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DIPLOMA THESIS

Effect of Storage Conditions the Biomass Briquettes on their Mechanical Properties and their Heating Value

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DECLARATION

I hereby declare that I have elaborated this master thesis independently. All information sources are quoted in References.

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ABSTRACT

The aim of this thesis is to identify and evaluate the impact of environment and way of handling briquettes, especially on their mechanical consistency, expressed by different sizes of abrasion of briquettes according to CEN/TC 335th. For research were selected two energy crops: *Miscanthus Sinensis* and *Miscanthus Gigantus*. These two varieties are known for their relatively large heating values but it have not been known how briquettes behave during transport and handling. This testing was being simulated in a rotary drum according to the above standards. Two environments were chosen on purpose with different temperatures and humidity, in order to determinate what environment is best suited for storage of briquettes.

Keywords: storage conditions, mechanical properties of briquettes, *Miscanthus Sinensis, Miscanthus Gigantus,* abrasion of briquettes

ABSTRAKT

Cílem práce je zjištění a vyhodnocení vlivu prostředí, směsi a způsobu manipulace s briketami a to především na jejich mechanickou soudržnost, vyjádřenou velikostí odrolu jednotlivých briket, zjišťovaného podle normy CEN/TC 335. Pro výzkum byly vybrány dvě energetické plodiny a to *Miscanthus Sinensis* a *Miscanthus Gigantus*. Tyto dvě odrůdy jsou známy svojí poměrně velikou tepelnou výhřevností, ale doposud nebylo známo, jak se brikety chovají při transportu a manipulaci s nimi. Toto je právě simulováno zkoušením v rotačním bubnu podle výše zmíněné normy. Záměrně byla vybrána dvě prostředí s rozdílnými teplotami a vlhkostí, aby bylo zjištěno, jaké prostředí je pro skladování briket nejvhodnější.

Klíčová slova: podmínky skladování, mechanické vlastnosti briket, *Miscanthus Gigantus, Miscanthus Sinensis*, odrol briket

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1 FOREWORD

Currently, much of the world depends on fossil fuels, among which belong mainly oil, natural gas and coal. Although this is relatively cheap source of energy, but it is non-renewable. Another major problem of using these fuels represents the environmental burden since the burning of fossil fuels produce hazardous waste products, such as carbon dioxide, methan and nitrogen oxides.

For these reasons, it is necessary to limit the use of fossil fuels and move to their appropriate alternatives.

One possibility is the use of renewable biofuels, so fuels produced from biomass.

In our climatic conditions are most commonly used solid biofuels, especially wood briquettes- they are solution for the disposal of wood waste- sawdust and wood shavings. Briquettes have excellent properties such as high calorific value, easy manipulation, renewable and last but not least, they are environmentally friendly.

2 OBJECTIVES

Objectives of this work are:

- to document and evaluate the impacts of type of storage of briquettes made from energy crop *Miscanthus Sinensis* and *Miscanthus Gigantus*
- to express the size of abrasion of each sample of briquettes according to current standards of CEN/TC 335th
- to evaluate the influence of variety and mixture of briquettes to their mechanical durability

3 INTRODUCTION

3.1 Miscanthus Characteristics

Miscanthus is a genus containing about 15 species of perennial grasses. *Miscanthus* was first cultivated in Europe in the 1930s but it is originally introduced from Japan (Lewandowski, 1998a).

Taxon:

- Kingdom: Plantae
- Family: Poaceae
- Subfamily: Panicoideae
- Genus: *Miscanthus*

For *Miscanthus* can be used several synonyms:

- Eulalia japonica
- *Miscanthus Sinensis* f. glaber
- *Miscanthus Sinensis* var. gracillimum
- *Miscanthus Sinensis* var. variegates
- *Miscanthus Sinensis* var. zebrinus
- Saccharum japonicum

From these species only M. tinctorius, M. *Sinensis* and M. saccharoflorus are mainly used for production of biomass and industrial use. In the term of zoning M. *Sinensis* is most suitable for North Europe, M. x *Gigantus* for middle Europe (Strašil, 2009).

Miscanthus Gigantus is a large perennial grass hybrid of *Miscanthus Sinensis* and *Miscanthus* sacchariflorus native to Japan (Hodkinson et al., 2002). When crossed, they create the sterile triploid hybrid M.x *Gigantus* (Figure 1), which is bigger than both parents. Further, it has inherited good cold tolerance and is currently the most productive crop known for cool, temperate regions of the world (Beale, et al., 1996). Most of the *Miscanthus* cultivars proposed as commercial crops in Europe are sterile hybrids.

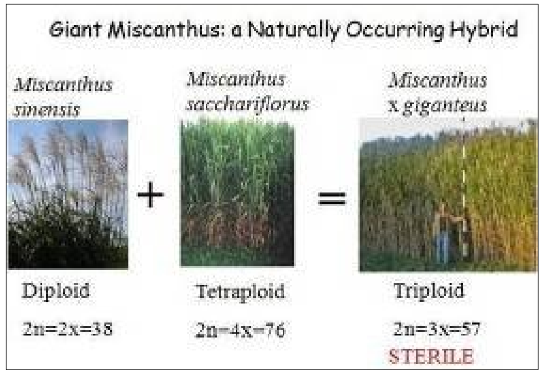


Figure 1: Creation of Miscanthus x gigantus

Source: Heaton et al, 2012

Representation of the hybrid origins of giant *Miscanthus* (M. x *Gigantus*), a naturally occurring hybrid grass first collected in Asia for use as an ornamental plant, and more recently for bioenergy (Heaton et al., 2012)

3.1.1 Botanical Characteristic of Miscanthus

Miscanthus belongs to the family Poaceae. For better understanding there is description of this family. Depending on the classification, the family includes approximately 668 genera. This family recognizes 12 subfamilies:

- Anomonchlooideae
- Phaoridaeae
- Puelioideae
- Pooideae
- Bambusoideae
- Ehrhartoideae
- Arundinoideae
- Centothecoideae
- Chloridoideae
- Panicoideae
- Micrairoideae
- Danthonioideae

The Poaceae is large family of monocot flowering plants, also called grass. With over 10 000 species, the Poaceae represent the fifth largest plant family (Stevens, 2007).They grow on all continents, in deserts to freshwater and marine habitats, and at all but the highest elevations. Plant communities dominated by grasses account for about 24 percent of the Earths vegetation (Campbell, 2012). Plant communities are called grasslands, wetlands, forests and tundra. The Poaceae are usually perennial and often rhizomatous herbs or bamboos, woody and tree-like (Gibson, 2009).

3.1.2 Physiology of Miscanthus

M. *Gigantus* is a C4 plant so it has more photosynthetic efficiency and lower water use requirement than other plants (Shawna et al, 2003). It has also very low nutritional requirements, it has high nitrogen use efficiency and it is capable for growing well without any or heavy fertilization. M. *Gigantus* is sterile hybrid so it is propagate vegetative through rhizomes (Lewandowski, et al., 2000).

Possessing C4 photosynthetic pathway, *Miscanthus* shows a remarkable combination of high light, water, and nitrogen use efficiencies. Its photosynthetic mechanism appears to be better adapted to low temperatures than that of many other C4 crops. Although water use efficiency is high, the crop may nevertheless require substantial amounts of water for maximal growth, because of its productivity (Walsh and McCarthy, 1998).

3.1.3 Demands on the Habitat

Miscanthus grows best on lighter soils in warmer regions, to an altitude of 700 m and rainfall around 500-600mm/year. It is better to have higher level of groundwater, but not more that 60cm. But in the achievement of 40 tons of dry matter per hectare should be at least 1000 mm of rainfall or underground irrigation. Optimum soil pH is 5 to 6.5 (Holub, 2007). At pH more than 7 were observed yield depression. (Strašil, 2009).

Miscanthus also tolerates heavy soils and periodic flooding. *Miscanthus* is adapted to many soil conditions, including marginal land, but is most productive on soils well suited for corn production (Heaton, 2009).

It is recommended plant into a clean field and the whole field may be tilled prior to planting. Soil should be finely tilled to a depth 15 cm (Heaton, et al., 2012).

Miscanthus has higher demands on the climatic conditions than on the soil. Prerequisite for high yields of biomass are, in addition to heavy rainfall, higher temperatures during the growing period, it is from late May to late September. Otherwise, *Miscanthus* is less demanding on temperature than sorghum. It also tolerates slight shade (Strašil, 2009).

This crop has rate of transpiration around 250 liters per kg of dry matter. Transpiration coefficient, according to Jacks-Stereenberg (1995) for *Miscanthus* is 250-340 liters per kg of dry matter. This coefficient put *Miscanthus* between sorghum and maize. In comparison, wheat transpiration coefficient is 540 or alfalfa 840 (Čvančara, 1962).

To reach 40 tones of dry matter per hectare of *Miscanthus* is theoretically needed 1000mm of rainfall. All types of *Miscanthus* sprout in late April. In experimental field in Prague-Ruzyne began to sprout in dependence on weather from 15th April to 3rd May (Strašil, 2009).

Miscanthus can also improve some soils properties. After years of cultivation of *Miscanthus* the soil has higher content of organic carbon (+0,29%), total nitrogen (+0,03%) and increase of soil organic matter. It is caused by high leaf drop and rich root system (Kahle et al., 2002).

Miscanthus does not grow at low temperatures below a threshold -6°C. This is lower than for maize and the potential growing season is longer (Strašil, 2009).

3.1.4 Pre-planting and Site Selection

For planting *Miscanthus* is best to choose a site where is no weeds and after suitable previous crop. The best previous crops are organically fertilized tuber crops- sugar beet, potatoes, legumes and cereals.

In autumn it is necessary to stubble with following deep tillage. Before planting in the spring, followed by seedbed to a depth 10cm, is necessary to make mechanical and chemical weed extermination (Strašil, 2009). If it is a grassland site, the best is to spray the site with broad spectrum herbicide (glyphosphate) for controlling perennial weeds. The site should be sprayed ant then ploughed to control perennial weeds. This may also help prevent lay pest such as the larvae of two moths; the common rustic moth and the ghost moth attacking the newly established plants, as any larvae or eggs already in the soil from the previous crop will have insufficient food over the winter to survive (Caslin, et al., 2010).

Grown young plants are planting in the DATE when the soil temperature exceeds 10°C, it is from mid April to mid July. Vegetation established from rhizomes should be plant earlier before the rhizomes begin to sprout. Rhizomes should be harvested when the *Miscanthus* is 3 years old and more. At this DATE the rhizomes are mature and sufficient for subsequent planting (Strašil, 2010). Rhizomes can be harvested by planting rotary cultivator and by subsequent collecting of rhizomes by harvester for potatoes (Pari, 1996).

3.1.5 Planting

Planting technology is one of the major limitations to giant *Miscanthus* use. It can be planted from rhizomes dug straight from a mother field (Heaton et al., 2012). It can be also planted with the seeds, by micro propagation and there were also examined the experiments with planting by the straws (Strašil, 2009).

Rhizome division is favored because it is less expensive and generally produces more vigorous plant (Caslin et al., 2010). The rhizomes must be cleaned and sized to fit trough the transplanters before planting. Furthermore is critical to apply water at planting stage to ensure good survival. Rhizomes should be planted to 5 to 10 cm deep and well covered. Both can be planted anytime after the frost-free date (Heaton et al., 2012).

Miscanthus can be also growing by sowing of the seeds. In Europe is not used sowing of the seed for several reasons. Climate in central and northern Europe does not allow receiving viable seeds. Most frequently used *Miscanthus* x *Gigantus* is triploid hybrid so is practically sterile. Seeds sprout badly so it is necessary to make bigger growing rate.

When *Miscanthus* grows from the stem, the stem must contain well developed nodal buds. Best results were achieved on the first two nodes at the base of the stem. 80% of cutting rooted and developed into young plants after 4 to 6 weeks. For planting are more suitable stems from older plants (6 years). For stem cutting the best month is August (Strašil, 2009).

3.1.6 Density of Vegetation

Selecting an appropriate density of *Miscanthus* is dependent on the dynamics of biomass above the plants and the economics aspects. In the first period depends on the density of vegetation. In denser vegetation are initially achieving higher returns. They later faint regardless on the density. Also the number of stems increases and reaches maximum value, than decreases and maintains the same level (Bullard et al., 1997).

For very dense vegetation in later years can leas to production of large amounts of the stem to the area. High density of the stem results in great competition for nutrient and lights, especially in the lower floors. A large number of stems die in early June (Jack-Sterrenberg, 1995). Currently, the recommended density of *Miscanthus* is from 10 000 to 20 000 plants per hectare (Strašil, 2009).

3.1.7 Pest Control

Weeds if it is not controlled will compete with the crop for light, water and nutrients and thus reduce yields. The level of weed interference will depend on the stage of maturity of the crop. In the researches was proved application of atrazine and pendimethalin. Third year after planting is recommended apply small amount of herbicide. At present, there are no commercial pests. Given the clonal nature of the crop, any pest issues that do arise may become serious (Heaton, et al., 2012).

Active ingredients	Example Product(s)	Notes
Bromoxylin/ioxynil	Capture	1.1 l/ha
Bromoxynil/ioxynil	Oxytril CM	2 l/ha
Bromoxynil/Mecroprop-P/ioxynil	Swipe P	5l/ha
Diflufencan/isoproturon	Panther or Cougar	2l/ha Isoxaben is used within 14 days of planting
Fluroxypyr	Starane 2, Floxy, Tomahawk	2l/ha
Glyphosate	Roundup or touchdown quatrro	6l/ha
Isoproturon	Tolkan Liquid	5l/ha
Metsulfuron-methyl	Ally SX	30g/ha
Metsulfuron-methyl/Tribenuron-metyl	Ally max SX	42g/ha
Tribenuron-methyl	Cameo SX	30g/ha
Metsulfuron-methyl/fluloxpyr	Ally	20g/ha
MCPA	Mortone	5l/ha
	M50, Mastercrop, MCPA amine 500, Agroxone of Argritox 50	3,5l/ha
Mecoprop-P	Duplosan New Syst	2,3l/ha
Mecropop-P/Dicamba	Foundation	1.25l/ha
Pendimethalin	Stomp or Alpha Pendimethalin	3.3l/ha or 4l/ha

Table 1: Overview of the Used Substances

Source: Bullard et al, 1995, Caslin et al, 2010

3.1.8 Fertilization

Miscanthus is perennial crop, but the stems and leaves only works one growing season. Persisted plant organs are only rhizomes that work to vegetative plant propagation and storing nutrients.

- *Miscanthus* is very efficient in the way it uses nutrients. There are number of reasons for this high level of efficiency.
- *Miscanthus* is deep rooted and can soak nutrients from a large area of soil
- *Miscanthus* has high nutrient efficiency compared to arable crops (wheat, barley) and native grasses. Less nutrients are needed for each kilogram or unit mass of biomass produced by the crop
- .Excess nutrients are exported from the above ground parts to the rhizome during the autumn as the leaves senesce. The nutrients are stored in the rhizome during the following spring.
- Leaves fall off the *Miscanthus* stems as winter progressed and accumulate as a litter layer on the surface of the soil. The litter layer is broken down over DATE and the nutrient find their way back into the soil where they can be once again absorbed by the root system. Additional nutrition is available to the crop through atmospheric deposition and soil mineralization (Caslin et al., 2010).

