310-2, 500 ± 50 g is taken (accuracy: 0.01 g), placed in a durability tester (CEN/TS 15210-1), and subjected to 500 rotations at 50 ± 2 revolutions per minute.
2) After the rotation test, the sample is sieved again using a 3.15-mm-diameter sieve, and the pellets remaining in the sieve are weighed.
3) Measurements should be made at least in duplicate. The percentage of the mass of the intact pellets after the durability test in relation to the baseline mass is calculated to 0.01% precision using the following formula. The mean value is rounded to the nearest 0.1% for recording.

$$DU = \frac{m_a}{m_e}$$

DU: durability
m_e: pre-test mass of pre-sieved pellets
m_a: post-test mass of sieved pellets

8. Calorific value

1) The calorific value of the sample shall be calculated by measuring the temperature rise while the sample is combusted in a manual or automatic bomb calorimeter. The calorific value per 1 g of sample is calculated and expressed in cal or J at 20℃.
2) Packages are opened by packing unit (e.g., 18, 20, or 50 kg) and representative samples are taken. Their calorific values are calculated after regulating pellet sizes to pass through 1-mm meshes.
3) The calorimeter shall be calorie-adjusted using benzoic acid, which is a standard substance.
4) The calorific value of the sample is measured using the adjusted calorimeter, and the calorific value of the oven-dried sample is recorded after rounding to the nearest ten.

$$Q_d = \frac{Q_{dm}}{m_{ds}}$$

Q_d: calorific value of the oven-dried sample per unit mass
Q_{dm}: calorific value of the oven-dried sample
m_{ds}: mass of the oven-dried sample

※ The calorific value of the sample on a wet mass basis is calculated using the following formula

$$Q_s = Q_d - (\frac{M_{ad}}{100} \times Q_d)$$

Q_s: calorific value on a wet mass basis
Q_d: calorific value of the oven-dried sample
M_{ad}: moisture content of pellets on a wet mass basis

The lower calorific value (= net calorific value) of the sample is calculated by applying *mutatis mutandis* the formula for the lower calorific value as specified by Korean Standard (KS) E 3707 "Determination of calorific value of coal and coke."

$$Q_{v,net}(J/g) = Q_{v,gr}(J/g) - 2512 \times \frac{9h + \omega}{100}$$

$Q_{v,\,net}$ (J/g): net calorific value (J/g)
h: hydrogen content (%)
w: moisture content of sample (%)

Here, it should be kept in mind that the total calorific value, moisture content, and hydrogen content used in the conversion formula should be determined by the same criteria.

9. Sulfur and chlorine

1) After combusting the sample in a sealed container, sulfur and chlorine are collected using rinse water.
   a. After remolding a pellet with 1 g of sample under necessary compression and measuring its mass to 0.1 mg precision, it is transferred to a quartz or metal crucible.
   b. The sample is burnt completely with cotton thread as a combustion aid and under oxygen supply, and the sealed container is rinsed with distilled water. The rinsed water is collected, and the sulfur and chlorine contents are measured using chromatography.
2) Sulfur and chlorine contents are determined via inductively coupled plasma (ICP) analysis as specified in EN ISO 11885.

10. Nitrogen

Nitrogen content is measured using an element analyzer in accordance with the specifications of the company providing the element analyzer.

11. As, Cd, Cr, Cu, Hg, Pb, Ni, and Zn

For methods used to test inorganic minerals, including As, Cd, Cr, Cu, Hg, Pb, Ni, and Zn, the European Union (EU) standards for test methods for inorganic materials (EN 15297:2011 Solid biofuels – Determination of minor elements – As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn) shall apply *mutatis mutandis*.

12. Ash Fusion Temperature

To determine the four characteristic temperatures of ash fusion (SST: shrinking starting temperature; DT: deformation temperature; HT: hemispherical temperature; FT: fluid temperature), the European Union (EU) standards for test methods for inorganic materials (prEN 15370:2011 Solid biofuels – Determination of ash melting behavior) shall apply *mutatis mutandis*.

