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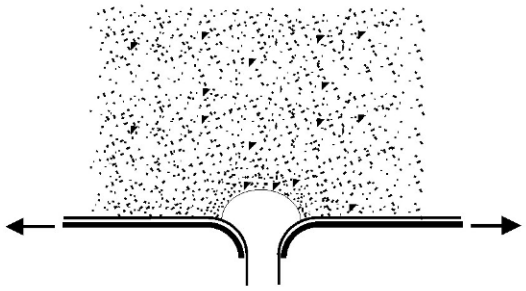
BioNorm II

Pre-normative research on solid biofuels for improved European standards

SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT

PRIORITY [6-1] – Sustainable energy systems



Deliverable DII.1.13

Best Practice Guidelines for the determination of the bridging properties

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Revisions

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1	07 December 2009	Stefan Hinterreiter, Hans Hartmann	-

Abstract

The suitability of the bridging test method for the determination of the bridging properties for solid biofuels was proven in the Bionorm-II-project. The technical apparatus described in deliverable DII.1.10 and the developed test guideline for the Bionorm-partner's tests can therefore serve as a basis for a new European standard.

In the here presented best practise guideline the attempt is made to describe all required properties and features of a suitable measuring apparatus and to define the measuring procedure in order to ensure reproducible and repeatable test results. In order to be able to easily transform the guideline into a European standard the format and structure of a CEN technical specification was here chosen. The details of the proposed standard test procedure are described on the following pages.

List of Abbreviations

Table of Contents

1 Introduction

The building of a fuel bridge over an opening ("bridging") is a generally unfavourable phenomenon of particulate biofuels. It is particularly severe with fuels whose capability of flowing or conveying is also low. With such fuels, interruptions or failures particularly during a vertical transport can occur. This can lead to clogging of silo outlets, down pipes, funnels or screw conveyors. The bridging property of a fuel is therefore a summary characteristic for several unfavourable phenomenons: Apart from the tendency to build a stable bridge over an opening, it is also synonymic with clogging hazards during conveying or with inhomogeneous horizontal distribution where this is required (e.g. in the fire bed of a boiler).

This guideline describes a method for the determination of bridging properties of solid biofuels.

2 Scope

The method is applicable to all particulate biofuels that either have been reduced in size (such as most wood fuels or cut straw) or which are physically in a particulate form (such as olive stones, nut shells, grain etc).

Note Bridging is not an absolute value, therefore the result of a test of the bridging properties of a fuel is only a measure of that particular fuel. Parameters such as the particle size and shape, the sample moisture content or bulk density are decisive for the bridging properties. Therefore it may be useful to determine these parameters parallel.

3 Normative references

prEN/TC 335 14778-1:2005 Solid biofuels – Sampling - Part 1: Methods for sampling

prEN/TS 14774-2:2004: "Solid biofuels - Methods for the determination of moisture content - Oven dry method - Part 2: Total moisture - Simplified method

4 Terms

OW opening width at 100 % bridge collapse

5 Principle

The determination of bridging properties is be done by creating a fuel bridge under controlled conditions. This is e.g. achieved by placing a sample over an expandable slot. The opening width (OW) of the slot at the moment when the bridge collapses is taken as a measure for the bridge building properties of the sample (see Figure 1).