On well-nourished soils *Miscanthus* can be the first year without fertilization. On soils with smaller supply of nutrients is recommended to fertilize the first year till middle of June by single application of 50 kg per hectare due to reduced possibilities of freezing of soil. The second year is necessary for fertilization with mineral fertilizers built on soil supply. On average, it is recommended to fertilize the second year and next years by 50-100 kg/ha N, 40 kg/ha P, 70kg/ha K. It is also recommended to fertilize by microelements Cu, Zn, B, Mn (Strašil, 2009). But according to Casling et al. (2010) the amount of N should be 60-100kg/ha, P should be 7-15 kg/ha and K should be 50-130 kg/ha.

Swarz (1994) indicates that the demand for mineral fertilizers measuring the yield of *Miscanthus* is smaller than in other plants. It indicates that in the third year of cultivation at the end of February were these nutrients removed at harvest 1 hectare (20 tons of dry matter per hectare): 100 kg N, 150 kg K2O, 18 kg P2O5, 23 kg MgO and 30 kg CaO. Around 100 to 130 kg/ha N was contained in the shed leaves in the field.

The effect of nitrogen fertilization on dry matter yields of biomass at two different sites in Germany for four years of cultivation shows Table 2 (Kolb, 1993). The results show that graduated N fertilization had no significant effect on final yields of biomass.

Also Bischoff, Emerling (1995) also comment that the yield of biomass was more affected by long plants than the number of stem.

Dose N (kg/ha)	Site Klaranlage Yield (t/ha)			
	1 year	2 year	3 year	4 year
0	1,1	8,3	17,5	22,2
50	0,8	5,8	14,7	20,4
100	1,1	6,7	14,2	21,1
150	1,0	6,9	15,6	22,2
250	0,8	6,9	16,1	21,4
Dose N(kg/ha)	Site Volkenhaus Yield (t/ha)			
	1 year	2 year	3 year	4 year
0	1,1	4,2	6,7	7,7
50	0,7	3,4	6,7	7,9
100	1,0	5,1	6,5	8,0
150	1,1	5,6	6,6	8,3
250	1,3	6,6	7,0	7,5

Table 2: Yields of dry matter (t/ha) of *Miscanthus* with different doses of N (1 to 4 year cultivation) at two sites

Source: Kolb, 1993

In Germany was also verified how *Miscanthus* affects the level of organic matter in soil. *Miscanthus* can produce about 8,2t/ha of organic substances witch are comparable with the manure. After 6 to 8 years of growing *Miscanthus* the soil was enriched with organic matter by 0, 5% on sandy soils and by 0, 2 on clay soils (Beuch, et al., 2000).

3.1.9 Harvest and Post-harvest Period

Harvesting is usually performed at a time when plants have low humidity. If it is not, it is need to be dry. Harvesting also depends on weather and crop maturity. Harvest of *Miscanthus* can be a single phase or multiphase. It is carried out by mobile cutter (Figure 2, 3) or by chipper (Strašil, 2009).

3.1.10 Final Drying and Storage

If the harvested plants are to wet, it is necessary to dry them. To drying can help direct sun or artificial final drying by cold or tempered air. Final drying in the field has a limited tome term and can be carried out according to the weather till the end of October.

For artificial drying can be used stores for potatoes (Strašil, 2009). Different methods for storage of moist have been examined. The simplest method was found to be outdoor storage in piles covered with plastic foil (Kristensen, 2001).

Miscanthus can be also silage. In silage must be appropriate pH, which is dependent on moisture content. Ensiled *Miscanthus* can be used for energy production or in paper industry (Strašil, 2009).

Figure 2: Mobile cutter

Source: Strašil, 2009

Figure 3: Mobil cutter

Source: Strašil, 2009

3.1.11 Potential Yields

Miscanthus yields are dependent on many factors, such as soil and climatic conditions of the site, selected clone, agronomic measures including tree density and fertilization, harvest date etc (Strašil, 2009).

Miscanthus is not harvested in first year, in the second year the production of biomass is 10t/ha, in the third year and following years is 15-25 t/ha. The biggest yield is in the anteze period and it is also necessary to minimize the water content in the plants, so that is usually harvested after winter when the water content is around 22-38% (Petrini et al., 1996).

Within comparison with another energy crops, *Miscanthus* grass produces more mass. For example, a typical acre of corn yields around 7, 6 tons of biomass/acre and 756 gallons of ethanol. Giant *Miscanthus* can produce up to 20 tons of biomass/acre and 3,250 gallons of ethanol fuel (University of Illinois, 2012).

The main feature distinguishing giant *Miscanthus* from other biomass crops is its high lignocelluloses yields. *Miscanthus* can yield more annual biomass than any other biomass crop (sugarcane, swichgrass), and has better growing range (Heaton et al., 2008a).

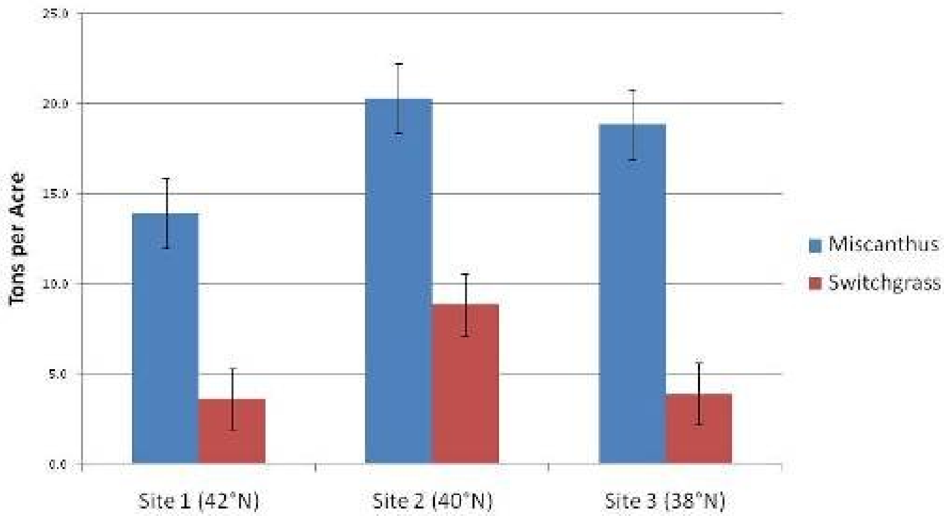


Figure 4: The average annual biomass yields of *Miscanthus* and *Switchgrass* harvested on 3 locations from 2004-2006

Source: Heaton et al., 2008

3.2 Energetical Potential of *Miscanthus*

3.2.1 Potential Use as a Biofuel

Miscanthus x *Gigantus* is nowadays well known as a source of energy. It can be either for direct combustion or biofuel production (NNFCC, 2011). *Miscanthus* is potentially an "ideal" energy crop because its annual cropping cycle provides a regular income for the grower (unlike woody crops, harvested only every 2-4 years) (Lewandowski 1998a).

It is grown in Europe for co-firing in coal power generating facilities and it can supply 12% of the EU energy need by 2050 (Dondini M. et al, 2009).

Miscanthus has:

- Relatively high yields — 8-15 t/ha (3-6 t/acre) dry weight,
- Low moisture content (as little as 15-20% if harvested in late winter or spring),
- Annual harvests, providing a regular yearly income for the grower,
- Good energy balance and output/input ratio compared with some other biomass options, and

- Low mineral content, especially with late winter or spring harvest, which improves fuel quality (The UK National Centre for Biorenewable Energy, Fuels and Materials).

3.2.2 Energy Content of the Dry Matter

The overall energy content of the harvested crop depends on quantity and energy content of individual plant organs. The energy on complete combustion of the dry plant matter is ranging between 16.0+/- 0.1 MJ kg for roots to 19.0 +/- 0.1 MJ kg for the leaves. The mean energy content of the above- ground dry matter was 18.4 MJ kg. Energy values of the total crop, inclusive the roots and rhizomes were lower at 18.1 MJ kg (Beale, 1996).

3.2.3 Energy Balance

Energetic evaluation is next to the economic evaluation one of the important objective criteria of usefulness of production. Energy balance compares energetically inputs with outputs. The gain energy is defined as the difference between collected and deposit energy. Specific energy consumption is calculated as the total energy per unit of final output (Haš, et al, 1985).

Energetic model of some crop production inputs, where is also indicated *Miscanthus* , are given in Table 4(Strašil, 200í). For plants growing only for biomass burning, then creates the largest energy *Miscanthus*, see the table. The table also shows that the energy inputs correspond to 4, 7% of energy output.

Plant	Energetic input necessary for crop (GJ)	Energy production (GJ)	Energetic profit (GJ)	Specific energy consumption (GJ)
Wheat-grain and straw biomass	26,10	156, 25	130,15	0,17
Rape- seed and straw biomass	22,32	140,50	118,27	0,16
Reed canary grass- whole plant	11,77	93,00	81,23	0,13
Miscanthus Gigantus	10,94	232,50	221,56	0,05

Table 4: Energetic balance of observing crops (GJ/ha/year)

Source: Strašil, 2003

Miscanthus is the most economical crop in Central Europe in the ratio of input energy to the growing and the energy yield of obtained materials (Holub, 2007).

3.2.4 Combustion Characteristics

Mineral concentrations are reported to be low at the DATE of the early spring harvest: 0.09-0.34% N; 0.37-1.12% K; 0.03-0.21% Cl (Lewandowski and Kicherer ,1997). Other reports suggest that *Miscanthus* has low mineral and ash content compared with other lignocelluloses species (Hasler et al. 1998). The mineral content is low compared with wheat straw. Like other biomass fuels, reactivity/ignition stability is high compared with coal. Overall, the CO2 balance shows a 90% reduction in emissions compared with coal combustion (Lewandowski et al. 1995).

The composition of *Miscanthus* ash includes approximately 30-40% SiO2, 20-25% K2O, 5% P2O5, 5% CaO, and 5% MgO -- a range of values is reported from different studies (Moilanen et al. 1996).

Miscanthus has been successfully burned on a commercial scale in Denmark, using a 78-MW circulating fluidized bed combustor (50% co-firing with coal) and a 160-MW powdered fuel combustor (20% co-firing). The plants were already adapted for co-firing with straw: 17 t of *Miscanthus* bales (Heston type, 450 kg, 12% moisture) were burned without major problems in the fluidized bed combustor, and 100 t in the powdered fuel combustor (Visser 1996).

3.2.5 Miscanthus as a Bioenergy Crop

In comparison with other bio-energy crops, *Miscanthus* is among one- year crops and perennial trees. If it reaches higher yields, its energy and carbon balance can be beneficial and nitrous oxide emissions are also low because of its high utilization of nutrients (Kaltschmitt et al. 1996; Lambert et al. 1996). However, energy balance modeling has suggested that overall energy output/input ratio may be as low as 1.1 in the case of co-firing *Miscanthus* with coal because of the high energy requirement for fuel pulverization. In the best case (small-scale heat and power cogeneration with fluidized-bed gasification/gas-turbine technology) the energy balance was 9.6 (Molenaar et al.1996). N2O emissions from normal levels of N-fertilizer application had only a modest effect on net offsets of greenhouse gas warming potential (6% of total CO2 displacement) (Jorgensen and Jorgensen 1996).

3.3 Further Use of *Miscanthus*

Miscanthus may be helpful in the construction industry for manufacturing prefab slabs or building blocks, of for production of fireboard, cardboard and woody mat (Harvey, 1994). *Miscanthus* stems can be also used as feed (Hayashi, 1994). Biomass of *Miscanthus* can be used while composting with manure from cattle and pigs (Eiland, et al., 2001). It can be also used in the production of natural light sandwich materials, which can substitute the materials made of light metal or plastic (Stršil, 2009).

3.4 Economy

There are cheaper ways of *Miscanthus* grown. When creating a stand of vegetation it is recommended density 10 000 plants per hectare, because plants are expensive. It is also recommended to be planted trough the rhizomes, because it is cheaper than other ways. The price of one rhizome is 0, 075€ (Strašil, 2009)

If the *Miscanthus* is fully used as fuel in the energy sector, will be economically viable if the revenue is higher than 18 t/ha of dry matter, which can be achieved on large farms. *Miscanthus* with high water content around 50% at harvest can be used for production of sandwich materials (Bullard, 2001).

The costs of giant *Miscanthus* production are front loaded (Table 4). Depending on the source, planting material alone can cost $1,000 to $10,000 per acre. When considered over the productive life time of a stand, which is likely 15 to 20 years, the costs of production are less than annual row crops, leading to increased profitability, even without subsidy. Once established, giant *Miscanthus* requires little maintenance, no annual replanting, and only an annual harvest. Given the low-input nature of the crop, it is likely that custom operators will arise to handle giant *Miscanthus* production for interested land managers (Heaton et al, 2004).

Costs ($/ton)	*Miscanthus*			
	1st year	2nd year	3rd-10th years	10 years
Fertilizer	25	24	9	98
Pesticides	6	0	0	6
Seed	128	0	0	128
Crop drain	0	0	0	0
Machinery repair, fuel, hire	18	41	38	257
Labor	34	33	31	228
TOTAL VARIABLE COSTS	211	98	79	717
Machinery, overhead, housing	0	0	0	0
Depreciation, non-land interest	9	23	22	146
Land	151	147	138	1011
TOTAL OTHER COSTS	160	170	160	1156
TOTAL ALL COSTS	371	268	239	1873
Yield (tons/acre)	0	0	0	0
Yield (dry tons/acre)	0	7	14	0
Value ($/ton)	40	39	38	
GROSS REVENUE ($/acre)	0	268	538	3047
NET PROFIT4 ($/acre)	-371	0	299	1174

Table 3: The cost of Giant Miscanthus production

Source: Heaton et al, 2004

3.5 Environmental Considerations

Several studies have demonstrated that compared to the arable or intensive grass which *Miscanthus* is more likely to replace, the impact is likely to be benign. *Miscanthus* has a very low agro- chemical requirement. As the site is only cultivated once, at establishment reductions in soil disturbance and erosion can also be achieved compared with conventional arable crops.

Miscanthus may be a good shelter for various species for birds and mammals such as beetles and spiders (Christian et al, 1997). Also has been detected seven bird species (Eppel-Hotz, Jodl, 1997).

Persistently vegetations are important for the protection of soil and landscape point of view. Large plantations can have negative effects on the landscape, but only in the case that is growing only one species (Strašil, 2009).

3.6 Briquettes

Briquettes are made by pressing of dry material as dry wood, bark, sawdust, fine wood shavings or plant debris in the form of debris in the cylinders, prisms or hexahedron with a diameter of 40–100 mm and length 300 mm. According to the selected type of material there are several forms of briquettes from wood, bark, straw, energy crops, and briquettes made of mixtures of these materials, so called mixed briquettes.

Briquettes can be of different color depending on the type of biomass, the quality of raw materials affected by moisture or by bark used in the process production. Briquettes are due to its high density, which is around 1000 to 1200 Kg/m3, stable and low humidity (water content is usually around 8%) and low ash content (about 1-3%)(Stupavsky, et al, 2010).

An important feature of briquettes is the consistency and impact resistance, which indicates the resistance to transport. The second parameter is the density, which is the concentration of energy in space (Plíštil, 2004).

3.7 Quality of Briquettes

High quality briquettes reach calorific value 18 MJ/Kg, which exceeds the normal value of brown coal (14 to 16 MJ/kg). The ratio of dry matter and water content (moisture) of briquettes affects their calorific value significantly. Humidity of wood briquettes have a major impact on their calorific value, because water has a large heat of evaporation with increasing water content is reduced the energy gain.

