



Project no. 038644

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.1.6

Provision of suitable test rig for impurities testing

Due date of deliverable: Month 7

Actual submission date: Month 7

Start date of project: 1/1/2007






Duration: 36 month

University of Copenhagen

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Revisions

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Abstract

The report describes two methods for separation of impurities of mineral origin from solid biofuel based on wet- and dry sedimentation, respectively. Further, a description of the methodology in identifying impurities of mineral origin is given, including short descriptions of disintegration of compressed biofuels, sieving and visual inspection and ash content determination. A detailed description of the complete procedure and methodology will be given in later reports.

List of Abbreviations

Table of Contents

2.5.1	Dry sedimentation principle	3
2.5.2	Dry sedimentation process	4
2.5.3	Description of dry sedimentation equipment.....	5
2.5.4	Wet sedimentation principle.....	6
2.5.5	Description of dry sedimentation equipment.....	6
2.5.6	Wet sedimentation process	7
2.5.7	Description of wet sedimentation equipment	7

1 Introduction and Objectives

Impurities in solid biofuels are non-biofuel material, which are physically attached to or mixed with the biofuel considered e.g. mineral matter such as stones, sand and soil or metal and plastic pieces. The impurities potentially reduce the quality of the fuel and lead to problems related to handling and combustion including slagging. The presence of impurities could be due to mixing of the fuel with non-biofuel material or reflect the logging or improper handling and storage.

The specific problems relate to the type of biofuel and impurity. High quality pellets produced of debarked spruce may have an ash content of 0.3 – 0.4%, and even small amounts of added mineral content could lead to lowered ash melting temperatures and consequently slagging in the boiler.

The detection methods for impurities described below refer primarily to particles of mineral origin, which may origin from soil and sand introduced to the biofuel during harvesting, transportation and storage operations.

2 Methods

2.1 Selected methods for determination of impurities

The proposed detection method is based on wet- or dry sedimentation in water or air, respectively. When the impurities are to be determined in compressed biofuel such as pellets or briquettes an initial disintegration shall be conducted before the determination. An initial screening and visual inspection of larger impurities may be useful together with a final ash content determination of the mineral impurities to remove any biofuel dust remaining in the impurities.

As the disintegration, sieving and ash content determination is based on methods that are described in standards or are under development within the CEN/TC 335 Solid Biofuels [1, 2, 3] the equipment and methodology for these operations will only be described briefly in the present report. A detailed description of the full procedure and test equipment will be given in later reports (DII.1.7 and DII.1.8) and in the best practice guideline (DII.1.9) when the results of the pre-tests and round robin are available.