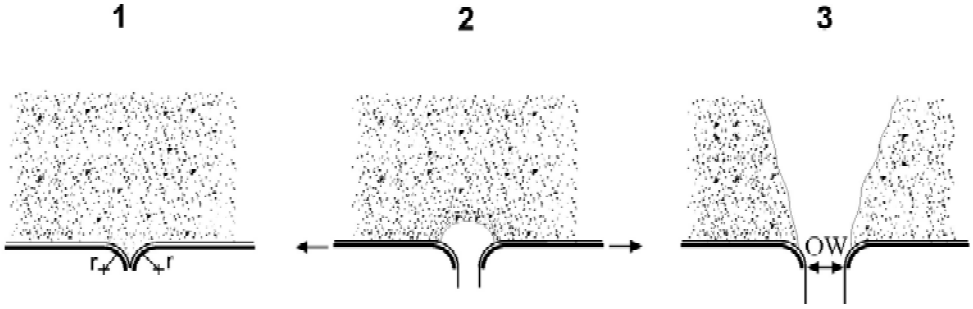

Figure 1: Operational principle of a bridging test apparatus

6 Apparatus

6.1 Bridging tester

A purpose built test apparatus is required for the determination of bridging properties. It consists of a test box (bulk container) with a bottom area of 1.1 × 2.0 m (± 0.01 m) and a minimum height of 1.0 m (± 0.05 m). The sides of the box shall be made of film coated plywood. The bottom is designed as an opening slot. This is achieved by using a divided floor of two movable bottom plates made from stainless steel. These bottom plates can move to the sides. Each floor plate is fully covered with a PVC-mat with low friction coating. The two opposite edges of the two steel plates are bended in a fixed radius forming a slim deflection edge of 25 mm (± 3 mm) radius (see radius *r* in Figure 1). When the bottom plates are fully closed, the two mats contact each other in order to close the gap fully. The contact position shall be in the middle of the full bottom length. The bottom shall be fully even and oriented horizontally to the ground, except at the round edges (see Figure 1). The slot shall be capable of being gradually expanded while the edges of the moving plates remain in a fully parallel orientation. A maximum tolerance of 10 mm slot opening over the full slot width is acceptable. During the opening procedure the PVC-mats shall slide over the rounded edged of the steel plate bottom.

Note 1 This design avoids that any friction between the bottom and the fuel sample in the box can occur when the slot is being expanded.

Note 2 It can be useful to apply a fixture for the PVC mats (e.g. by a cable) to prevent their free endings from disturbing the collection of the sample material when falling through the slot into a container.

The bottom shall be prevented from becoming inclined during any phase of the opening procedure. The apparatus shall enable a synchronic opening movement of the two bottom plates, thus ensuring that the slot's centre shall not change its position during widening. The maximum opening width shall be 1.5 m. The opening mechanism shall be designed using a crank handle. The applied speed shall be 180 mm/min which shall be achieved in 15 crank rotations per minute.

The bulk container shall be positioned firmly on a frame at a height, which ensures that all sample material can freely fall through the slot without causing any blockages (e.g. 1.5 m height of container bottom).

On the inside walls of the bulk container a filling level indication shall be given. It shall indicate the filling level of 1.65 m³ sample volume.

An example of the apparatus construction is given in Annex A.

6.2 Sample loading and collecting vehicle

The filling of the sample into the bridging test apparatus can be done by using a high tilting container mounted on a loading vehicle. This can for example be a special tilting container or a similar loading bucket which is mounted on a fork lifter or wheel loader. Such device shall have a capacity of minimum 1.7 m³ and it should fit below the bottom plates of the bulk container box of the apparatus.

An example of the apparatus design and the loading operation is given in Annex B.

6.3 Rake

A rake is needed for leveling the sample in the bulk container.

6.4 Shovel

A shovel is needed for emptying the bulk container.

Note Do not use a shovel with sharp edges as it can damage the wooden walls of the bridging tester and the PVC mats.

6.5 Healthcare respirator

To avoid pneumoconiosis and damages caused to the health (e.g. due to fungi spores), a healthcare respirator should be used during the sample handling phase of a bridging test.

7 Sample size

A loose sample volume of minimum 1.65 m³ is required for the test. The sample shall be homogeneous.

8 Procedure

8.1 Prearrangements

8.1.1 Fuel sample

Special care must be taken for the homogeneous condition of the fuel sample.

Note The fuel can be homogenized by transferring it by hand or by wheel loader 5 times from one place to another.

8.1.2 Bridging tester

Ensure that the bridging tester is in a planar position. Close the bottom plates completely and check the measuring scale. If required, adjust it to zero when the movable floor is completely closed.

Note Be sure that the bulk container is completely empty before the sample is filled in.

8.2 Filling of the bridging tester

Fill the sample into the bridging apparatus by using the loader as mentioned in Clause 6.2. This is done by applying a dropping height of about 140 cm above the movable floor of the bulk container.

Note 1 The height of about 140 cm above the movable floor is required in order ensure that any tilting operation of the loader can happen freely without causing damage to the bridging apparatus.

The filling shall be carried out evenly.

Note 2 An optimum solution is for example achieved when the lifting and tilting procedure of the loader is performed simultaneously. This can be enabled by the hydraulic control unit of the fork lifter.

Note 3 The use of a conveyor belt for the filling process is not recommended, as I can cause deviating results.

Any compaction of the sample shall be avoided. Ensure that the sample is completely filled into the bridging apparatus.