By burning the water evaporates, reducing the basic calorific value of dry matter biomass. Besides the calorific value and ash content is important pressing value of biofuels, expressed by density. Biofuels may be lighter than water. High density of biofuels ensures that they do not accept air humidity, so it extends their storage and length of combustion (Perďochová, 2010).

3.8 Briquetting - Production of Briquettes

While briquetting should be followed certain basic technical parameters such as:

- Heating power: 12 to 18 MJ/kg
- Weight/ volume: up to 1200kg/m3
- Humidity: up to 15% (Stupavsky, et al, 2010).

Before making briquettes itself, the material should have following characteristic:

- Purity of the material: the material should be free of dirt, such as the soil on the biomass
- Size of the input fraction: in the briquettes is needed to have biomass maximum length 200mm (Plíštil, 2004).
- Low moisture content- should be as low as possible, in the range of 10-15 percent (Grover et al, 1994). If the biomass contains more that 20% of water, briquettes can not be compressed because they disintegrate (Plíštil, 2004).
- Ash content and composition- biomass normally have low ash content but have higher content of alkaline minerals. These minerals have tendency to evaporate during combustion and condense on tubes and also lower the sintering temperature of ash, leading to ash deposition of the boilers exposed surfaces.
- Flow characteristics- the material should be uniform so it can flow easily in bunkers and storages (Grover et al, 1996).
- Pressure- Increasing pressure increases the density of briquettes (Plíštil, 2004).

Briquettes are made from wood or plant residues by strong compression, which is called briquetting. By briquetting is created a new type of solid biofuels, ranking its calorific value from 12 to 18 MJ/kg.

To ensure proper size fractions of the material, the material passes through the crusher (Plíštil, 2004). Crushers should be used for the preparation of raw materials; whose size exceeds the permitted size of 15mm. Briquettes can not be produced only from crushed material without the addition of sawdust. The proportion of sawdust should be at least 50%. The crusher should be always equipped with a sieve with diameters of less than 15mm (Briklis)

The progress of shaping or pressing biomass is most affected by its compressibility (Osobov, 1970). Pressing biomass in the form of briquettes is one of the most basic kinds of pressing. Briquettes are compressed by high pressure to form of a full cylinder, prism, or a load with a central hole (Sladký, Dvořák, Andert, 2002). The production of briquettes occurs when pressing the appropriate granularity in the briquetting press (Simanov, 1995). Biomass, which is compacted into compact shape- briquettes for better handling compared to bulk biomass. Briquetting biomass is also suitable for other technological operations which are: combustion, storage and transportation (Plíštil, 2003). Briquetting can achieve a substantial reduction in waste volume, and thereby neutralize the waste difficult to use. The result of briquetting is briquette, which has smaller volume than the original material and thus obtains higher density briquettes (Bartoš, 2000).

3.9 Use of Briquettes

Briquettes can be burned in any wood boilers, can be used in fireplaces, tiled stoves and central heating boilers. The highest efficiency of the combustion of biomass briquettes is achieved in boilers for wood gas. Due to the nature of fuels from biomass briquettes they are completely clean and renewable source of energy (Stupavsky, et al, 2010).

Burning briquettes from wood waste in comparison to fossil due to pollute less sulfur oxides and certain heavy metals. Ash from burning briquettes of pure wood waste is not necessary to landfill, but can be used as a compost substrate or directly injected to the soil (Směrnice MŽP č. 14, 2006).

4 MATERIALS AND METHODS

4.1 Plant Material

To create a solid fuel which was further tested were used two varieties of *Miscanthus*, *Miscanthus Sinensis* and *Miscanthus Gigantus*. Both varieties were grown on the land of CZU, particularly in horticulture. These varieties were planted in year 2009 and because its perennial crop it could be harvested every year. The material used for research purposes was harvested in April 2011 and has been dried under natural conditions in the sun. For research was used 30 kg of dry *Miscanthus*.

4.2 Crushing of Material

For further processing of *Miscanthus* it was necessary to crush it. For crushing was used crushing press slam sieve with a diameter 8mm.

Figure 5: Crushing press

Source: Bartoš, 2000

4.3 Production of Briquettes

The next step was crushed material is processed to the briquettes by briquetting press BrikStar CS 25 from the company Briklis s,r.o. The press is equipped with filling device of 0,7 cubic meters and it is suitable for production of briquettes from energetic crops. Briquettes had cylinder shape with diameter 65 mm and length 30-50 mm. They can be incinerated in all types of combustion devices, boilers and incinerators for burning solid fuels. By briquetting the material was reduced eight times.

For research purposes was *Miscanthus* mixed with sawdust and wooden shavings because of combination of materials.

The following table 5 shows the six types of produced briquettes. With M. *Gigantus* were produced 3 types of briquettes. The first type was only clean *Miscanthus*; the second type was made by 50% of sawdust and 50% of *Miscanthus*. The third type was mixed by 50% of wood shavings. The same procedure was repeated with M. *Sinensis*.

For each file was produced at least 30 briquettes and in results were used the average value for one briquette expressed in grams.

	Variety	
Type of briquette	**Miscanthus gigantus**	**Miscanthus Sinensis**
	Clean	Clean
	50% sawdust+ 50% M.G	50% sawdust+ 50% M.S
	50%wood shavings+M.G	50% woodshavings+M.S.

Table 5: Types of made briquettes

Source: author

For the purpose of sighting mechanical properties of briquettes due to the environment, briquettes were stored (from 15.11 2011 to 21.3. 2012) 4 months in two different environments with different moisture. First environment was outside in area of CZU, were they were sufficiently protected against adverse conditions (wind, rain) and with an average temperature and humidity. An average temperature and humidity was measured by meteorological station in ČZU. The average temperature during this four months (15.11- 21.3. 2012) was 1, 717965°C and average relative humidity was 74, 74882

%. Second environment was a laboratory with an average temperature 23 °C and relative humidity between 45- 60 %.

4.4 Testing of Durability

4.4.1 Principle

The test sample is subjected to controlled shocks by collision of briquettes against each other and against the walls of a defined rotating test chamber. The durability is calculated from the mass of sample remaining after separation of abraded and fine broken particles (CEN/TC 335th).

The mechanical strength of briquettes can be also characterized by a force that is necessary for its destruction (Brožek, ročník 5), but in this work the mechanical durability is expressed by calculation of DU and by average size of abrasion.

4.4.2 Briquette Tester

The durability drum is a cylindrical steel drum with a nominal volume of 160 l having the following dimensions (see Figure 6).

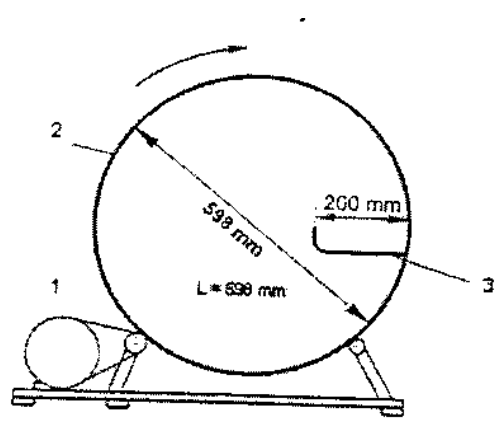


Figure 6: Rotary drum

Notes: **1- Motor, 2- Drum, 3- Baffle**

Source: CEN/TC 335

The drum shall be made of minimum 1mm steel plate. The internal surface area of the drum shall be smooth and any disturbances of the surface such as ridges of furrows shall be avoided. The drum shall be capable of being constantly driven at 21 +/- 0,1 rpm by an electronic motor, by suitable pulleys or gearings, in order to avoid vibrations. A rotation counter should be connected to the drum.

4.5 Testing of Briquettes

A prepared sample (2+/-1)kg was placed in the durability drum and that rotated 4min 20 seconds. Furthermore the each briquette was measured individually by its weight to determine the weight from abrasion. This was repeated every time in given time period.

4.6 Calculations

Research results are expressed by weight and size for every single abrasion. For every environment, mixture and the variety are attributed to a particular graph, which is located in annexes.

To every chart is enclosed table of data, so it is easily seen which values belongs to individual columns. The charts are also divided according to individual environments. The individual weights are given as average weight (Arithmetic mean) of all the varieties of all briquettes from a mixture and for each measurement are also given standard deviation.

Arithmetic mean is calculated :

$$A = \frac{1}{n} * \sum_{i=1}^{n} x_i$$

Where

- A = average (or arithmetic mean)
- n = the number of terms (e.g., the number of items or numbers being averaged)
- x1 = the value of each individual item in the list of numbers being averaged

Standard deviation is calculated:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

Where

- σ = standard deviation
- xi = each value of dataset
- x (with a bar over it) = the arithmetic mean of the data
- N = the total number of data points
- ∑ (xi - mean)2 = The sum of (xi - mean)2 for all data points

To test the results were used test analysis of variance (ANOVA) with significance level α=0,05. In the test were compared environment and variety (see appendixes).

4.6.1 Calculation of Durability

According to the norm CEN/TC 335 the mechanical durability of briquettes shall be calculated using the following equation:

DU=(M4/M0)*100 (%)

Where:

- DU is the mechanical durability in percent
- M0 is the mass of pre-sieved briquettes before the drum treatments in grams
- M4 is the mass of sieved briquettes after the drum treatment in grams

M0 shows the weight of fresh made briquettes so it is set as the default weight. M1 is the mass after the first abrasion which was performed immediately after the briquettes were made it. M2 is the mass after first month of storage and abrasion, M3 is the mass after the second month of storage and third abrasion and M4 is the mass of the fourth month of storage and fourth abrasion.

Due to this variation can determine the quality of briquettes. With increasing standard deviation is decreasing the quality of briquettes. Larger standard deviation is caused because it counts with value 0 which meant the total dissolution of the sample (see appendixes).

Individual data was achieved using Microsoft Excel by filtering an average weight and their classification due to their various mixtures.

As the most important we can regard the mentioned last measurement (M4), because it is clearly evident, which mixes, environment and variety are best for briquette durability. All these data are explained further (see Table 6, 7).

Consequently, it is ale expressed the size of the abrasion of briquettes, which was measured by weighing the individual briquettes and it is expressed by an arithmetic mean.

5 RESULTS AND DISCUSSION

5.1 Gradually Declining Average Weight of Briquettes

For each of the following samples it can be seen the gradual disintegration of briquettes expressed by declining of its weight. Average value of M0 is ranged from 127 to 140g but this value is also dependent on number of briquettes. It is also seen that there has been a growth of standard deviation. As already mentioned above it was because in to the file entered value 0, which means complete breakdown of the sample.

Explanatory Notes:

- MG- *Miscanthus Gigantus*
- MS- *Miscanthus Sinensis*
- 1- pure *Miscanthus*
- 2- mixture with sawdust
- 3- mixture with wood shavings

					Outside				
Mixture	Number of briquettes		M0	M1	M2	M3	M4		Remaining briquettes
		Diameter [g]	127,0968	116,3871	112,1935	97,53871	92,22258	MG	
1	31	Standard deviation	20,47007	20,46734	20,62539	41,48428	40,0188	MG	27
		Diameter [g]	139,7442	133,5349	129,5581	122,9209	119,3744	MG	
2	43	Standard deviation	22,40546	22,84768	23,42576	34,79614	34,66432	MG	41
		Diameter [g]	126,8281	120,2381	114,1635	111,0984	104,0938	MG	
3	64	Standard deviation	24,99813	23,01172	27,16139	27,35881	32,91837	MG	61
		Diameter [g]	133,7674	127,1395	121,7605	112,8814	113,1442	MS	
2	43	Standard deviation	21,25675	22,82081	23,81013	35,312	32,19598	MS	42
		Diameter [g]	133,3778	122,2667	114,3311	109,4689	98,04444	MS	
3	45	Standard deviation	15,63546	16,24444	16,87227	17,98255	30,11795	MS	45

Table 6: Average falling of weight of briquettes per time under outside conditions

Source: author

In results is missing pure *Miscanthus* Sinesis (MS1). This sample has disintegrated immediately after the first abrasion, thus is not included in the tables.

Inside									
Mixture	Number of briquettes		M0	M1	M2	M3	M4		Remaining briquettes
		Diameter	137,3333	127,1	119,8	115,1667	102,7833	MG	
1	30	Standard deviation	21,90156	22,68882	23,40115	23,56538	36,63725	MG	28
		Diameter	140,7442	134,6977	128,2326	124,0884	115,6674	MG	
2	43	Standard deviation	23,10751	22,69732	22,45825	22,61564	28,31682	MG	42
		Diameter	133,6	126,7	121,1667	116,44	112,5467	MG	
3	30	Standard deviation	11,37935	11,98893	12,55082	13,16054	12,94856	MG	30
		Diameter	137,8276	130,8966	124,5517	121,6	118,8793	MS	
2	29	Standard deviation	20,56708	21,38649	26,91068	26,29188	25,77943	MS	28
		Diameter	138,7333	127,5333	117,1333	108,9333	104,6933	MS	
3	15	Standard deviation	19,64858	23,83535	26,48414	37,15998	36,44459	MS	14

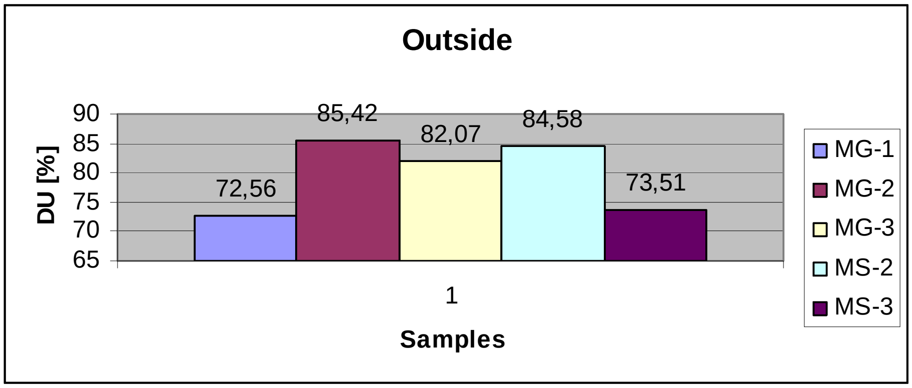
Table 7: Average falling of weight of briquettes per time under inside conditions

Source: author

A best result in terms of mechanical durability in outdoor environment was achieved for *Miscanthus* Gignatus mixed with sawdust (mixture number 2) and its mechanical durability was over 85%. The similar result was achieved by *Miscanthus Sinensis* with mechanical durability over 84% and with same ingredients. As worst were reflected pure *Miscanthus Gigantus* and mixed with wood shavings (see graph 1).

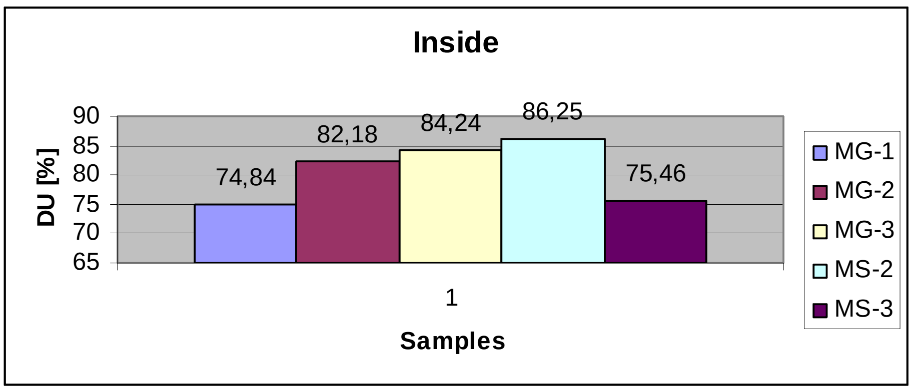
In graph 2 it is shown inside environment and it clear that the samples are almost always +/- 2 % greater then in chart above, which implies, in the terms of mechanical durability that this environment was better.