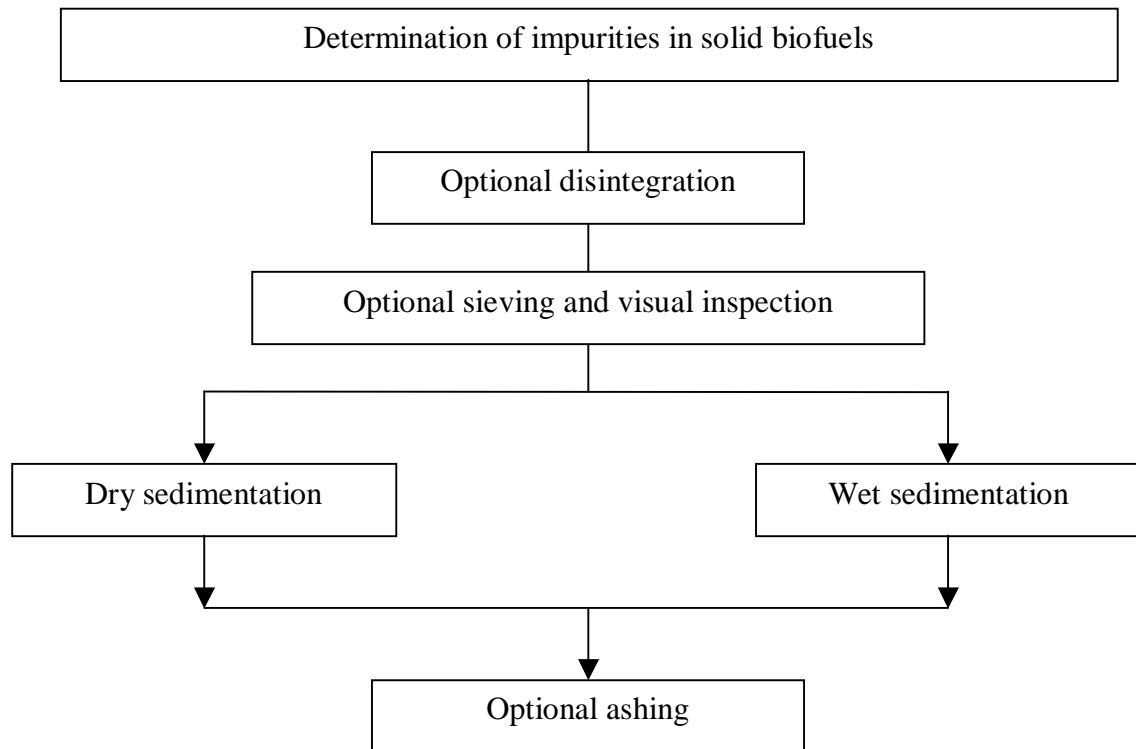


Figure 1. Suggested flow diagram describing the determination of impurities in solid biofuels.

2.2 Disintegration

For determination of impurities in compressed biofuels such as pellets and briquettes, an initial disintegration of the fuel into the original particles may be necessary. The sample shall be disintegrated in water as described below.

The test portion is placed in a clean and dry disintegration container. 700 ml of deionised water at a temperature of $95^{\circ}\text{C} (\pm 3^{\circ}\text{C})$ per 100 g of sample is poured over the test portion. The slurry is stirred carefully with a spoon from the bottom and up until a smooth mush is obtained. The spoon is rinsed with deionised water, the rinse being added to the slurry. The slurry is sealed with a cover and left for 24 hours to complete the disintegration.

Using a spoon, the slurry is homogenised and transferred quantitatively to an adequate number of drying containers. The spoon is rinsed with deionised water, the rinse being added to the slurry. The slurry is dried at $60^{\circ}\text{C} (\pm 5^{\circ}\text{C})$ until a moisture content between 5 – 15% is reached. In order to bring the moisture content of the disintegrated and dried material in equilibrium with ambient conditions, the dried material is left at room temperature for 48 hours after the drying.

2.3 Sieving and visual inspection

For the sieving, a number of sieves and a collection pan are required. The effective sieve area of the sieves should be at least 1200 cm². The geometry of the apertures, the thickness of the sieves, the hole distances and the opening of the holes shall be in accordance with ISO 3310-1 [4] and ISO 3310-2 [5].

Required sieves shall reflect the biofuel in question e.g. chips could be round hole sieves with hole diameters of 45 mm, 16 mm and 8 mm respectively and a metal wire cloth sieve of 2 mm opening.

The sample is sieved on the 45 mm sieve until no further passing of particles can be observed. The particles retained on the 45 mm sieve are spread on a flat surface and any visible impurities are collected manually and weighed to the nearest 0,01 g. The material, which passed the 45 mm sieve is placed on the 16 mm and the procedure is repeated continuously until the fraction of biofuel and impurities below 2 mm is obtained.

The content of impurities in the fraction below 2 mm is determined with wet- or dry sedimentation (Section 2.5).

2.4 Ash content determination

The fraction of mineral impurities obtained with the wet- or dry sedimentation may have a minor content of biofuel. Any visible biofuel particles are going to be handpicked with a pair of tweezers and any remaining fraction could be removed by ash content determination according to [3] in an oven at 550°C.

2.5 Sedimentation

2.5.1 Dry sedimentation principle

Dry sedimentation is based on separation due to density differences of particles subjected to a vertical upward or horizontal moving air stream. The horizontal stream principle is used e.g. for aerodynamic size classification.

The method selected for the present project is based on the vertical principle where the particles are subjected to an upward moving air stream, which carries the biomass with a relatively lower particle density upwards and let the particles with a higher density fall through the air stream. The principle is well known from the particleboard industry where it is used to separate stone and sand from the chips (Figure 2).