Level out the surface of the filled bridging box with the rake so that the sample is evenly spread in the container. For correct levelling the filling level indication in the bulk container shall be used as orientation. Surplus material shall be removed from the apparatus.

Note 4 When levelling the sample, do not to compact it.

Note 5 If only one person is executing the filling and the levelling, avoid any shaking of the bridging tester when climbing onto it (it is suggested that two persons perform the measurements)

Start the test procedure directly after the filling. The sample shall not stay for a longer time (e.g. one full day) in the apparatus before performing the bridging test.

Note 6 Longer storage in the container can lead to higher measured opening widths.

Before starting the floor opening procedure place the empty loader below the slot (between the stilts), so that all the sample material will be collected for the next replication or for disposal.

8.3Opening of the movable floor

Start the slot opening procedure by using the crank handle in a uniform motion (avoid jerkily motions). The opening speed shall be about 15 rotations per minute. Keep on turning the crank handle until the first particles start to fall through the slot. Then wait for the falling to stop in order to confirm, that the bridge will not already collapse. If necessary continue and stop the process again, until the bridge has collapsed completely over the full width of the slot.

Note 1: It is advised to perform the test with two persons in order to execute the test procedure properly. One person shall stand on the walking platform of the tester and the other is standing downstairs at the measuring scale. The complete bridge collapse can then be verified by the person on the walking platform without any disturbance by climbing upwards (see example in Figure 2).

Sometimes only one or two particles remain to form a bridge over the opening slot (“single particle bridge”). In this case the opening procedure shall terminate and the bridge collapse shall be regarded as “full”.

Figure 2: *100 % bridge collapse (view from top)*

Read the opening distance at the scale to the nearest 1 mm and record it. This distance is the measured opening width (OW).

Then empty the bridging apparatus completely.

Note 2 Avoid the use of any sharp tools in order to prevent damage of the movable floor.

Then fully close the movable floor for the next measurement. Repeat the bridging procedure with the same sample 9 times, so that a total of 10 tests have been performed. For easily percolating fuels such as grain kernels or cylindrical wood pellets a total of 5 measurements is sufficient.

After the final test collect a representative sub-sample and perform a determination of the moisture content according to prEN/TS 14774-2.

9 Calculation

Calculate the mean value of all measured opening widths from each measurement. Record the result to the nearest 1 mm.

10 Test reporting

The test report shall include at least the following information:

- Identification of the laboratory and the testing date
- The results from the calculation in Clause 9.
- The results of the moisture content determination
- Any deviation from this guideline

11 Bibliography

[1] Hinterreiter, S.; Hartmann, H. (2007): Provision of a prototype device for bridging property determination (Deliverable DII.1.10). Project "Pre-normative research on solid biofuels for improved European standards" (BioNorm II). Unpublished Report, http://www.bionorm2.eu/, 16 p.

[2] Hartmann, H., Hinterreiter, S.; Turowski, P.; Kallio, M.; Lazdiņš, A.; Zimelis, A.; Rathbauer, J.; Sulzbacher, L.; Sønderstgaard Sørensen, K.; Temmerman, M. (2009): Determination of bridging properties – Experimental and model approach. In: German Biomass Research Centre (eds.): Proceedings Final Conference BioNorm II: "Pre-normative research on solid biofuels for improved European standards", Leipzig, Nov 4th 2009, pp. 22-31

Annex A

Example for construction of a bridging test apparatus

In the following an example of the technological implementation of the measuring principle (the "bridging apparatus") is documented by a series of mechanical drawings, which explain the basic functional elements and the dimensions of the apparatus. The descriptions were taken from Reference [1] and [2].