In this environment was again achieved the best result by *Miscanthus Sinensis* mixed with sawdust (MS2), the value of DU reached more than 86%. It is evident from the point of view of mechanical durability, that this sample is the best.



Graph 1: Mechanical durability expressed in % for each sample, environment outside

Source: author



Graph 2: Mechanical durability expressed in % for each sample, environment inside

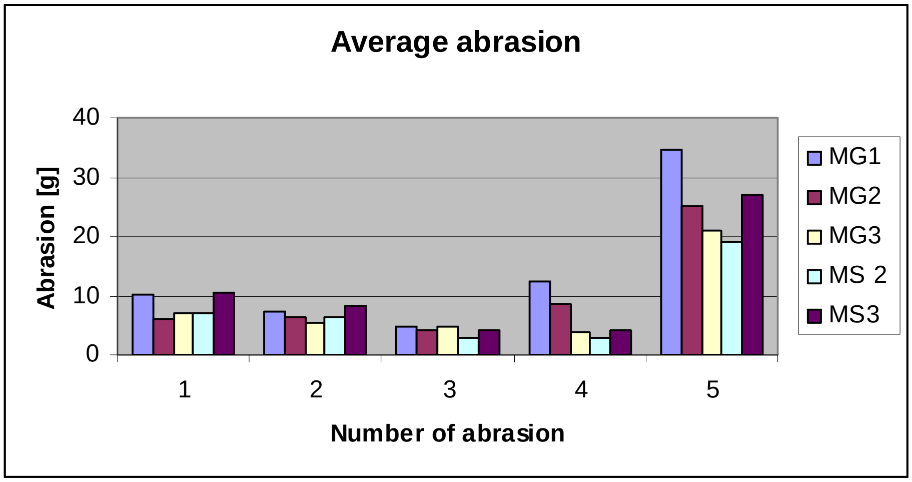
Source: author

5.2 Average Abrasion of Briquettes

In comparison with graphs above, which show the average weight of briquettes which gradually fell, these graphs show that the abrasion depends on time. The highest abrasion was achieved immediately upon first abrasion.

The following graphs show the average abrasion per unit briquettes. In laboratory environment it is clear that the best result, so the smallest abrasion, was again achieved by *Miscanthus Sinensis* mixed with sawdust. In outside environment the best result was again achieved by *Miscanthus Gigantus* mixed with sawdust followed by *Miscanthus Sinensis* with sawdust and *Miscanthus Gigantus* with wood shavings. The briquettes which were stored in a laboratory environment had greatest abrasion immediately after the briquettes were made and further abrasion size had decreased.

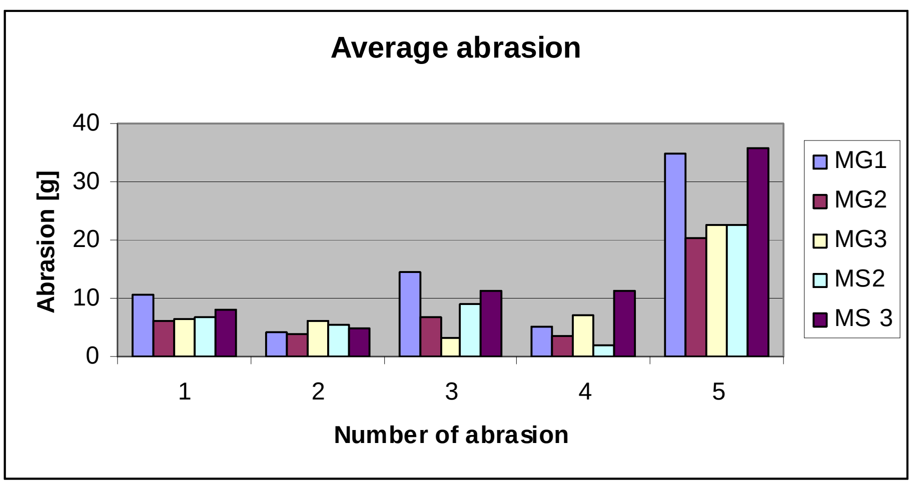
For outdoor environment was abrasion, after the briquettes were made, also large but mainly increased after the second month of storage.



Graph 3: Average abrasion of each sample in inside environment

Notes: 1-first abrasion, 2-second abrasion, 3-third abrasion, 4-fourth abrasion, 5-overall average abrasion

Source: author



Graph 4: Average abrasion of each briquette in outside environment

Notes: 1-first abrasion, 2-second abrasion, 3-third abrasion, 4-fourth abrasion, 5-overall average abrasion

Source: author

5.3 The Impact of Type of Storage

Due to the evaluation of moisture and due to the past experiences have been selected two environments with different humidity. According to Perďochová (2010) the ratio of dry matter and water influence and affects calorific value of briquettes, because the water contained in the briquettes has a large heat of vaporization and with increasing water content is reduced the energy gain.

In the production of briquettes moisture content should not exceed 15% because otherwise they rapidly disintegrate (Plíštil, 2004). From this is evident that the greater moisture, the faster disintegrate.

The results show that higher moisture negatively affects the mechanical consistency of the briquettes because the briquettes stored outside had worst result, despite the fact that was protected from rain and other conditions. All briquettes that have been stored outside had in the end lower weight and larger DU with comparing briquettes stored in laboratory.

This is because of the greater moisture entering to the briquettes. Briquette will swell, it enters the air and therefore it is lighter and easier to break (Stupavsky et al, 2010). By this is briquette influenced both in the storage, so when testing abrasion. Briquettes should be therefore stored in drier places.

5.4 Effect of Storage Time on the Briquettes

For the quality of briquettes is also very important time of storage. Briquettes were stored for 4 months and were not mechanically stressed. The mechanical stress was simulated by briquette tester (rotary drum). The result shows that the most abrasion occurred immediately after the production of briquettes. This was caused because at first are destroyed the edges, so the shape was evident particularly at the edges.

Here we see again the difference between the moisture in individual environments and how they affect the briquettes. The laboratory environment was the biggest abrasion after the production of briquettes and later values remained the same. The lowest quality sample (MG1 and MG2) with increasing time, the abrasion has increased also. In contrast, the best sample (MS 2 and MG3) abrasion declined. This is due to the value of DU which in these samples was also the highest. In contrast, the biggest abrasion in outside environment was achieved after the second month of storage which confirms that with increasing humidity of material increase abrasion.

5.5 The Influence of Material

From previous research implies that the best plant for pressing briquettes is exactly *Miscanthus Sinensis* (Plíštil, 2004). The author states that have the greater density and that it is need large force to destroy the briquette. However, this research implies that the worst crop for production of briquettes is pure *Miscanthus Sinensis*, which disintegrate immediately after first abrasion. In contrast, *Miscanthus Sinensis* stored in inside environment and mixed with sawdust had the best results.

6 CONCLUSION

From the measured fuel briquettes, which were made, implies that the best environment for their storage are are dry and warm places. With increasing moisture increase their abrasion.

The results also implies that for the production of briquettes from *Miscanthus* is the best variety *Miscanthus Sinensis*, but in the ratio 1:1 with sawdust.

For futher observation of briquettes from *Miscanthus* it is recommended to add another type of storage and also extend the time of it.

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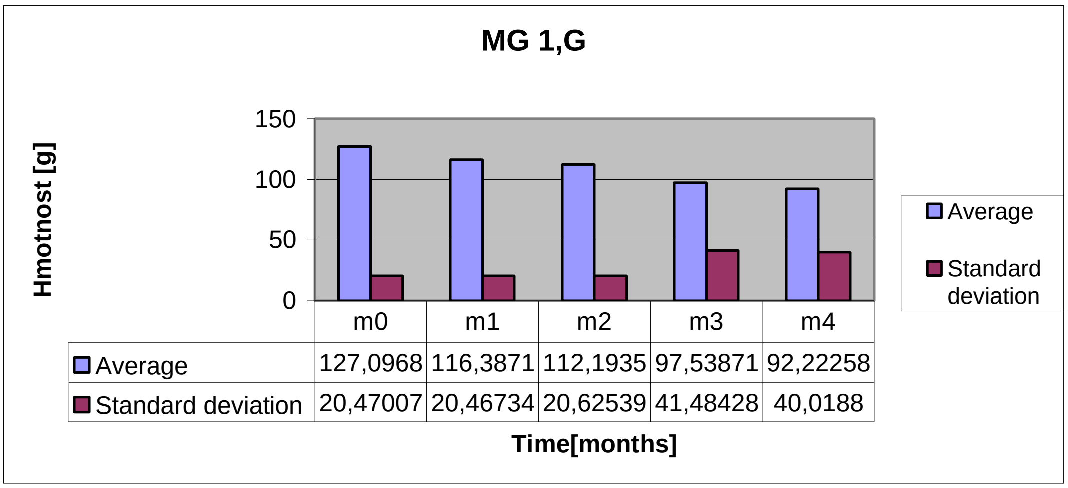
APENDIXXES

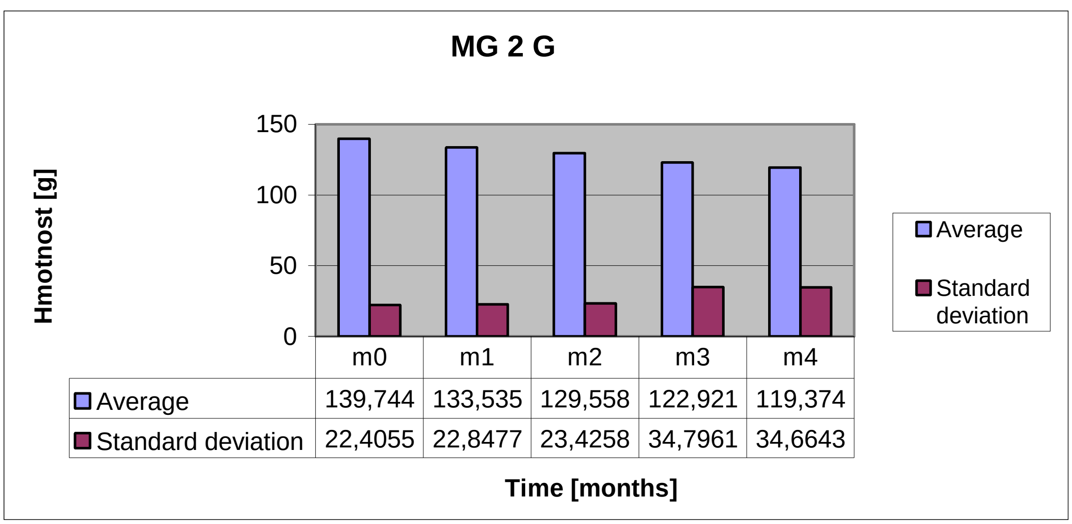
Environment 1: Outside

Graph 1:Dependence of disintegration of briquettes on time (pure M.G.)



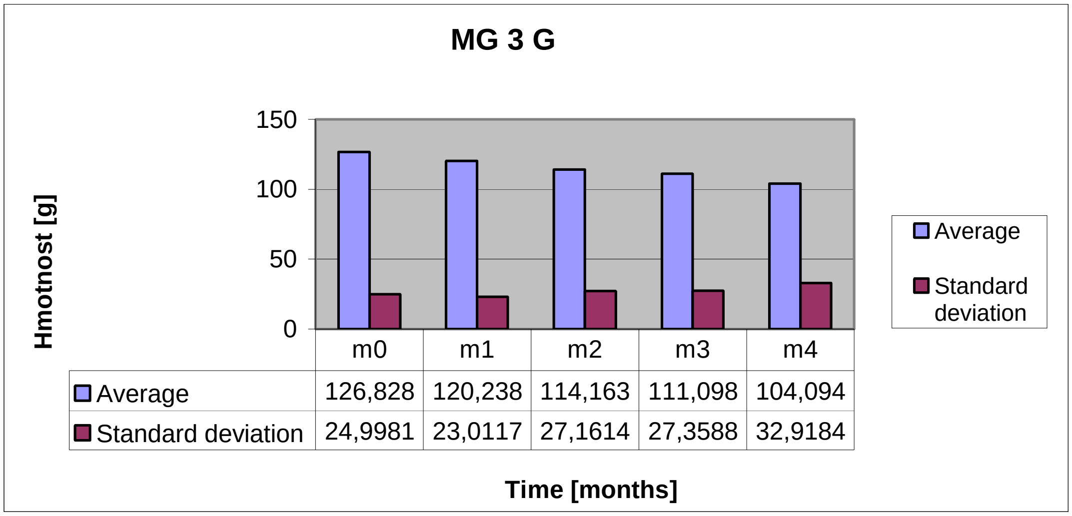
Source: author

Graph 2: Dependence of disintegration of briquettes on time (MG mixed with sawdust)



Source: author

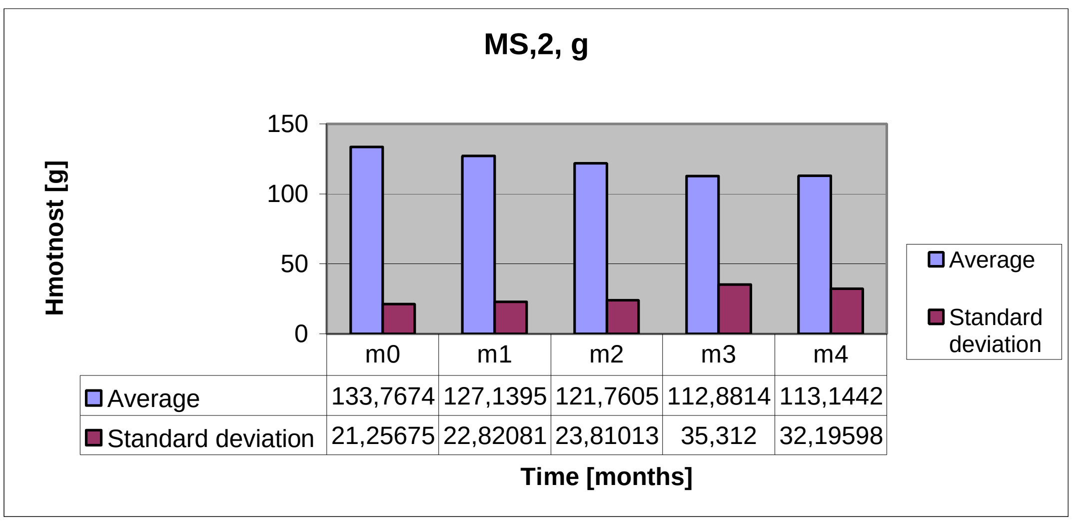
Graph 3: Dependence of disintegration of briquettes on time (MG mixed with wood shavings)



	m0	m1	m2	m3	m4
Average	126,828	120,238	114,163	111,098	104,094
Standard deviation	24,9981	23,0117	27,1614	27,3588	32,9184

