Sampling and sample reduction of solid biofuels

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CEN 335 - Technical Specifications

Currently
- CEN/TS 14778-1:2006 Solid biofuels – Sampling
  Part 1: Methods for sampling
- CEN/TS 14778-2:2006 Solid biofuels – Sampling
  Part 2: Methods for sampling of particulate material transported in lorries
- CEN/TS 14779:2006 Solid biofuels – Sampling – Methods for preparing sampling plans and sampling certificates

In preparation
- EN 14778 Solid biofuels – Sampling
- EN 14780 Solid biofuels – Methods for sample preparation
Important of sampling

Deviate analyses results from “true” value depending on:

- Sampling: 80%
- Sample preparation: 15%
- Analyses: 5%

National Coal Board (GB) also verified for other bulk materials as farm products, industrial minerals etc.
Principle of correct sampling

Every particle in the lot should have an equal probability of being included in the sample. When this principle cannot be applied in practice, the sampler shall note the limitations in the sampling plan.
Sampling plan

What kind of job?

- Full sampling plan
- Brief sampling plan

1. Calculate the number of increments per lot
2. Calculate the increments size
3. Calculate the required volume (mass) needed for the required determinations
4. Visually inspected the lot
5. Determine the sampling method

- Fuels in motion
- Stationary materials
- Specific materials
<table>
<thead>
<tr>
<th><strong>Sampling plan 1</strong></th>
<th>sampling plan reference number</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>unique sample identification number</strong></td>
<td>date</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>name of sampler</strong></td>
<td>time</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E-mail</strong></td>
<td>telephone</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>lot or sub-lot identification number</strong></td>
<td>packaging of the laboratory sample</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>product</strong></td>
<td>airtight plastic container</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>trade name</strong></td>
<td>other:</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>biofuel supplier</strong></td>
<td></td>
<td></td>
<td>Comments</td>
</tr>
<tr>
<td><strong>approximate nominal top size</strong></td>
<td>mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>mass or volume of sub-lot</strong></td>
<td>kg ton or m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>mass of laboratory sample and container</strong></td>
<td>kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>type of sub-lot</strong></td>
<td>stationary:</td>
<td>lorry-load</td>
<td>small stockpile</td>
</tr>
<tr>
<td></td>
<td>moving:</td>
<td>conveyor</td>
<td>silo</td>
</tr>
<tr>
<td><strong>address of supplier</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>address of carrier</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>address of sampler</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>address of laboratory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sampling plan

- Type of fuel:
  - Homogeneous: e.g. sawdust, nutshells, pellets, woodchips
  - Inhomogeneous e.g. bark, used wood

- Number of increments stationary:
  - \( n = 5 + 0.025 \times m_{\text{LOT}} \) for homogeneous
  - \( n = 10 + 0.040 \times m_{\text{LOT}} \) for homogeneous

- Number of increments moving:
  - \( n = 3 + 0.025 \times m_{\text{LOT}} \) for homogeneous
  - \( n = 5 + 0.040 \times m_{\text{LOT}} \) for homogeneous

- Sample amount required
- Determine minimum amount per increment (depending on particle size)
Number of increments

1 homogenous, nominal top size < 10 mm
2 homogenous, nominal top size > 10 mm
<table>
<thead>
<tr>
<th>Property</th>
<th>CEN method</th>
<th>Mass required</th>
<th>Location of sampling point:</th>
</tr>
</thead>
<tbody>
<tr>
<td>moisture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>particle size distribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bulk density</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>particle density</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mechanical durability</td>
<td></td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td>ash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>caloriﬁc value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sulphur</td>
<td></td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td>nitrogen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>chlorine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>others</td>
<td></td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td>total mass required for tests</td>
<td></td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td>bulk density</td>
<td></td>
<td>kg/litre</td>
<td></td>
</tr>
<tr>
<td>total volume required for tests ($V_{tot}$)</td>
<td></td>
<td>litre</td>
<td></td>
</tr>
</tbody>
</table>

If total volume required ($V_{tot}$) exceeds the calculated volume of combined sample ($V_{comb}$), then increase the number of increments: $N_{inc} = V_{tot}/V_{comb}$.

Method of preparing the laboratory sample from the combined sample:

- Volume of the laboratory sample: $V_{lab}$
Bulk density is useful for the calculation of solid biofuel mass.