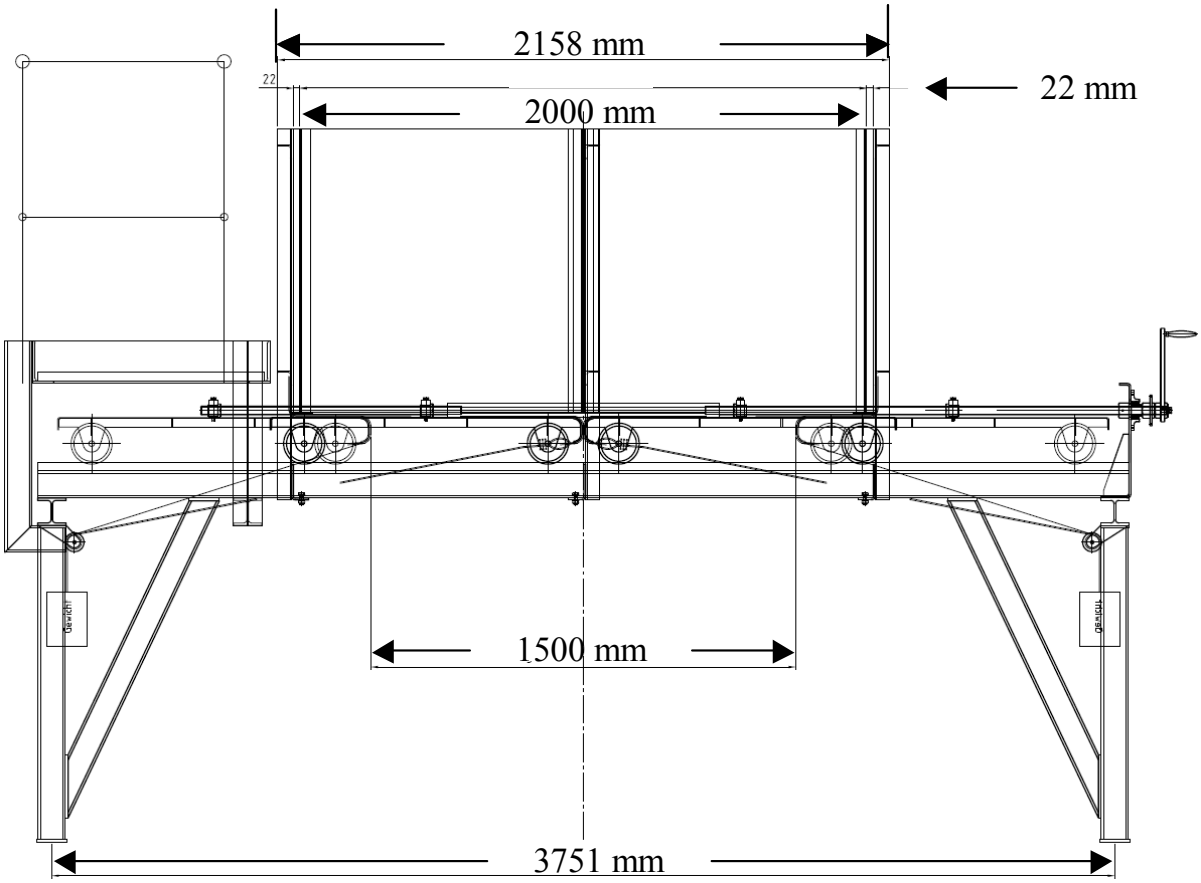

Figure 3: *Front view on the bridging tester*

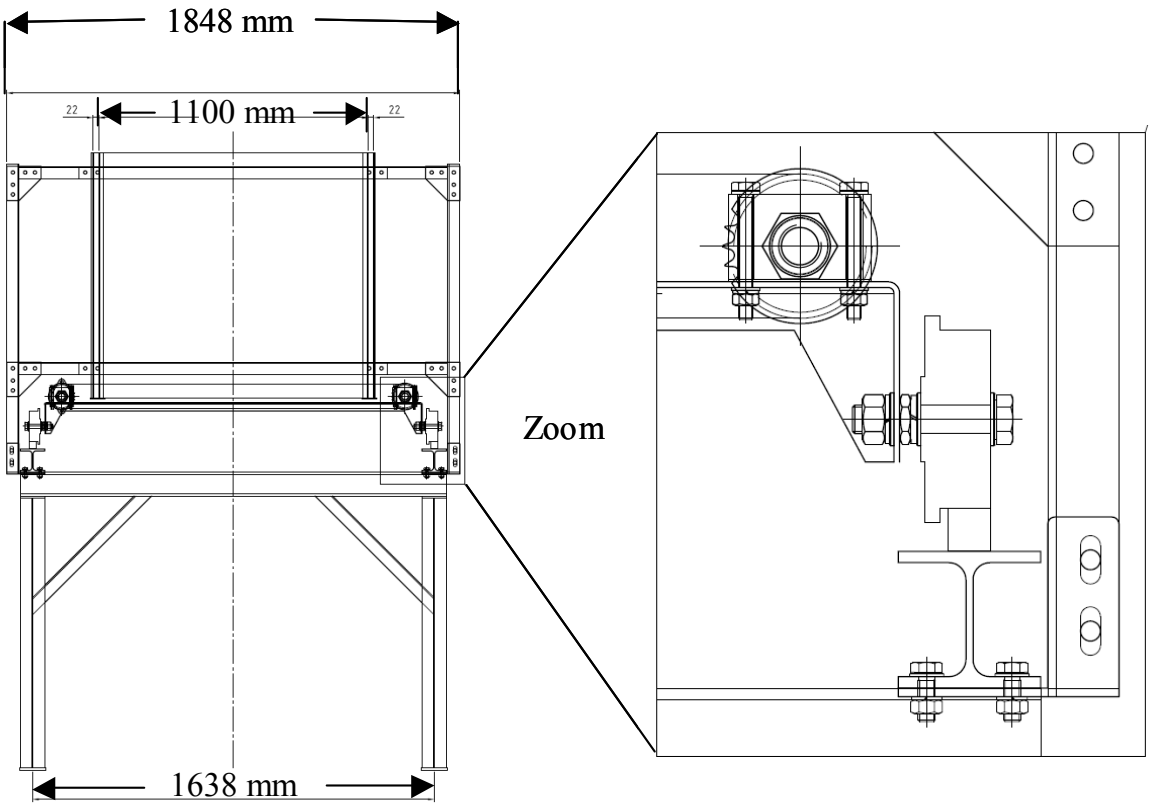

Figure 4: *Side-view (left) with a detailed view on the