Source: author

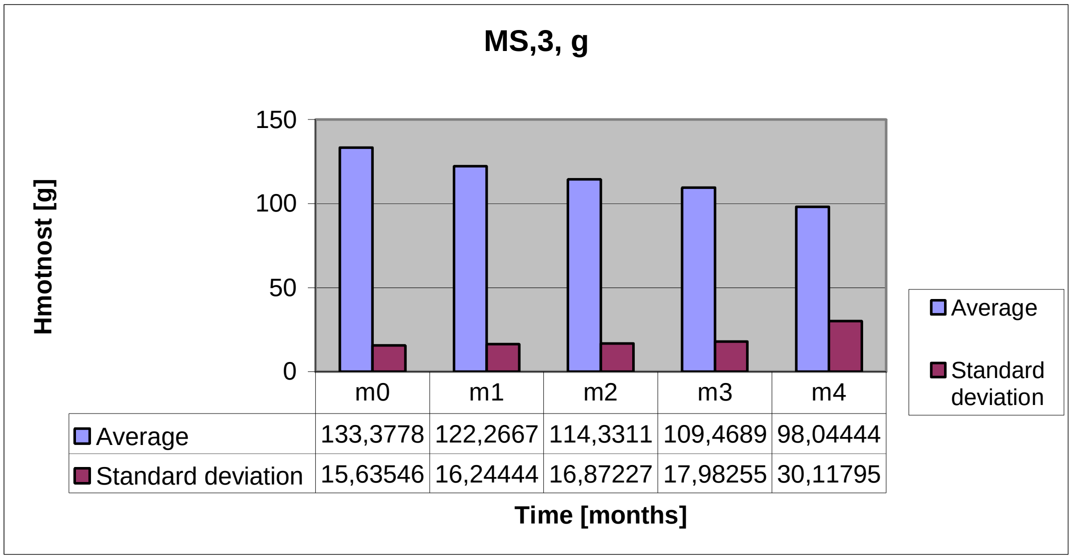
Graph 4: Dependence of disintegration of briquettes on time (MS mixed with sawdust)



	m0	m1	m2	m3	m4
Average	133,7674	127,1395	121,7605	112,8814	113,1442
Standard deviation	21,25675	22,82081	23,81013	35,312	32,19598

Source: author

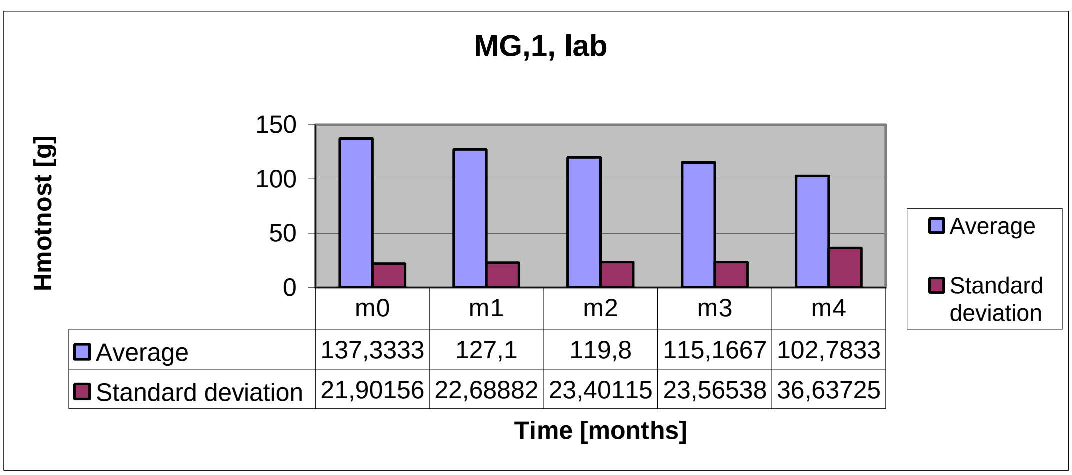
Graph 5: Dependence of disintegration of briquettes on time (MS mixed with wood shavings)



Source: author

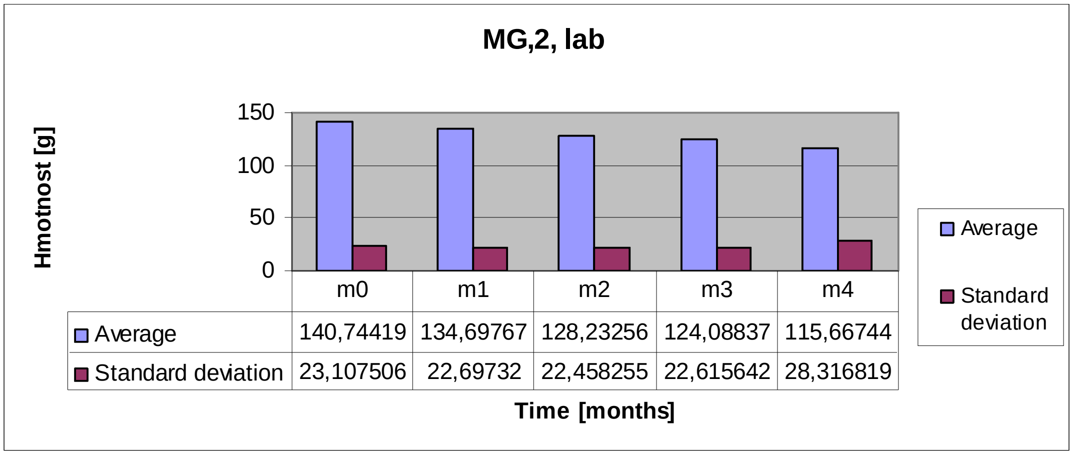
Environment 2: Laboratory

Graph 6: Dependence of disintegration of briquettes on time (pure M.G.)



Source: author

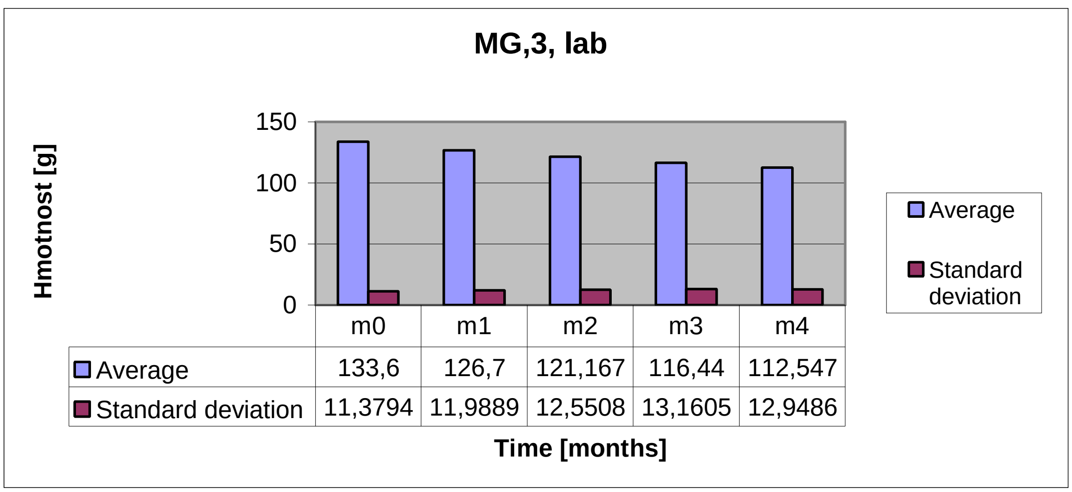
Graph 7: Dependence of disintegration of briquettes on time (M.G. mixed with sawdust)



	m0	m1	m2	m3	m4
Average	140,74419	134,69767	128,23256	124,08837	115,66744
Standard deviation	23,107506	22,69732	22,458255	22,615642	28,316819

Source: author

Graf 8: Dependence of disintegration of briquettes on time (MS mixed with wood shavings)



	m0	m1	m2	m3	m4
Average	133,6	126,7	121,167	116,44	112,547
Standard deviation	11,3794	11,9889	12,5508	13,1605	12,9486

Source: author

Evaluation of ANOVA

Dependence on environment

MG1 Labx MG 1Out

Anova: One factor

Factor

Selection	*number*	*sum*	*average*	*dispersion*
Line1	155	16908,6	109,0877	1055,395
Line2	252	33097	131,3373	455,324

ANOVA

source of variability	*SS*	*difference*	*MS*	*F*	*P-value*	*F krit*
amongSelectiony	47509,52	1	47509,52	69,50927	1,2E-15	3,864521
all Selectiony	276817,1	405	683,4991			
total	324326,6	406				

MG2 labx MG2 gar

Anova: One factor

Factor

Selection	*number*	*sum*	*average*	*dispersion*
Line1	215	27740,7	129,0265	835,5689
Line2	215	27667,5	128,686	637,4659

ANOVA

source of variability	*SS*	*difference*	*MS*	*F*	*P-value*	*F krit*
amongselection	12,46102	1	12,46102	0,016919	0,89657	3,863277
all selection	315229,4	428	736,5174			
total	315241,9	429				

MG3 LABx MG3 GAR

Anova: One factor

Factor

Selection	*number*	*sum*	*average*	*dispersion*
Line1	252	29103,8	115,4913	864,8815

Line2	150	18313,6	122,0907	206,0686

ANOVA

source of variability	*SS*	*difference*	*MS*	*F*	*P-value*	*F krit*
amongselection	4095,192	1	4095,192	6,610759	0,010497	3,864811
all selection	247789,5	400	619,4737			
total	251884,7	401				

MS 2 GARx MS2 LAB

Anova: One factor

Factor

Selection	*number*	*sum*	*average*	*dispersion*
Line1	215	26173,8	121,7386	815,8644
Line2	145	18378,9	126,751	622,6017

ANOVA

source of variability	*SS*	*difference*	*MS*	*F*	*P-value*	*F krit*
amongselection	2175,708	1	2175,708	2,947604	0,08687	3,867565
all selection	264249,6	358	738,1275			
total	266425,3	359				

MS3 LABx MS3 GAR

Anova: One factor

Factor

Selection	*number*	*sum*	*average*	*dispersion*
Line1	226	25987	114,9867	596,2973
Line2	90	9075,4	100,8378	2562,79

ANOVA

source of variability	*SS*	*difference*	*MS*	*F*	*P-value*	*F krit*
amongselection	12885,82	1	12885,82	11,16933	0,000932	3,871244
all selection	362255,2	314	1153,679			
total	375141	315				

MS2GARxMG2GAR

Anova: one factor

factor

selection	number	sum	average	dispersion
line1	215	27740,7	129,0265	835,5689
line2	215	26173,8	121,7386	815,8644

ANOVA

source of variability	SS	difference	MS	F	P-value	F krit
among selectiony	5709,711	1	5709,711	6,914855	0,008856	3,863277
allselectiony	353406,7	428	825,7167			
total	359116,4	429				

MG3 GARx MS3 GAR

Anova: one factor

factor

selection	number	sum	average	dispersion
line1	252	29103,8	115,4913	864,8815
line2	226	25987	114,9867	596,2973

ANOVA

source of variability	SS	difference	MS	F	P-value	F krit
among selectiony	30,33049	1	30,33049	0,041102	0,839427	3,861068
allselectiony	351252,2	476	737,9247			
total	351282,5	477				

MG2LABx MS2 LAB

Anova: one factor

factor

selection	number	sum	average	dispersion
line1	215	27667,5	128,686	637,4659
line2	145	18378,9	126,751	622,6017

ANOVA

source of variability	SS	difference	MS	F	P-value	F krit

among selectiony	324,2435	1	324,2435	0,51346	0,474112	3,867565
allselectiony	226072,3	358	631,487			
total	226396,6	359				

MG3LABxMS3 LAB

Anova: one factor

factor				
selection	*number*	*sum*	*average*	*dispersion*
line1	150	18313,6	122,0907	206,0686
line2	90	9075,4	100,8378	2562,79

ANOVA						
source of variability	SS	difference	MS	F	P-value	F krit
among selectiony	25407,3	1	25407,3	23,36596	2,4E-06	3,880827
allselectiony	258792,5	238	1087,364			
total	284199,8	239				

Measured Data

MG 1 outside

DK-MG81-4 Sample	**OUTSIDE DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	G	g
1		146	134	12
2		128	119	9
3		104	96	8
4		109	101	8
5		161	150	11
6		147	136	11
7		99	89	10
8		149	140	9
9		96	87	9
10		180	167	13
11		114	96	18
12		118	107	11
13		106	97	9
14		110	101	9
15		109	102	7
16		131	124	7

DK-MG81-4 OUTSIDE

Sample	DATE	M1	M2	Abrasion
	15.12.2011	g	G	g
1		134	127,1	6,9
2		119	116,3	2,7
3		96	93	3
4		101	98,3	2,7
5		150	146,3	3,7
6		136	131,4	4,6
7		89	85,7	3,3
8		140	133,8	6,2
9		87	84,4	2,6
10		167	162,2	4,8
11		96	90,6	5,4
12		107	103,7	3,3
13		97	88,4	8,6
14		101	97,4	3,6
15		102	99,8	2,2
16		124	120,5	3,5

DK-MG81-4	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		127,1	115,8	11,3
2		116,3	115	1,3
3		93	90,5	2,5
4		98,3	95,7	2,6
5		146,3	143,9	2,4
6		131,4	0	131,4
7		85,7	82,1	3,6
8		133,8	126,7	7,1
9		84,4	0	84,4
10		162,2	155,6	6,6
11		90,6	87,2	3,4
12		103,7	99,4	4,3
13		88,4	0	88,4
14		97,4	94,4	3
15		99,8	98,7	1,1
16		120,5	116,3	4,2

DK-MG81-4	OUTSIDE			
Sample	DATE	M3	M4	Abrasion
	20.3.2012	g	g	g
1		115,5	108,7	6,8
2		115,5	111,6	3,9
3		91	85,9	5,1
4		95,9	92,3	3,6
5		144,7	141,9	2,8
6		0	0	0

7	82,5	76,8	5,7
8	126,8	120,1	6,7
9	0	0	0
10	156,8	152,8	4
11	87,5	66,4	21,1
12	98,8	91,1	7,7
13	0	0	0
14	95,9	90,3	5,6
15	99,9	93,9	6
16	117,3	108	9,3

DK-MG81-3 Sample	**OUTSIDE DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		132	118	14
2		143	137	6
3		123	111	12
4		124	112	12
5		147	139	8
6		107	100	7
7		125	113	12
8		90	75	15
9		123	107	16
10		140	123	17
11		145	138	7
12		127	116	11
13		145	132	13
14		124	113	11
15		138	128	10

DK-MG81-3 Sample	**OUTSIDE DATE**	**M1**	**M2**	**Abrasion**
	15.11.2011	g	g	g
1		118	115,6	2,4
2		137	132,6	4,4
3		111	108,9	2,1
4		112	109,4	2,6
5		139	132,2	6,8
6		100	96,8	3,2
7		113	111,7	1,3
8		75	63,8	11,2
9		107	101,5	5,5
10		123	117	6
11		138	130,6	7,4
12		116	112,4	3,6
13		132	131,1	0,9
14		113	110	3
15		128	125,5	2,5

DK-MG81-3	**OUTSIDE**

Sample	DATE	M2	M3	Abrasion
	17.11.2012	g	g	G
1		115,6	114,6	1
2		132,6	130,6	2
3		108,9	106,7	2,2
4		109,4	107,8	1,6
5		132,2	129,9	2,3
6		96,8	95,2	1,6
7		111,7	108,6	3,1
8		63,8	0	63,8
9		101,5	98,6	2,9
10		117	114,1	2,9
11		130,6	129,1	1,5
12		112,4	109,9	2,5
13		131,1	127,9	3,2
14		110	107,1	2,9
15		125,5	122,3	3,2