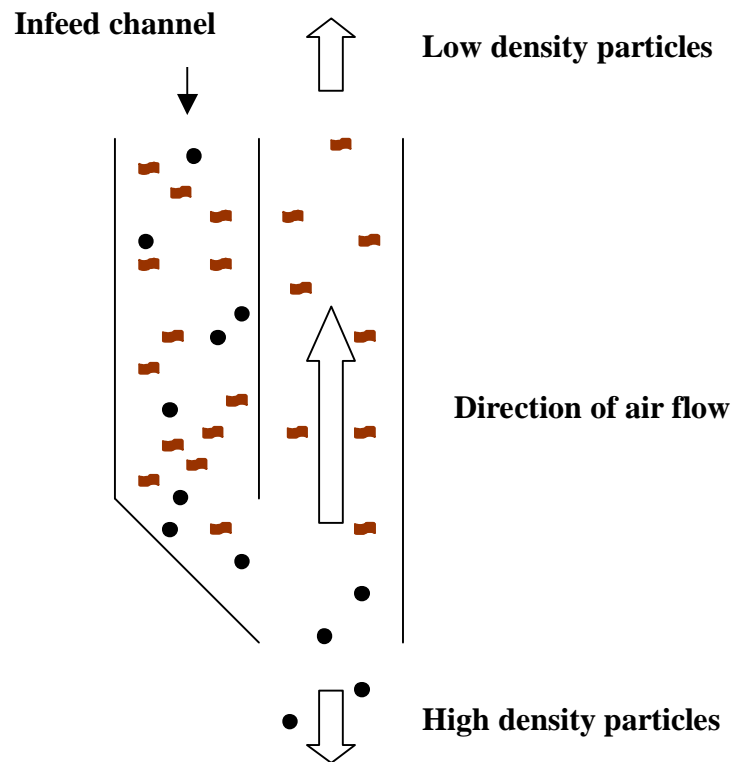


Figure 2. Dry sedimentation principle. An upward air stream carries the low density particles whereas the high density particles sediment in the bottom of the system.

2.5.2 Dry sedimentation process

The sample (biomass and impurities) are fed into a sample container above the infeed channel. When the sample container is opened the sample will fall to the bottom of the infeed channel where it is met by an upward air stream. The air stream carries the low-density particles to a cyclone where they are collected. The high-density particles fall through the air stream to a collecting box placed below the device.

A number of parameters potentially influence the results of the sedimentation process including the following:

- Air velocity
- Number of cyclones
- Particle size of biomass and impurities
- Concentration of impurities
- Particle density of biomass and impurities
- Moisture content of the biomass

2.5.3 Description of dry sedimentation equipment

The Sample Cleaner model MLN from Rational Kornservice (Figure 3) uses the vertical air stream principle described in section 2.4.1.1 to clean the impurities from the biomass.

The device consists of the following parts:

A	:	Sample container
B	:	Lid
C	:	Sampling bag for low-density particles collected in the cyclone
D and E	:	Screens
F and G	:	Collection trays

Further, the devices are equipped with a fan with adjustable air velocity, which lead the low density particles into the cyclone.

The specification of the device is as follows:

Height	:	735 mm
Width	:	580 mm
Length	:	680 mm
Weight	:	55 kg
Sample size	:	aprox. 1 kg
Motor	:	230 V – 0,37 kW
Sound level	:	82/78 dB

More details can be found in Annex A.