undercarriage of moving floor (right)*

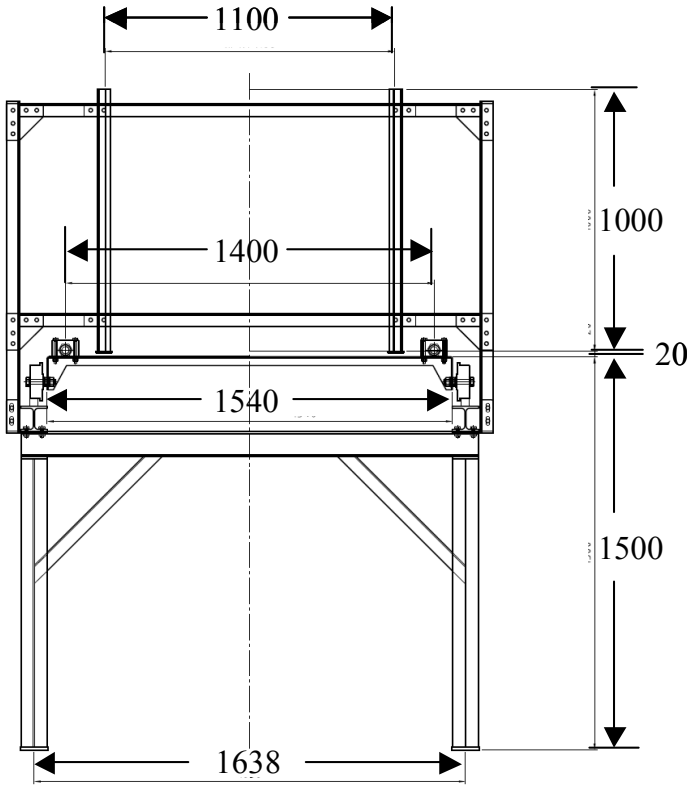

Figure 5: *Side-view (right)*

Figure 6: *Complete picture of the bridging tester (final version for bias testing)*