DK-MG81-3	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	21.3.2012	g	g	G
1		114,9	111,7	3,2
2		131,2	123,7	7,5
3		107,9	102,4	5,5
4		107,9	104,1	3,8
5		130	124	6
6		94,5	91,7	2,8
7		108,2	99,2	9
8		0	0	0
9		98,6	93,4	5,2
10		113,6	104,4	9,2
11		128,9	116,2	12,7
12		110,3	107,3	3
13		127,4	120,9	6,5
14		107,1	100,6	6,5
15		122,4	119,5	2,9

MG2 outside

DK-MG82-4					
Sample	DATE	OUTSIDE	M0	M1	
	15.11.2011	g	g	G	
1		146		141	5
2		152		148	4
3		167		159	8
4		158		153	5
5		151		146	5
6		175		170	5
7		167		161	6
8		131		125	6
9		141		137	4

10		76	64	12
11		131	128	3
12		131	125	6
13		149	143	6
14		151	145	6

DK-MG82-4	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		141	137,8	3,2
2		148	145,2	2,8
3		159	154,9	4,1
4		153	148,9	4,1
5		146	140	6
6		170	167,4	2,6
7		161	158	3
8		125	121,1	3,9
9		137	133,6	3,4
10		64	56,7	7,3
11		128	124,5	3,5
12		125	119,3	5,7
13		143	136	7
14		145	140,3	4,7

DK-MG82-4	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2011	g	g	g
1		137,8	134,3	3,5
2		145,2	142,8	2,4
3		154,9	153,8	1,1
4		148,9	146,6	2,3
5		140	136,8	3,2
6		167,4	167,7	-0,3
7		158	156,8	1,2
8		121,1	rozpad	
9		133,6	132,7	0,9
10		56,7	rozpad	
11		124,5	123,7	0,8
12		119,3	118,1	1,2
13		136	129,3	6,7
14		140,3	138,5	1,8

DK-MG82-4	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	20.3.2012	g	g	g
1		134,2	129,5	4,7
2		142,9	134,3	8,6
3		154,3	151,2	3,1
4		147,2	144,4	2,8
5		137,3	133,3	4
6		167,2	163,8	3,4
7		157,7	154,5	3,2
8		X	x	
9		133,2	129,3	3,9

10		X	x	
11		123,8	120,8	3
12		118,3	115,6	2,7
13		129	109,7	19,3
14		138,4	133,5	4,9

DK-MG82-6	**OUTSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		95	91	4
2		146	142	4
3		94	87	7
4		188	180	8
5		144	134	10
6		127	122	5
7		139	136	3
8		102	92	10
9		146	141	5
10		143	136	7
11		146	140	6
12		140	136	4
13		148	143	5
14		152	146	6
15		93	87	6

DK-MG82-4	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.11.2011	g	g	g
1		91	86,3	4,7
2		142	139,5	2,5
3		87	82,2	4,8
4		180	176,7	3,3
5		134	124,5	9,5
6		122	119,6	2,4
7		136	131,9	4,1
8		92	83,4	8,6
9		141	138	3
10		136	131,3	4,7
11		140	136,8	3,2
12		136	132,7	3,3
13		143	140,7	2,3
14		146	141,4	4,6
15		87	84,6	2,4

DK-MG82-4	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		86,3	84,3	2
2		139,5	138,1	1,4
3		82,2	75,2	7
4		176,7	175,2	1,5
5		124,5	122,3	2,2
6		119,6	118	1,6
7		131,9	130,2	1,7

8		83,4	73,6	9,8
9		138	135,2	2,8
10		131,3	129,4	1,9
11		136,8	134,7	2,1
12		132,7	130,6	2,1
13		140,7	138,5	2,2
14		141,4	139,2	2,2
15		84,6	82,4	2,2

DK-MG82-4	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		84,8	77,9	6,9
2		138,7	136,6	2,1
3		75,3	71,9	3,4
4		176,2	172	4,2
5		135,7	133,4	2,3
6		118,9	114,3	4,6
7		130,7	126,7	4
8		73,6	66	7,6
9		122,7	119,7	3
10		130,1	126,8	3,3
11		135,2	131,9	3,3
12		131,1	129,1	2
13		139,2	136,6	2,6
14		140	136,7	3,3
15		83,2	79,5	3,7

DK-MG82-4	**OUTSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		134	128	6
2		136	123	13
3		116	111	5
4		150	143	7
5		144	142	2
6		155	151	4
7		146	134	12
8		148	142	6
9		159	154	5
10		131	126	5
11		151	145	6
12		112	107	5
13		154	139	15
14		144	139	5

DK-MG82-4	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		128	126	2
2		123	116	7
3		111	108	3
4		143	138,5	4,5
5		142	137,7	4,3

6		151	148,5	2,5
7		134	132,3	1,7
8		142	137,8	4,2
9		154	151,7	2,3
10		126	123,8	2,2
11		145	142,3	2,7
12		107	105,4	1,6
13		139	134,8	4,2
14		139	126	13

DK-MG82-4 **Sample**	**OUTSIDE** **DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		126	123,8	2,2
2		116	110,2	5,8
3		108	104,8	3,2
4		138,5	135,4	3,1
5		137,7	136,9	0,8
6		148,5	146,3	2,2
7		132,3	129,7	2,6
8		137,8	134	3,8
9		151,7	149	2,7
10		123,8	121,9	1,9
11		142,3	140	2,3
12		105,4	103,1	2,3
13		134,8	130,4	4,4
14		134,9	132,1	2,8

DK-MG82-4 **Sample**	**OUTSIDE** **DATE**	**M3**	**M4**	**Abrasion**
	17..2012	g	g	g
1		124,8	121,9	2,9
2		110,4	101,6	8,8
3		105,4	101,9	3,5
4		136,3	134,1	2,2
5		137,2	135,2	2
6		147,4	144,5	2,9
7		130,6	128,4	2,2
8		134,7	130,3	4,4
9		149,9	147,1	2,8
10		123	119,5	3,5
11		141	138,2	2,8
12		103,7	100,1	3,6
13		130,6	121,5	9,1
14		132,8	129,8	3

MG3 Outside

DK-MG83-1 **Sample**	**OUTSIDE** **DATE**	**MO**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		198	193	5
2		185	173	12

3		132	122	10
4		152	146	6
5		153	148	5
6		137	132	5
7		115	110	5
8		107	102	5
9		154	149	5
10		137	130	7
11		123	114	9
12		116	111	5
13		153	150	3
14		96	90	6
15		134	129	5

DK-MG83-1	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		193	183,9	9,1
2		173	164,5	8,5
3		122	117,1	4,9
4		146	141,4	4,6
5		148	143,5	4,5
6		132	126,8	5,2
7		110	105,8	4,2
8		102	0	102
9		149	144,5	4,5
10		130	125,2	4,8
11		114	108,5	5,5
12		111	107,6	3,4
13		150	146	4
14		90	85,5	4,5
15		129	125	4

DK-MG83-1	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		183,9	179,9	4
2		164,5	162,6	1,9
3		117,1	114,4	2,7
4		141,4	137,1	4,3
5		143,5	141,2	2,3
6		126,8	122,3	4,5
7		105,8	103,6	2,2
8		0	0	0
9		144,5	142,7	1,8
10		125,2	116,6	8,6
11		108,5	105,4	3,1
12		107,6	105,8	1,8
13		146	143,7	2,3
14		85,5	83,4	2,1
15		125	121,1	3,9

DK-MG83-1	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**

	20.3.2012	g	g	g
1		181,1	176,3	4,8
2		163,2	157,8	5,4
3		114,8	110,2	4,6
4		139,5	134,6	4,9
5		141,8	134,4	7,4
6		123,5	113,5	10
7		104,1	97,3	6,8
8		0	0	0
9		142,1	133,8	8,3
10		115,6	103,9	11,7
11		105,6	100,4	5,2
12		106,1	103,2	2,9
13		144,7	141,5	3,2
14		84,5	78,8	5,7
15		120,5	113	7,5

DK-MG83-1	**OUTSIDE**			
Sample	**DATE**	**MO**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		105	101	4
2		146	140	6
3		134	129	5
4		150	145	5
5		142	138	4
6		131	123	8
7		139	135	4
8		161	90	71
9		126	120	6
10		120	116	4
11		103	95	8
12		121	117	4
13		93	88	5
14		149	143	6
15		129	123	6
16		97	91	6

DK-MG83-1	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		101	96,8	4,2
2		140	135,7	4,3
3		129	124,6	4,4
4		145	142,4	2,6
5		138	133,8	4,2
6		123	117,6	5,4
7		135	131,5	3,5
8		90	86,6	3,4
9		120	114,4	5,6
10		116	112,7	3,3
11		95	91,2	3,8
12		117	114,4	2,6
13		88	85,2	2,8

14		143	138,9	4,1
15		123	119,3	3,7
16		91	85	6

DK-MG83-1	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		96,8	94,1	2,7
2		135,7	133,1	2,6
3		124,6	121,8	2,8
4		142,4	140,7	1,7
5		133,8	131,6	2,2
6		117,6	115,5	2,1
7		131,5	129,7	1,8
8		86,6	84,9	1,7
9		114,4	112,2	2,2
10		112,7	110,5	2,2
11		91,2	88,6	2,6
12		114,4	110,7	3,7
13		85,2	83,2	2
14		138,9	137	1,9
15		119,3	117	2,3
16		85	81,2	3,8

DK-MG83-1	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		94,9	91,2	3,7
2		134,4	130,1	4,3
3		123,4	120,7	2,7
4		142,3	139,4	2,9
5		132,3	130,2	2,1
6		116,3	114	2,3
7		132	126,3	5,7
8		85,6	82,8	2,8
9		112,9	110,2	2,7
10		111,6	108,8	2,8
11		89,2	80,6	8,6
12		119,9	107,5	12,4
13		84,6	79,6	5
14		138,7	135,5	3,2
15		118	108,4	9,6
16		82,4	76,2	6,2

DK-MG83-3	**OUTSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		92	85	7
2		144	136	8
3		137	132	5
4		146	141	5
5		97	92	5
6		141	108	33
7		118	113	5

8		130	125	5
9		116	112	4
10		124	117	7
11		49		
12		114	107	7
13		139	131	8
14		130	121	9
15		129	122	7
16		84	79	5
17		101	90	11

DK-MG83-3	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		85	80	5
2		136	133,2	2,8
3		132	124,9	7,1
4		141	136,7	4,3
5		92	88,7	3,3
6		108	130	-22
7		113	110,1	2,9
8		125	121,9	3,1
9		112	107,8	4,2
10		117	113,8	3,2
11				0
12		107	104,7	2,3
13		131	127,9	3,1
14		121	116,9	4,1
15		122	116,1	5,9
16		79	77,1	1,9
17		90	81,1	8,9

DK-MG83-3	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		80	76,8	3,2
2		133,2	131,4	1,8
3		124,9	122,1	2,8
4		136,7	134,6	2,1
5		88,7	81	7,7
6		130	126,6	3,4
7		110,1	107,5	2,6
8		121,9	116,3	5,6
9		107,8	105,2	2,6
10		113,8	111,4	2,4
11				0
12		104,7	102,9	1,8
13		127,9	125,5	2,4
14		116,9	114,8	2,1
15		116,1	114,3	1,8
16		77,1	75,2	1,9
17		81,1	75,9	5,2

DK-MG83-3	**OUTSIDE**

Sample	DATE	M3	M4	Abrasion
	20.3.2012	g	g	g
1		77,1	72,9	4,2
2		132,8	128,9	3,9
3		122,6	119,9	2,7
4		135,1	131,6	3,5
5		81,7	70,7	11
6		127,5	123,9	3,6
7		108,4	103,7	4,7
8		115	106	9
9		105,8	103,4	2,4
10		111,8	106,5	5,3
11				0
12		103,9	100,8	3,1
13		127	121,3	5,7
14		115	112,2	2,8
15		114,5	110,9	3,6
16		75,8	72,6	3,2
17		76,1		76,1

DK-MG83-6	OUTSIDE			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		152	143	9
2		125	118	7
3		143	135	8
4		126	120	6
5		142	136	6
6		147	141	6
7		132	120	12
8		142	129	13
9		107	100	7
10		79	75	4
11		140	132	8
12		110	106	4
13		79	69	10
14		133	128	5
15		101	93	8
16		130	126	4

DK-MG83-6	OUTSIDE			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		143	138	5
2		118	113	5
3		135	130	5
4		120	114	6
5		136	129	7
6		141	131	10
7		120	114	6
8		129	123	6
9		100	91	9
10		75	70	5

11		132	124	8
12		106	101	5
13		69	55	14
14		128	124	4
15		93	88	5
16		126	121	5

DK-MG83-6	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		138	134,3	3,7
2		113	108,4	4,6
3		130	127,7	2,3
4		114	111,5	2,5
5		129	125,3	3,7
6		131	128,1	2,9
7		114	110,4	3,6
8		123	119,9	3,1
9		91	86,2	4,8
10		70	65,2	4,8
11		124	120,7	3,3
12		101	96,9	4,1
13		55	45,9	9,1
14		124	121,2	2,8
15		88	85,9	2,1
16		121	118,5	2,5

DK-MG83-6	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		133,5	130,8	2,7
2		107,9	104,2	3,7
3		126,9	123,3	3,6
4		110,9	106,9	4
5		124,7	121	3,7
6		127,7	124,5	3,2
7		109,7	105,4	4,3
8		119,2	116,2	3
9		85,6	81,6	4
10		65	62,7	2,3
11		120	116	4
12		96,3	93,6	2,7
13		45,4	34,6	10,8
14		120,8	116,9	3,9
15		85,6	82,7	2,9
16		117,7	116,1	1,6

MS2

DK-MS2-2	**OUTSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		109	105	4
2		146	141	5

3		137	130	7
4		122	117	5
5		124	121	3
6		104	101	3
7		98	84	14
8		125	121	4
9		127	120	7
10		84	58	26
11		74	67	7
12		160	150	10
13		165	159	6
14		131	125	6
15		143	139	4
16		121	115	6

DK-MS2-2 Sample	**OUTSIDE DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		105	102	3
2		141	137	4
3		130	127	3
4		117	111	6
5		121	116	5
6		101	98	3
7		84	71	13
8		121	116	5
9		120	114	6
10		58	50	8
11		67	59	8
12		150	144	6
13		159	154	5
14		125	114	11
15		139	135	4
16		115	110	5

DK-MS2-2 Sample	**OUTSIDE DATE**	**M2**	**M3**	**Abrasion**
	17.1.2011	g	g	g
1		102	98,9	3,1
2		137	134,7	2,3
3		127	124,2	2,8
4		111	107,3	3,7
5		116	113,3	2,7
6		98	95,3	2,7
7		71	58,9	12,1
8		116	112,4	3,6
9		114	110,6	3,4
10		50	45,3	4,7
11		59	54	5
12		144	140,6	3,4
13		154	150,1	3,9
14		114	109,6	4,4
15		135	132,4	2,6

16		110	107	3

DK-MS2-2	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	17.1.2011	g	g	g
1		98,9	90,1	8,8
2		134,7	131,2	3,5
3		124,2	119,8	4,4
4		107,3	106,9	0,4
5		113,3	108,7	4,6
6		95,3	91,2	4,1
7		58,9	44,5	14,4
8		112,4	110,1	2,3
9		110,6	101,2	9,4
10		45,3	33,1	12,2
11		54	39,8	14,2
12		140,6	123,8	16,8
13		150,1	142,8	7,3
14		109,6	108,7	0,9
15		132,4	130	2,4
16		107	102	5