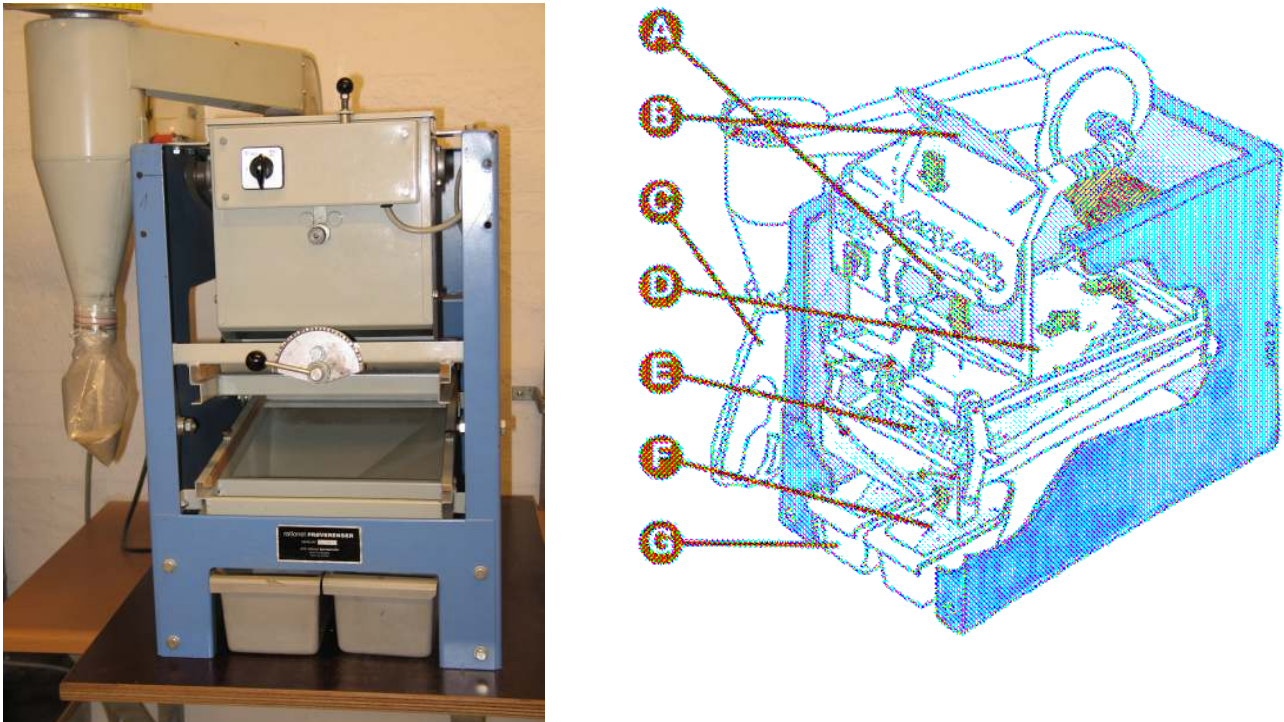


Figure 3. Sample cleaner model MLN for testing of impurities (left) and principal drawing (right).

2.5.4 Wet sedimentation principle

Wet sedimentation is based on density dependent separation of particles in a liquid where the low-density particles stay suspended in the slurry and the high-density particles sediment at the bottom of the container. The slurry is subjected to a vortex or ultrasound to facilitate the sedimentation. When the sedimentation process is terminated the deposited particles (impurities) are collected at the bottom of the container (Figure 4).

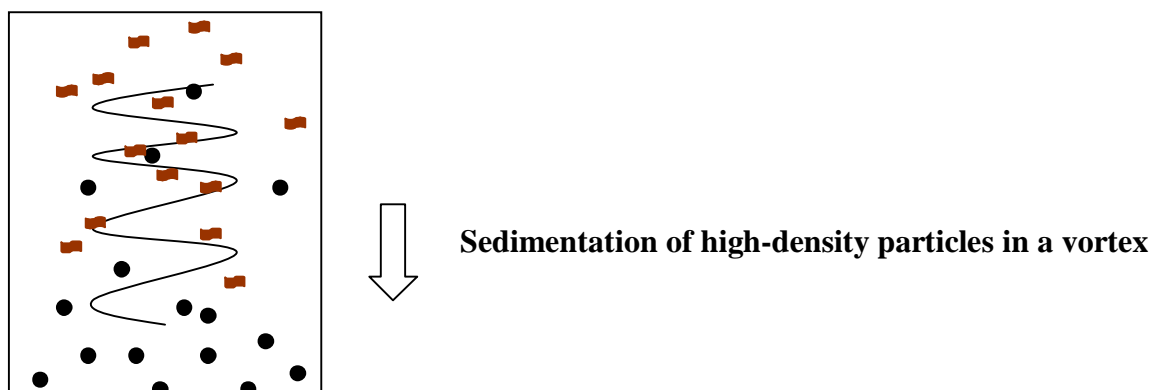


Figure 4. Wet sedimentation principle. A vortex separates the impurities from the biofuel, and subsequently the high-density impurities sediment at the bottom of the container.