Article 6 (Description of the Specifications and Standards for Wood Pellets)

The specifications and standards for wood pellets are formulated according to the checklist in Appended Table 2. The content should be made visible on the side of packages for customers to easily recognize.

A D D E N D U M

This notification shall come into force with effect from the 28th day of June 2013.

[Appended Table 1]

Specifications and Quality Standards for Wood Pellets

Properties	Unit	Grade 1	Grade 2	Grade 3	Grade 4
Size (diameter)	mm	6-8	6-8	6-8	6-25
Size (length)	mm	≤32	≤32	≤32	≤32
Bulk density	kg/m^3	≥640	≥600	≥550	≥500
Moisture content	%	≤10	≤10	≤15	≤15
Ash content	%	≤0.7	≤1.5	≤3.0	≤6.0
Fine content	%	< 1.0	< 1.0	< 2.0	< 2.0
Durability	%	≥97.5	≥97.5	≥95	≥95
Calorific value	kcal/kg (MJ/kg)	≥4,300 (≥18.0)	≥4,300 (≥18.0)	≥4,040 (≥16.9)	≥4,040 (≥16.9)
Sulfur content	%	< 0.05	< 0.05	< 0.05	< 0.05
Cl content	%	< 0.05	< 0.05	< 0.05	< 0.05
N content	%	< 0.3	< 0.5	< 0.7	< 1.0
As content	mg/kg	≤1.0	≤1.0	≤1.0	≤1.0
Cd content	mg/kg	≤0.5	≤0.5	≤0.5	≤0.5
Cr content	mg/kg	≤10	≤10	≤10	≤10
Cu content	mg/kg	≤10	≤10	≤10	≤10
Pb content	mg/kg	≤10	≤10	≤10	≤10
Hg content	mg/kg	≤0.05	≤0.05	≤0.05	≤0.05
Ni content	mg/kg	≤10	≤10	≤10	≤10
Zn content	mg/kg	≤100	≤100	≤100	≤100
Ash melting behavior	℃	to be stated as recommendation			
Other additives	%	< 2.0	< 2.0	< 2.0	< 2.0

[Appended Table 2]

Specifications for the Marking of Quality Standards of Wood Pellets

1 Marking of the Quality Standards

Specifications and quality description		
Product name		Company and brand names
Grade		Grade 1 through 4
Type		White wood, bark, and common pellets
Place of origin		Country of production
Quality	Size	The pellet diameter is indicated in mm units.
	Bulk density	Values greater than 000 kg/m^3 rounded to the second digit
	Moisture content	Values lower than 0.0% rounded to the tenth place
	Ash content	Values lower than 0.0% rounded to the tenth place
	Calorific value	Values greater than 0,000 kcal/kg rounded to the second digit in tandem with parenthesized 00.0 MJ/kg rounded to the tenth place
	Chemical composition	Values lower than S 0.00%, Cl 0.00%, N 0.0%
	Inorganic materials	Values lower than As 0.0 mg/kg, Cd 0.0 mg/kg, Cr 00 mg/kg, Cu 00 mg/kg, Pb 00 mg/kg, Hg 0.00 mg/kg, Ni 00 mg/kg, Zn 000 mg/kg
	Ash fusion temperatures	SST, DT, HT, and FT (℃) measured under oxidizing conditions
	Additives	Adhesive, values lower than OOO 0.0%
Mass		Unit: kg
Producer or importer	Address	Address of producer/importer with tel. number in parentheses
	Name	Name of the company head and company name
Date of production		Year and month of production

2 Standards for Format and Attachment

1) The size of the quality tag can be adjusted within the minimum criteria of length of at least 20 cm and width-length ratio of 2:3.
2) The quality tag can be directly printed on or attached to the package surface. If the package has rough surfaces, such as jute, the tag can be pinned to it.