DK-MS2-5	**OUTSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		155	148	7
2		166	158	8
3		124	114	10
4		145	139	6
5		126	122	4
6		133	127	6
7		148	141	7
8		135	130	5
9		144	138	6
10		139	130	9
11		139	125	14
12		143	138	5
13		132	127	5

DK-MS2-5	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		148	145	3
2		158	153,8	4,2
3		114	111,3	2,7
4		139	136,9	2,1
5		122	118,2	3,8
6		127	123,4	3,6
7		141	135,7	5,3
8		130	127,6	2,4
9		138	134,9	3,1
10		130	126,8	3,2
11		125	120,6	4,4
12		138	135,3	2,7

13		127	124	3

DK-MS2-5	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		145	141,1	3,9
2		153,8	146,8	7
3		111,3	0	111,3
4		136,9	134,4	2,5
5		118,2	114	4,2
6		123,4	121,1	2,3
7		135,7	132,5	3,2
8		127,6	124,2	3,4
9		134,9	132,1	2,8
10		126,8	124,5	2,3
11		120,6	117	3,6
12		135,3	132,5	2,8
13		124	122,8	1,2

DK-MS2-5	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		142,3	135,1	7,2
2		147,2	140,8	6,4
3		0	0	0
4		135	131,8	3,2
5		114,7	107,6	7,1
6		121,6	118,6	3
7		133	127,2	5,8
8		123,9	121	2,9
9		132,5	127,8	4,7
10		125,3	123	2,3
11		117,3	113,3	4
12		132,9	129,8	3,1
13		123,4	121,1	2,3

DK-MS2-4	**OUTSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		137	127	10
2		188	184	4
3		139	131	8
4		106	98	8
5		137	133	4
6		140	134	6
7		141	137	4
8		133	126	7
9		161	157	4
10		145	141	4
11		137	126	11
12		139	137	2
13		142	139	3
14		108	107	1

DK-MS2-4	**OUTSIDE**

Sample	DATE	M1	M2	Abrasion
	15.12.2011	g	g	g
1		127	111,3	15,7
2		184	177,1	6,9
3		131	126,9	4,1
4		98	88,6	9,4
5		133	126,2	6,8
6		134	128,4	5,6
7		137	131,4	5,6
8		126	119,1	6,9
9		157	151,3	5,7
10		141	137,7	3,3
11		126	121,4	4,6
12		137	131,7	5,3
13		139	132,4	6,6
14		107	100,7	6,3

DK-MS2-4	OUTSIDE			
Sample	DATE	M2	M3	Abrasion
	17.1.2012	g	g	g
1		111,3	104,2	7,1
2		177,1	176,2	0,9
3		126,9	124,9	2
4		88,6	83,8	4,8
5		126,2	124,1	2,1
6		128,4	0	128,4
7		131,4	129,6	1,8
8		119,1	117,7	1,4
9		151,3	149,5	1,8
10		137,7	135,6	2,1
11		121,4	112,6	8,8
12		131,7	130,5	1,2
13		132,4	130,3	2,1
14		100,7	97,3	3,4

DK-MS2-4	OUTSIDE			
Sample	DATE	M3	M4	Abrasion
	20.3.2012	g	g	g
1		104,2	94,6	9,6
2		176,6	170,7	5,9
3		125,5	123	2,5
4		83,8	74,2	9,6
5		124,3	122,2	2,1
6		0	0	0
7		130,7	128,3	2,4
8		118,1	115,5	2,6
9		150,4	148	2,4
10		136,3	133,4	2,9
11		111,5	103,6	7,9
12		130,3	126	4,3
13		130,9	128,2	2,7
14		97,2	92,5	4,7

MS3 Out

DK-MS83-1 Sample	OUTSIDE DATE	M0	M1	Abrasion
	15.11.2011	g	g	g
1		121	110	11
2		142	127	15
3		132	128	4
4		152	146	6
5		140	134	6
6		178	155	23
7		126	119	7
8		143	132	11
9		146	139	7
10		128	120	8
11		114	111	3
12		129	117	12
13		137	127	10
14		121	115	6
15		122	93	29

DK-MS83-1 Sample	**OUTSIDE DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	G
1		110	87	23
2		127	116	11
3		128	119	9
4		146	136	10
5		134	124	10
6		155	138	17
7		119	111	8
8		132	118	14
9		139	134	5
10		120	111	9
11		111	103	8
12		117	109	8
13		127	109	18
14		115	107	8
15		93	83	10

DK-MS83-1 Sample	**OUTSIDE DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		87	81	6
2		116	108,4	7,6
3		119	115	4
4		136	133,3	2,7
5		124	120,3	3,7
6		138	130	8
7		111	107	4
8		118	111,9	6,1
9		134	120,3	13,7
10		111	107,1	3,9

11		103	93,2	9,8
12		109	104,4	4,6
13		109	102,9	6,1
14		107	103,4	3,6
15		83	75,3	7,7

DK-MS83-1	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		81	79,1	1,9
2		108,4	100,1	8,3
3		115	99,8	15,2
4		133,3	130	3,3
5		120,3	119,6	0,7
6		130	123,3	6,7
7		107	105	2
8		111,9	110	1,9
9		120,3	111	9,3
10		107,1	106	1,1
11		93,2	88,6	4,6
12		104,4	100	4,4
13		102,9	98,5	4,4
14		103,4	98,5	4,9
15		75,3	70,1	5,2

DK-MS83-3	**OUTSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		131	120	11
2		138	128	10
3		155	146	9
4		142	133	9
5		133	120	13
6		150	138	12
7		84	60	24
8		116	107	9
9		96	90	6
10		136	126	10
11		127	121	6
12		119	103	16
13		156	141	15
14		129	120	9
15		136	124	12

DK-MS83-3	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		120	112,7	7,3
2		128	122,2	5,8
3		146	139,3	6,7
4		133	126,7	6,3
5		120	106,3	13,7
6		138	128,4	9,6
7		60	48,3	11,7

8		107	101,6	5,4
9		90	84,6	5,4
10		126	120,3	5,7
11		121	114,2	6,8
12		103	99,6	3,4
13		141	136,6	4,4
14		120	114,9	5,1
15		124	119,2	4,8

DK-MS83-3	**OUTSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		112,7	35,8	76,9
2		122,2	116	6,2
3		139,3	131	8,3
4		126,7	120	6,7
5		106,3	101,1	5,2
6		128,4	121,3	7,1
7		48,3	109,7	-61,4
8		101,6	94,9	6,7
9		84,6	82,2	2,4
10		120,3	113,1	7,2
11		114,2	105,6	8,6
12		99,6	94,7	4,9
13		136,6	131,9	4,7
14		114,9	111,2	3,7
15		119,2	112,7	6,5

DK-MS83-3	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		35,5	0	35,5
2		116,2	109,2	7
3		109,4	106,3	3,1
4		120,1	107,1	13
5		101,3	94,4	6,9
6		121,5	112,3	9,2
7		0	0	0
8		94,3	0	94,3
9		82,6	76,2	6,4
10		113	105,8	7,2
11		105,5	100,7	4,8
12		95,1	89,8	5,3
13		132,7	125,7	7
14		111,6	107	4,6
15		112,9	108	4,9

DK-MS83-4	**OUTSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		129	118	11
2		151	114	37
3		137	125	12
4		129	120	9

5		135	125	10
6		136	127	9
7		139	132	7
8		129	119	10
9		121	116	5
10		152	143	9
11		142	135	7
12		133	119	14
13		118	106	12
14		129	119	10
15		143	134	9

DK-MS83-4	**OUTSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		118	111	7
2		114	140,8	-26,8
3		125	121,1	3,9
4		120	114,7	5,3
5		125	120,1	4,9
6		127	121,1	5,9
7		132	121,7	10,3
8		119	110	9
9		116	111,5	4,5
10		143	110,1	32,9
11		135	131,1	3,9
12		119	108,7	10,3
13		106	100,7	5,3
14		119	111,8	7,2
15		134	130,6	3,4

DK-MS83-4	**OUTSIDE**			
Sample	**DATE**	**M2**	**M2**	**Abrasion**
	17.1.2012	g	g	g
1		111	101,7	9,3
2		140,8	135,2	5,6
3		121,1	117,1	4
4		114,7	109,9	4,8
5		120,1	115,9	4,2
6		121,1	118,5	2,6
7		121,7	123,7	-2
8		110	107,2	2,8
9		111,5	107,2	4,3
10		110,1	132,8	-22,7
11		131,1	128,7	2,4
12		108,7	98	10,7
13		100,7	98	2,7
14		111,8	109,6	2,2
15		130,6	127,9	2,7

DK-MS83-4	**OUTSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		100,4	93,9	6,5

2	135,5	128,8	6,7
3	117,3	113,4	3,9
4	109,6	103,7	5,9
5	116,6	109,9	6,7
6	118,9	114,7	4,2
7	124,2	117,3	6,9
8	107,4	98,1	9,3
9	107,6	103,1	4,5
10	133	129,9	3,1
11	129	125,2	3,8
12	97,6	71,3	26,3
13	98,5	92	6,5
14	109,5	105,3	4,2
15	128,1	123,3	4,8

Inside

MG1

DK-MG81-2 Sample	**INSIDE DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		94	86	8
2		139	124	15
3		109	96	13
4		133	123	10
5		142	132	10
6		139	132	7
7		104	83	21
8		141	132	9
9		99	92	7
10		118	109	9
11		164	153	11
12		121	115	6
13		129	123	6
14		144	136	8
15		132	119	13
16		130	116	14

DK-MG81-2 Sample	**INSIDE DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		86	75	11
2		124	118	6
3		96	89	7
4		123	117	6
5		132	127	5
6		132	126	6
7		83	71	12
8		132	127	5
9		92	89	3
10		109	102	7

11		153	145	8
12		115	109	6
13		123	117	6
14		136	131	5
15		119	112	7
16		116	110	6

DK-MG81-2	**INSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		75	70,4	4,6
2		118	114,1	3,9
3		89	85,3	3,7
4		117	109,2	7,8
5		127	124,5	2,5
6		126	122,4	3,6
7		71	64,9	6,1
8		127	123,3	3,7
9		89	86,2	2,8
10		102	98,3	3,7
11		145	140	5
12		109	105,3	3,7
13		117	114,6	2,4
14		131	128,4	2,6
15		112	110,5	1,5
16		110	107,7	2,3

DK-MG81-2	**INSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		69,2	66,7	2,5
2		113,2	110,4	2,8
3		84,8	80,3	4,5
4		109,6	104,9	4,7
5		123,3	121	2,3
6		121,2	117,8	3,4
7		63,8	55,5	8,3
8		122,5	120,4	2,1
9		85,5	83,4	2,1
10		97,8	94,1	3,7
11		0	0	0
12		104,4	101,8	2,6
13		113,7	109,8	3,9
14		127,3	124,2	3,1
15		109,5	106,6	2,9
16		107,1	103,7	3,4

DK-MG81-1	**INSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		177	166	11
2		176	169	7
3		128	115	13
4		146	128	18

5		151	137	14
6		140	133	7
7		131	124	7
8		130	122	8
9		157	150	7
10		117	110	7
11		161	154	7
12		134	118	16
13		181	173	8
14		153	143	10

DK-MG81-1	**INSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		166	161	5
2		169	162	7
3		115	102	13
4		128	110	18
5		137	128	9
6		133	126	7
7		124	118	6
8		122	114	8
9		150	144	6
10		110	104	6
11		154	147	7
12		118	111	7
13		173	166	7
14		143	136	7

DK-MG81-1	**INSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		161	154,6	6,4
2		162	157,3	4,7
3		102	93,8	8,2
4		110	97,1	12,9
5		128	123,4	4,6
6		126	120,2	5,8
7		118	112,2	5,8
8		114	110,2	3,8
9		144	139,8	4,2
10		104	99,7	4,3
11		147	141,1	5,9
12		111	106,1	4,9
13		166	162,3	3,7
14		136	132,1	3,9

DK-MG81-1	**INSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3..2012	g	g	g
1		153,1	150,1	3
2		155,6	152,2	3,4
3		93,1	88,3	4,8
4		96,3	90,9	5,4

5		122,6	119,6	3
6		119,5	111,7	7,8
7		111,3	109	2,3
8		109,5	0	109,5
9		138,3	136	2,3
10		98,9	94,6	4,3
11		140,1	134	6,1
12		105,4	101,1	4,3
13		161,3	158,5	2,8
14		130,2	136,9	-6,7

MG2

DK-MG82-3 Sample	INSIDE DATE	M0	M1	Abrasion
	15.11.2011	g	g	g
1		148	139	9
2		140	134	6
3		127	123	4
4		135	129	6
5		152	148	4
6		146	140	6
7		98	88	10
8		113	104	9
9		130	126	4
10		132	129	3
11		144	130	14
12		102	96	6
13		128	125	3
14		131	126	5
15		162	154	8

DK-MG82-3 Sample	INSIDE DATE	M1	M2	Abrasion
	15.12.2011	g	g	g
1		139	133	6
2		134	127	7
3		123	117	6
4		129	124	5
5		148	141	7
6		140	136	4
7		88	81	7
8		104	99	5
9		126	120	6
10		129	124	5
11		130	85	45
12		96	120	-24
13		125	120	5
14		126	120	6
15		154	144	10

DK-MG82-3 Sample	INSIDE DATE	M2	M3	Abrasion

	17.1.2012	g	g	g
1		133	130,2	2,8
2		127	124,6	2,4
3		117	106,4	10,6
4		124	121,9	2,1
5		141	137,4	3,6
6		136	132,7	3,3
7		81	75,9	5,1
8		99	94	5
9		120	119,6	0,4
10		124	121	3
11		85	121,4	-36,4
12		120	81,6	38,4
13		120	116,9	3,1
14		120	117,1	2,9
15		144	140,1	3,9

DK-MG82-3	**INSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		129,4	127,5	1,9
2		123,7	121,5	2,2
3		105,5	102,9	2,6
4		121,2	119,7	1,5
5		136,6	134,3	2,3
6		131,8	130,1	1,7
7		75,2	71,1	4,1
8		93,2	90,7	2,5
9		118,8	114,1	4,7
10		120	118,1	1,9
11		120,6	118,1	2,5
12		80,9	78,3	2,6
13		116,2	113	3,2
14		116,1	113,5	2,6
15		139,1	136,2	2,9

DK-MG82-2	**INSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		136	131	5
2		100	92	8
3		144	136	8
4		171	156	15
5		154	149	5
6		151	147	4
7		190	184	6
8		187	182	5
9		159	152	7
10		163	154	9
11		133	131	2
12		123	120	3
13		211	202	9

DK-MG82-2 **INSIDE**

Sample	DATE	M1	M2	Abrasion
	15.12.2011	g	g	g
1		131	126	5
2		92	86	6
3		136	128	8
4		156	151	5
5		149	145	4
6		147	141	6
7		184	176	8
8		182	177	5
9		152	144	8
10		154	146	8
11		131	126	5
12		120	116	4
13		202	192	10

DK-MG82-2	INSIDE			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		126	122,7	3,3
2		86	82,9	3,1
3		128	123,4	4,6
4		151	145	6
5		145	142,9	2,1
6		141	135,9	5,1
7		176	170,1	5,9
8		177	174	3
9		144	138,5	5,5
10		146	143,5	2,5
11		126	122	4
12		116	113,3	2,7
13		192	186	6

DK-MG82-2	INSIDE			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	20.3.2012	g	g	g
1		123,2	118,3	4,9
2		81,6	78,8	2,8
3		122	118,6	3,4
4		143,6	136,2	7,4
5		141,5	138,9	2,6
6		134,3	132,3	2
7		0	0	0
8		172,2	168,8	3,4
9		137	132,8	4,2
10		141,8	139,2	2,6
11		120,6	119,2	1,4
12		112,4	109,7	2,7
13		183,8	179,4	4,4