2.5.5 Wet sedimentation process

The sample (biomass and impurities) is stirred with a liquid (water) in a sample container. The high density particles deposit at the bottom of the container. The high-density particles can be collected with a pipette or, alternatively, the slurry can be removed from the container.

The gravimetric determination of impurities in solid biofuels could proceed as follows:

1. Representative sampling according to [6, 7]
2. Mixing of sample and water in container, applying either stirring of mixture with magneto-motive force or Ultrasound
3. Sedimentation of impurities
4. Retrieval of impurities on filter paper (e.g. by applying vacuum)
5. Drying of filter paper and sample at 105°C
6. Weighing of sample filter paper
7. Calculating of the relative mass of impurities

A number of parameters potentially influence the results of the sedimentation process including the following:

- Ultra sound or vortex
- Particle size of biomass and impurities
- Concentration of impurities
- Particle density of biomass and impurities
- Moisture content of the biomass

2.5.6 Description of wet sedimentation equipment

The wet sedimentation equipment consists of a sample container for sedimentation of impurities (Figure 5A), a vortex mixer (or equivalent equipment with magneto-motive forces) or equipment for ultra sound treatment of the slurry and a filter system including a funnel and filter paper fitted to a vacuum pump (Figure 5B and C). The speed of the stirred, and the retrieval of impurities in the filter system, can be adjusted through the capacity of the mixer (alternatively the ultra sound equipment) and the vacuum pump, respectively. In this matter, the sedimentation rate (distance per time unit) probably will become the limiting factor in the system in terms of time consumption.

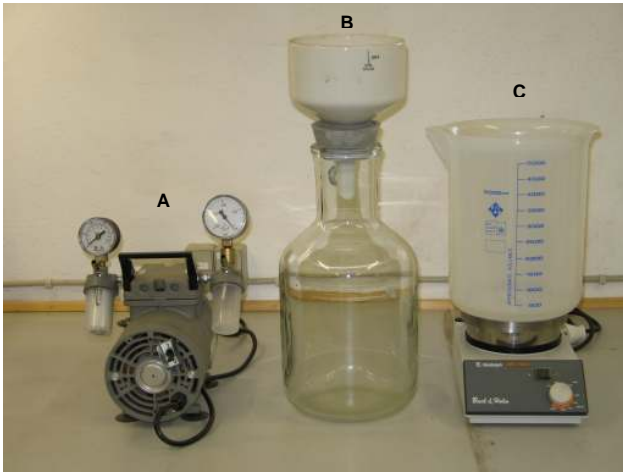


Figure 5. Equipment for wet sedimentation of mineral impurities from solid biofuels. A: Vacuum pump. B: Funnel with filter paper and filter flask. C: Sample container with vortex mixer.

The equipment presented in figure 5 is fitted for a sample volume of approximately 5 litres (biomass/impurities and liquid) where the limiting factors for a larger sample volume primarily will be the sample container and the funnel. This equipment can however be adjusted to fit practically any desired realistic sample size by increasing the size of the sample container and funnel.

All the apparatus have the advantage of being standard laboratory equipment and can thus be purchased from any national or international company trading laboratory utensils.

3 Literature

- [1] 00335032 Method for the determination of particle size distribution of disintegrated pellets
- [2] CEN/TS 15249-1:2005 Methods for particle size distribution – Part 1: Oscillating screen method using apertures 3.15 mm and above
- [3] CEN/TS 14775:2004 Method for ash determination
- [4] ISO 3310-1 test sieves – Technical requirements and testing – Part 1: test sieves of metal wire cloth
- [5] ISO 3310-2 test sieves – Technical requirements and testing – Part 2: test sieves of perforated metal plate
- [6] CEN/TS 14778-1:2005 Sampling Part 1: Methods for sampling
- [7] CEN/TS 14780:2005 Methods for sample preparation

Annex A**rational kornservice****Sample Cleaner model MLN**for testing of grain samples
for impurities**Advantages:**

1. An accurate assessment of the total consignment is obtained.
2. Price can be negotiated on the basis of a cleaned representative sample.
3. Access to all vital parts of the machine is simple.
4. Silent and vibration free operation.
5. A wide range of products can be cleaned ranging from oil seed, rape, to grain and beans etc.
6. Change of screens can be made in seconds.