<table>
<thead>
<tr>
<th>Solid biofuel</th>
<th>Bulk density, kg/m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pellets</td>
<td>550–700</td>
</tr>
<tr>
<td>Briquettes</td>
<td>500–650</td>
</tr>
<tr>
<td>Fuel powder</td>
<td>150–250</td>
</tr>
<tr>
<td>Sawdust</td>
<td>290–380</td>
</tr>
<tr>
<td>Shavings</td>
<td>140–170</td>
</tr>
<tr>
<td>Wood chips</td>
<td>250–400</td>
</tr>
<tr>
<td>Straw bales</td>
<td>130–180</td>
</tr>
<tr>
<td>Chopped straw</td>
<td>80–120</td>
</tr>
</tbody>
</table>
Lot 10 t

Sample

Pretreated sample

Analysis sample ~5 g

The sample should present the whole lot!
Sampling from a heap
Equipment for sampling

\[ d = \text{nominal top size of sample (95\% of material pass the screen)} \]
Sampling errors: Impurities

Snow and ice are typical impurities in the Nordic countries

Other types of impurities in solid biofuels are:
- Soil
- Sand and stones
- Ropes, plastics
Segregation of fines during transport

Original

During transport
Scoops - 2.5 x nominal top size of solid biofuels
Sampling from tipped lorry load (pile)

Side view of an example of sampling points on a small stockpile
Sampling of pellets from storage rooms
Sampling from bales

Coring machine
Sampling from moving streams
Examples of sampling and equipment for moving material

Cross belt sampling

Sampling box

\[ d = d_{95} = \text{nominal top size} \]
Sampling from lorry during unloading (preferred to sampling from pile)
Sampling from a stopped conveyor belt
Combined sample

- Take increments
- Mix to get combined sample (s)
- Perform sample reduction if necessary
Labelling, packaging and shipping

- To preserve physical and chemical properties of samples, packaging is an important issue.
  - Airtight plastic packaging (e.g.: plastic bags)
  - Protection against direct sunlight
  - Protection against adulteration if necessary: sealing of container
  - Cooling (5°C) to avoid biological activity if necessary (especially for moisture contents above 20% and longer storage.)
Packaging and shipment

BAD EXAMPLES !!!

Information of customers and clients is necessary to avoid these mistakes!
Packaging and shipment

MORE BAD EXAMPLES !!!
Stages in the laboratory

1. Sample division. Combined sample
   - Initial sample division
   - Weight the sample
   - Dry the sample if necessary, and allow it to rest in the laboratory for at least 24 hours at
   - Size-reduction to <30 mm by coarse cutting
   - Mass-reduction by a suitable method for the material
   - Size-reduction to <1 mm using a cutting mill
   - Take out analysis samples
   - Size-reduction to <0.25 mm using a cutting mill

Combined sample

Sub-samples for determination of:
- bulk density, durability of pellets, etc.
- particle size distribution, abrasion resistance, etc.
- moisture content, etc.
- ash, calorific value, chemical analysis, etc.

Sub-samples for analysis where <0.25 mm is required
Principles of correct sample reduction

- During a mass-reduction stage, every particle in the sample before mass-reduction should have an equal probability of being included in the sub-sample retained after mass-reduction.

- Care is needed to avoid loss of fine particles during milling and other operations.
Riffle boxes
  - A riffle box shall have at least 16 slots, with adjacent slots directing material into different sub-samples, and the width of the slots shall be at least 2.5 times the nominal top size of the material to be riffled.

Rotary sample dividers
  - A rotary sample divider shall have a feeder device adjusted so that the divider rotates at least 20 times while the sample is being divided.

Shovels and scoops
  - A shovel or scoop used for manual mass-reduction shall have a flat bottom, edges raised high enough to prevent particles rolling off, and shall be at least 2.5 times as wide as the nominal top size of the material to be processed.

Apparatus for size-reduction
  - Coarse cutting mill
  - Cutting mill
  - Sieves
  - Balance
Apparatus for mass reduction

- **Rotary sample dividers**
  The divider should rotate at least 20 times while the sample is being divided

- **Shovels and scoops**
  - For manual mass-reduction
  - Should have a flat bottom, and raised edges to prevent particles rolling off
  - At least 2.5 times as wide as the nominal top size, $d_{95}$
Apparatus for mass reduction: Riffle boxes

- At least 16 adjacent slots
- Width of the slots shall be at least 2.5 times the nominal top size ($d_{95}$)
Manual mass reduction: Quartering
Strip mix
Particle size reduction of straw
Size reduction apparatus

- Coarse cutting mill
- Cutting mill
- Sieve
- Balance

Grinder for size reduction:
- Low self heating
- Different sieves
- Easy to clean
- Resistant to impurities
Minimum masses to be retained during mass-reduction stages

<table>
<thead>
<tr>
<th>Nominal to size (mm)</th>
<th>Minimum masses, g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bulk density &lt; 200 kg/m³</td>
</tr>
<tr>
<td>≥100</td>
<td>10 000</td>
</tr>
<tr>
<td>50</td>
<td>1 000</td>
</tr>
<tr>
<td>30</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>150</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>≤ 2</td>
<td>20</td>
</tr>
</tbody>
</table>
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This material was produced in cooperation between: VTT, Finland, SLU, Sweden, ofi, Austria, CEN/TC 335, WG3