DK-MG82-1	INSIDE			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		152	148	4

2		126	121	5
3		125	122	3
4		138	134	4
5		160	156	4
6		127	124	3
7		118	112	6
8		123	120	3
9		132	127	5
10		150	144	6
11		135	132	3
12		159	155	4
13		112	108	4
14		147	137	10
15		138	125	13

DK-MG82-1	**INSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		148	141	7
2		121	114	7
3		122	117	5
4		134	129	5
5		156	148	8
6		124	120	4
7		112	107	5
8		120	116	4
9		127	122	5
10		144	138	6
11		132	128	4
12		155	150	5
13		108	101	7
14		137	123	14
15		125	115	10

DK-MG82-1	**INSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		141	137,7	3,3
2		114	111,5	2,5
3		117	113	4
4		129	123,9	5,1
5		148	145,4	2,6
6		120	117,2	2,8
7		107	104,4	2,6
8		116	112,7	3,3
9		122	120	2
10		138	132	6
11		128	125,3	2,7
12		150	146,6	3,4
13		101	96,8	4,2
14		123	109,6	13,4
15		115	98,7	16,3

DK-MG82-1 **INSIDE**

Sample	DATE	M3	M4	Abrasion
	17.1.2012	g	g	g
1		137	134,5	2,5
2		110,6	108,2	2,4
3		112,2	110,1	2,1
4		122,8	119,2	3,6
5		144	140,6	3,4
6		116,6	114,8	1,8
7		103,4	100,7	2,7
8		112	109,5	2,5
9		119,1	116,5	2,6
10		131,1	128,4	2,7
11		124,2	121,7	2,5
12		145,6	142,9	2,7
13		96,3	84	12,3
14		108,8	92,8	16
15		97,6	88,5	9,1

MG3

DK-MG83-5 Sample	INSIDE DATE	M0	M1	Abrasion
	15.11.2011	g	g	g
1		143	134	9
2		144	136	8
3		121	112	9
4		143	138	5
5		150	144	6
6		125	120	5
7		138	131	7
8		134	125	9
9		135	128	7
10		135	130	5
11		131	125	6
12		148	142	6
13		119	111	8
14		131	122	9
15		108	100	8

DK-MG83-5 Sample	INSIDE DATE	M1	M2	Abrasion
	15.12.2011	g	g	g
1		134	127	7
2		136	129	7
3		112	106	6
4		138	131	7
5		144	137	7
6		120	115	5
7		131	126	5
8		125	117	8
9		128	122	6
10		130	126	4

11		125	121	4
12		142	135	7
13		111	106	5
14		122	117	5
15		100	85	15

DK-MG83-5	**INSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		127	124,7	2,3
2		129	126,8	2,2
3		106	103,3	2,7
4		131	128,7	2,3
5		137	133,3	3,7
6		115	111,7	3,3
7		126	122,5	3,5
8		117	113,6	3,4
9		122	120	2
10		126	123,5	2,5
11		121	118,4	2,6
12		135	131,8	3,2
13		106	102,7	3,3
14		117	114,2	2,8
15		85	80,1	4,9

DK-MG83-5	**INSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		123,4	120,3	3,1
2		126	123,6	2,4
3		102,8	100,5	2,3
4		128,3	125,2	3,1
5		132,8	128,6	4,2
6		111	108,4	2,6
7		121,3	118	3,3
8		113	106,1	6,9
9		119,4	117,3	2,1
10		122,6	120,9	1,7
11		117,4	114,7	2,7
12		131,2	126,2	5
13		102,4	99,7	2,7
14		113,5	111,2	2,3
15		79,8	76	3,8

DK-MG83-4	**INSIDE**			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		103	98	5
2		142	137	5
3		129	121	8
4		132	125	7
5		127	120	7
6		144	139	5
7		128	119	9

8		148	141	7
9		144	140	4
10		134	130	4
11		121	110	11
12		131	123	8
13		135	128	7
14		143	138	5
15		142	134	8

DK-MG83-4	**INSIDE**			
Sample	**DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		98	92	6
2		137	132	5
3		121	118	3
4		125	120	5
5		120	123	-3
6		139	130	9
7		119	115	4
8		141	137	4
9		140	137	3
10		130	126	4
11		110	106	4
12		123	122	1
13		128	117	11
14		138	133	5
15		134	127	7

DK-MG83-4	**INSIDE**			
Sample	**DATE**	**M2**	**M3**	**Abrasion**
	17.1.2012	g	g	g
1		92	90,7	1,3
2		132	128,9	3,1
3		118	115,4	2,6
4		120	116,8	3,2
5		123	109	14
6		130	127,1	2,9
7		115	112,6	2,4
8		137	92,8	44,2
9		137	133,6	3,4
10		126	123,1	2,9
11		106	102,2	3,8
12		122	113,5	8,5
13		117	118,3	-1,3
14		133	130,1	2,9
15		127	123,8	3,2

DK-MG83-4	**INSIDE**			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		89,7	87,7	2
2		128,1	122,5	5,6
3		114,3	112,5	1,8
4		115,8	113	2,8

5	107,8	103,9	3,9
6	126,3	123,6	2,7
7	111,7	110,1	1,6
8	92,1	89,4	2,7
9	132,4	129,7	2,7
10	122,3	118,9	3,4
11	101,6	99	2,6
12	112,9	108,8	4,1
13	117,1	114	3,1
14	129,3	126,6	2,7
15	122,7	120	2,7

MS2

DK-MS82-1 Sample	INSIDE DATE	M0	M1	Abrasion
	15.11.2011	g	g	g
1		146	142	4
2		58	42	16
3		130	123	7
4		153	149	4
5		124	119	5
6		139	136	3
7		136	129	7
8		142	136	6
9		158	155	3
10		144	138	6
11		121	118	3
12		137	136	1
13		128	124	4
14		156	147	9
15		138	133	5

DK-MS82-1 **Sample**	**INSIDE** **DATE**	**M1**	**M2**	**Abrasion**
	15.12.2011	g	g	g
1		142	140	2
2		42	0	42
3		123	119	4
4		149	142	7
5		119	115	4
6		136	134	2
7		129	124	5
8		136	130	6
9		155	148	7
10		138	128	10
11		118	115	3
12		136	128	8
13		124	120	4
14		147	138	9
15		133	129	4

DK-MS82-1	**INSIDE**

Sample	DATE	M2	M3	Abrasion
	17.1.2012	g	g	g
1		140	138,3	1,7
2		0	0	0
3		119	116,8	2,2
4		142	139,7	2,3
5		115	144,4	-29,4
6		134	112,9	21,1
7		124	122,3	1,7
8		130	126,2	3,8
9		148	132	16
10		128	125,6	2,4
11		115	113,4	1,6
12		128	126,8	1,2
13		120	118	2
14		138	133,3	4,7
15		129	126,7	2,3

DK-MS82-1	INSIDE			
Sample	**DATE**	**M3**	**M4**	**Abrasion**
	20.3.2012	g	g	g
1		137,5	135,3	2,2
2		0	0	0
3		116,2	113,8	2,4
4		139,1	137	2,1
5		112,4	109,8	2,6
6		131,3	129,9	1,4
7		121,6	119,5	2,1
8		125,6	123,3	2,3
9		143,7	141,2	2,5
10		125,3	123	2,3
11		112,7	110,8	1,9
12		126,1	125	1,1
13		117,3	115,2	2,1
14		132,1	129,1	3
15		125,9	123,2	2,7

DK-MS82-3	INSIDE			
Sample	**DATE**	**M0**	**M1**	**Abrasion**
	15.11.2011	g	g	g
1		150	145	5
2		136	130	6
3		127	119	8
4		144	137	7
5		143	131	12
6		155	146	9
7		122	116	6
8		168	147	21
9		126	116	10
10		133	126	7
11		131	125	6
12		176	168	8
13		150	144	6

14		126	119	7

DK-MS82-3 Sample	INSIDE DATE	M1	M2	Abrasion
	15.12.2011	g	g	g
1		145	142	3
2		130	126	4
3		119	115	4
4		137	133	4
5		131	128	3
6		146	138	8
7		116	111	5
8		147	140	7
9		116	110	6
10		126	122	4
11		125	119	6
12		168	163	5
13		144	139	5
14		119	116	3

DK-MS82-3 Sample	INSIDE DATE	M2	M3	Abrasion
	17.1.2012	g	g	g
1		142	139,3	2,7
2		126	123,9	2,1
3		115	112	3
4		133	129,9	3,1
5		128	123,9	4,1
6		138	132,9	5,1
7		111	105,5	5,5
8		140	135,4	4,6
9		110	105,9	4,1
10		122	118,2	3,8
11		119	116,5	2,5
12		163	157,9	5,1
13		139	135,5	3,5
14		116	113,2	2,8

DK-MS82-3 Sample	INSIDE DATE	M3	M4	Abrasion
	20.3.2012	g	g	g
1		139,3	137,4	1,9
2		123,9	121,2	2,7
3		112	109,5	2,5
4		129,9	127,2	2,7
5		123,9	121,6	2,3
6		132,9	130,1	2,8
7		105,5	101,7	3,8
8		135,4	131,7	3,7
9		105,9	103,9	2
10		118,2	116,1	2,1
11		116,5	113,8	2,7
12		157,9	154	3,9
13		135,5	133,2	2,3

14		113,2	110	3,2

MS3

DK-MS83-2 Sample	INSIDE DATE	M0	M1	Abrasion
	15.11.2011	g	g	G
1		131	121	10
2		129	116	13
3		153	147	6
4		114	83	31
5		150	143	7
6		145	135	10
7		139	131	8
8		142	137	5
9		141	132	9
10		180	166	14
11		140	134	6
12		89	70	19
13		141	127	14
14		147	140	7
15		140	131	9

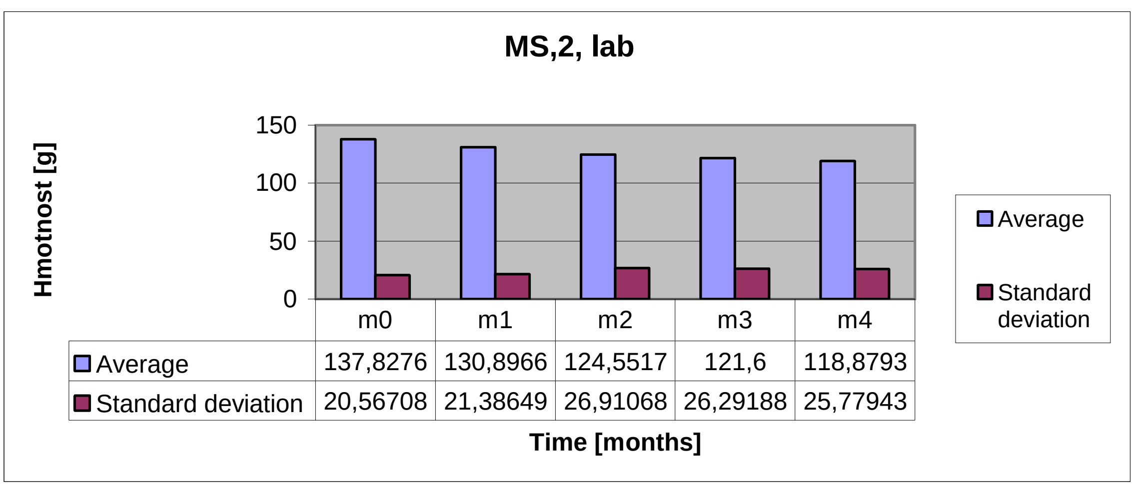
DK-MS83-2 Sample	INSIDE DATE	M1	M2	Abrasion
	15.12.2011	g	g	g
1		121	114	7
2		116	110	6
3		147	130	17
4		83	63	20
5		143	133	10
6		135	128	7
7		131	120	11
8		137	126	11
9		132	123	9
10		166	157	9
11		134	127	7
12		70	52	18
13		127	119	8
14		140	131	9
15		131	124	7

DK-MS83-2 Sample	INSIDE DATE	M2	M3	Abrasion
	17.1.2012	g	g	g
1		114	110,6	3,4
2		110	105,4	4,6
3		130	126,2	3,8
4		63	0	63
5		133	130,8	2,2

6		128	119,2	8,8
7		120	114,7	5,3
8		126	120,4	5,6
9		123	117,7	5,3
10		157	151,2	5,8
11		127	125,2	1,8
12		52	47,8	4,2
13		119	116,4	2,6
14		131	127,1	3,9
15		124	121,3	2,7

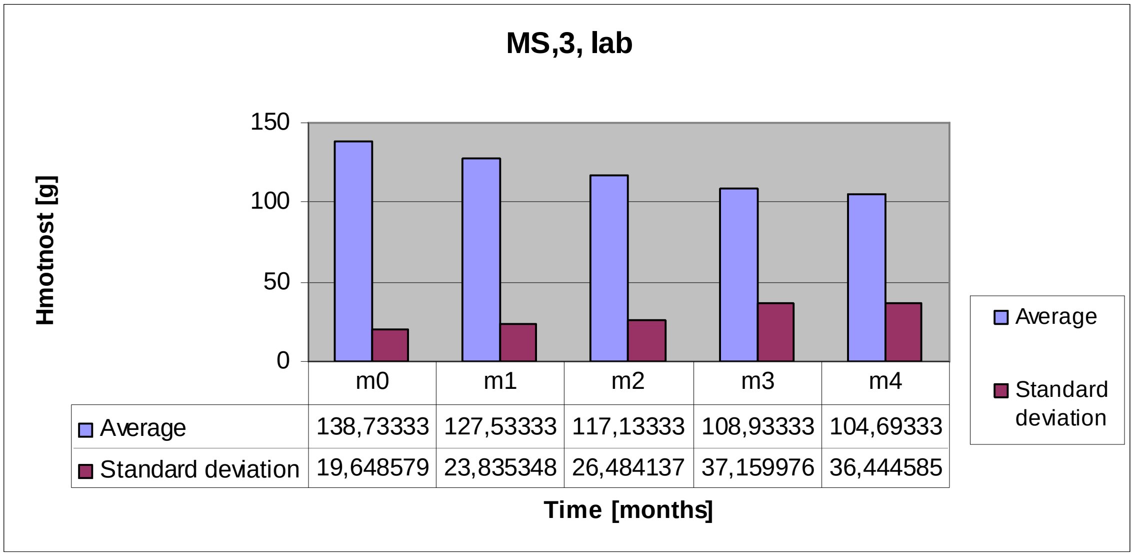
DK-MS83-2 Sample	**INSIDE DATE**	**M3**	**M4**	**Abrasion**
	17.1.2012	g	g	g
1		110,6	106,6	4
2		105,4	100,9	4,5
3		126,2	122,3	3,9
4		0	0	0
5		130,8	113,7	17,1
6		119,2	114,2	5
7		114,7	109,5	5,2
8		120,4	113,2	7,2
9		117,7	127,5	-9,8
10		151,2	146,5	4,7
11		125,2	119,9	5,3
12		47,8	41,8	6
13		116,4	113,5	2,9
14		127,1	123	4,1
15		121,3	117,8	3,5

Graf 9: Dependence of disintegration of briquettes on DATE (MS mixed with sawdust)



Source: author

Graf 10: Dependence of disintegration of briquettes on DATE (MS mixed with wood shavings)



Source: author