Application:

The machine is ideal for laboratory or intake facility or indeed where ever a cleaned sample of grain from a large consignment is required.

The cleaned sample also enables a more accurate moisture measurement to be obtained.

CE

Manufacturer:

a/s rational kornservice

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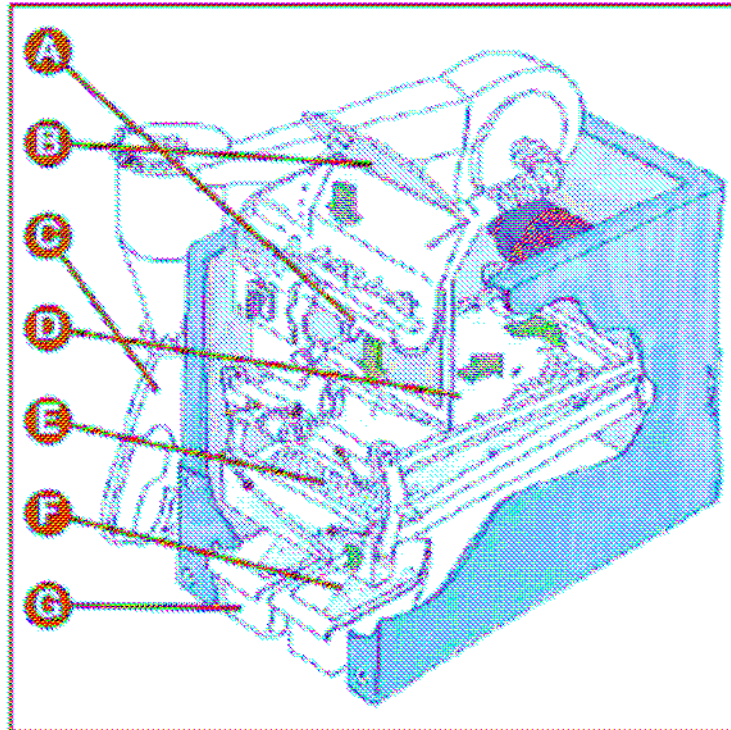
Fax: +45 75 12 90 89

E-mail: rational@post10.tele.dk

Agent:

Principal sketch:

- A. The deawner bottom gate is closed and the preweighed grain sample is poured into the deawner.
- B. The lid is closed and the machine starts. After 20-60 secs (adjustable) the deawner discharges the sample on to the screen.
- C. The light waste is air lifted into the cyclone and precipitated into the plastic bag.
- D. The good grain is passed through the top screen and the large impurities carried over.
- E. The good grain is carried over the second screen and the sand and weed passed through the screen.
- F. The good cleaned grain feeds into the right collecting tray.
- G. The sand, small weed and light material not separated by the aspiration system feeds into the left hand tray.



Standard Equipment:

- 4 plastic trays of uniform weight.
- 2 metres cable.
- 2 screens.

Extra Equipment:

- Screen plates, extension hopper, run through trays and sack holder for continuous cleaning.
- PC program for calculating percentage of impurities, fractions in gram and percentage and correction to basis 14.5 % humidity.
- Electronic balance to be connected to PC.

Guarantee:

The deawner is guaranteed for one year in respect of manufacturing failure. During the guarantee period defective parts will be replaced free of charge subject to those parts being returned for examination.

Dimension Sketches:

- 1) Switch for start and manual release of deawner.
- 2) Filling cover.
- 3) Deawner outlet.
- 4) Outlet regulation.
- 5) Top screen.
- 6) Lower screen.
- 7) Fan.
- 8) Deawner.
- 9) Cyclone.
- 10) Air regulation.
- 11) Electro magnet for automatic discharge of deawner.
- 12) Plastic bag for aspirated waste.
- 13) Tray for sand and non aspirated waste.
- 14) Tray for cleaned grain.
- 15) Potentiometer time.
- 16) Springs.

Specifications:

Height H1	735 mm
Height H2	535 mm
Width W1	560 mm
Width W2	420 mm
Length L	660 mm
Weight	55 kg
Motor	230 V - 0.37 kW
Sample size approx.	1 kg
Sound level	62/79 dB(A)