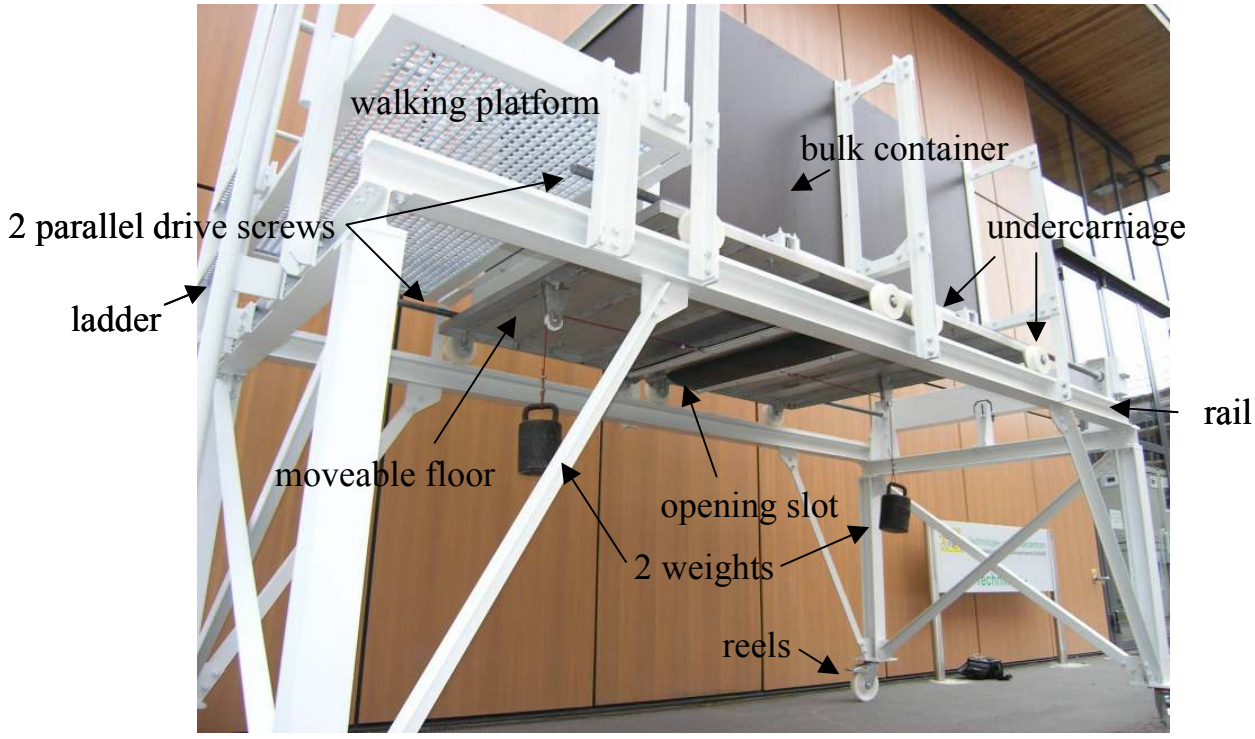

Figure 7: *Description of the main constituents of the bridging tester*

Figure 8: *View from below on the closed opening slot (with movable floor and undercarriage)*

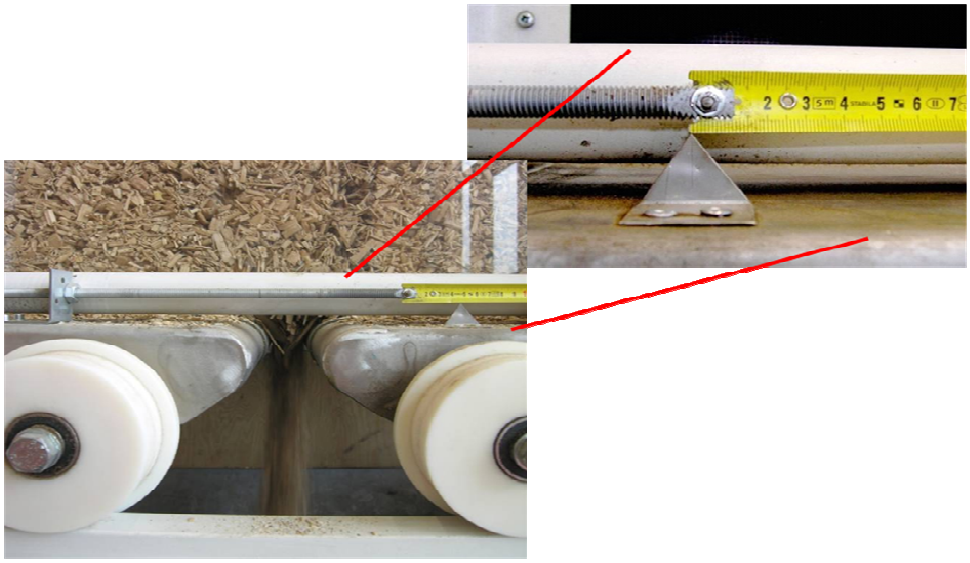

Figure 9: *Measuring unit for the opening width (OW)*

Annex B

Illustration of the loading operation

Figure 10: *Filled tilting container mounted on a fork lifter before dropping the sample into the tester*