Handbook

Thermo-Wood
Terrace deckings

THERMORY
Excellence in Wood

Contents

1. Preface

Thermally modified wood (so-called thermo-wood) shall show advantages over untreated wood in terms of dimensional stability, resistance to decay, and delamination. If thermal modification is carried out with insufficient technology and/or lack of process know-how, these advantages will most likely not show, the wood will be deteriorated permanently instead.

Brenstol relies for the production of thermo-wood terrace decking on the reliable steam-heat-process, which was developed to industrial maturity in Finland. These days, four kilns with a combined capacity of 40.000 m³ are operated. These kilns were built by the Finnish company Jartek according to the specification provided by Brenstol concerning control unit, steam and ventilation power, and re-moisturizing capacity. The kilns are able to measure the humidity level of the wood at the beginning of the treatment process applying special sensors. The whole process is guided so that homogenous conditions with respect to humidity and temperature are created in all parts of the kiln. This forms the precondition to produce consistent quality from charge to charge, as well as within one charge. The measuring devices in the kiln support the kiln operator in controlling the process parameters of point in time, length of time, temperature and humidity level.

An essential step in the treatment process is the drying to 0% moisture level and the consecutive temperature increase and thermal treatment to up to 215 °C. Wrong decisions taken by the process operator concerning point in time and length of time of temperature increase or decrease respectively humidity level in form of steam may bring about irrevocable damage to the wood, which becomes obvious in the form of cracks, brittleness, or significant color differences directly after taking the goods out of the kilns.

One of the most important steps in manufacturing thermally modified ash his carried out towards the end of the process. Thermo-treatment causes the equilibrium moisture of wood to decrease. It is important to increase the moisture level of the wood at the end of the process to its new equilibrium moisture. This step requires profound know-how by the process operator. The operator decides when, how long, at which temperature level, which amount of steam will yield homogenous, not brittle thermo-wood. If this process of re-moisturizing is not or wrongly carried out, internal cracks will appear already in the kiln or at the storage site. Clearly visible become the cracks usually only after planing. During the planing process, such boards are singled out and/or re-sized. If such boards still enter the market, the installer needs to single out such boards directly prior installation.

Heat treatment shall increase the durability of wood and its dimensional stability to avoid dangerous delamination. Both aspects can only be achieved in practice, if constructional wood protection requirements are followed. Installations in constantly moist environments, respectively wood in direct contact to wood will cause pre-mature failure also of thermally modified timber. If deckings with top side tongue & groove profiles are applied, the direct contact of wood on wood at these top sides has to be reduced by applying special top side wax sealers two times. This reduces moisture uptake and constant moisture penetration into the wood.

All constructions with thermo-wood need to consider the local conditions and follow the local construction rules.

2. Processing guidelines

a) Bearing points

At installation one must take care that the bearing points (under construction) are not further than 50 cm apart. If decking boards with top side tongue & groove are used, the bearing point distance is reduced to 40 cm.

b) Distance between boards

The higher the density of a thermally modified wood species, the higher the capacity to take up water. Correspondingly we see stronger swelling of wood in exterior application. A minimum distance between the boards needs to be respected therefore, to minimize tension cracks. Following rules of thumb can be applied for our wood species respectively:

1) Thermo-spruce/pine: Decking width in mm divided by 40
2) Thermo-ash/hickory: Decking width in mm divided by 18

Example:
Depending on constructional set-up and location of the deck, thermo-ash may swell up to 4% in width. If conditions are constantly wet one needs to choose the maximum installation gap. A decking board with 150 mm width would require a gap of 8,3 mm (150:18). This allows for 6 mm swelling. This gap can be reduced if smart installation systems are used.

c) Ventilation

A fundamental constructional requirement is to avoid the direct contact of wood on wood. We recommend the use of distance holders of at least 5 mm in height. The support construction must make sure that no stagnant moisture can build. Minimum distance from soil to decking board should not fall below 10 cm. Boards with top side tongue & groove have to be waxed twice with special top side waxes.

d) Fixation materials

Screwing must be done exclusively with screws made of stainless steel. Other metal materials may cause dark spots on the wood in exterior application. Screwing must always involve pre-drilling of a hole that is 1 mm bigger in diameter than the screw (for example a 4,0x40 mm screw requires a 5,0 mm bore hole). The screw head's conus must be counter-bored as well. We recommend the utilization of a depth stop. The size of the screw head must match the size of the counterbore. Any kind of screw must be pre-drilled. Fixation systems must allow the wood some sort of „working" or „moving" after installation. Minimum distance side wise 20mm, minimum distance front wise 40mm.

Storage:
Before installation it must be considered that the thermo-ash deckings are stored at the installation site or outside for about 48 hours (not at some inside place like for example a closed carport). The deckings gain the appropriate equilibrium moisture for installation thereby.

3. Modification of (thermo-)wood in exterior situation

Wood in exterior applications underlies – simply spoken – two formative impacts:

Ultraviolet light
and
water

General:
UV-light splits in a photolytic process a substance called lignin. The purpose of lignin is to bind the cellulose fibers in wood like a glue. Lignin becomes water soluble due to the splitting process. Humidity renders lignin therefore soft, driving rain may wash it out. Whitish cellulose fibers are left which are the ground for micro organisms that create a silver-gray patina onto the wood. Over time, the cellulose fibers start to erode since they are lacking the lignin glue. A relief-like surface is created that stresses the natural grain of the wood. In shady spots blue stain and mold may form, especially close to vegetation. This can also lead to color variations, but does not damage the wood in the application considered here. A significant impact is the constant shift between humidity penetration and drying-up. Driving rain and condensate is taken up by capillary action of untreated wood. The wood is swelling. The cross-section shrinks again with the drying-up process caused by sun and wind. This cycle repeats itself which leads to surface cracks and distortion, that can be depending on quality and condition very small or bigger.

Color:
The color of thermally modified wood is not resistant to UV radiation. Wood that has fallen gray is not less resistant to decay. To maintain the color for a longer time, we recommend to oil the wood after installation at least once. Oil closes the wood's pores which inhibits dirt from sticking to the wood, which again facilitates the cleaning process. We can recommend our deckimg oils (see pager 9), which we made good experiences with in terms of slower graying and new application after some time has passed.

Durability towards wood destroying funghi:
Our thermo-ash and thermo-walnut treated at 215 °C have achieved a clear **resistance class 1** in laboratory tests. Also thermo-spruce manages in average a resistance class 1, however with partly clear deviations down to class 4. Our th-pine is by average in resistance class 2, with slightly smaller deviations down to class 4. Thermo-wood is from a durability perspective therefore a convincing alternative to tropical hardwoods and wood plastic composites. It contributes tp saving the tropical rain forests which is the same class predominant for all tropical hardwoods on the market. Thermo-ash is therefore an alternative to tropical hardwoods. The application of thermo-ash contributes to saving tropical forests, and avoids energy intensive plastics production and uncertain disposal.

Cracks:

We distinguish between 4 sorts of crack types:

1. Drying cracks
   The reason for such cracks lies in mistakes during the pre-drying process. Are moisture enclosures in the wood before the high temperature phase starts, the high temperatures will damage the wood by means of steaming water. Normally such cracks become visible directly after planing, and are cut out. If such boards are installed, they may break in longitudinal direction.

2. Tension cracks
   Tension cracks are to a certain degree growth related. A combination of bad ventilation, rigid fixation, and nervous ground may be other factors that trigger the appearance of tension cracks.

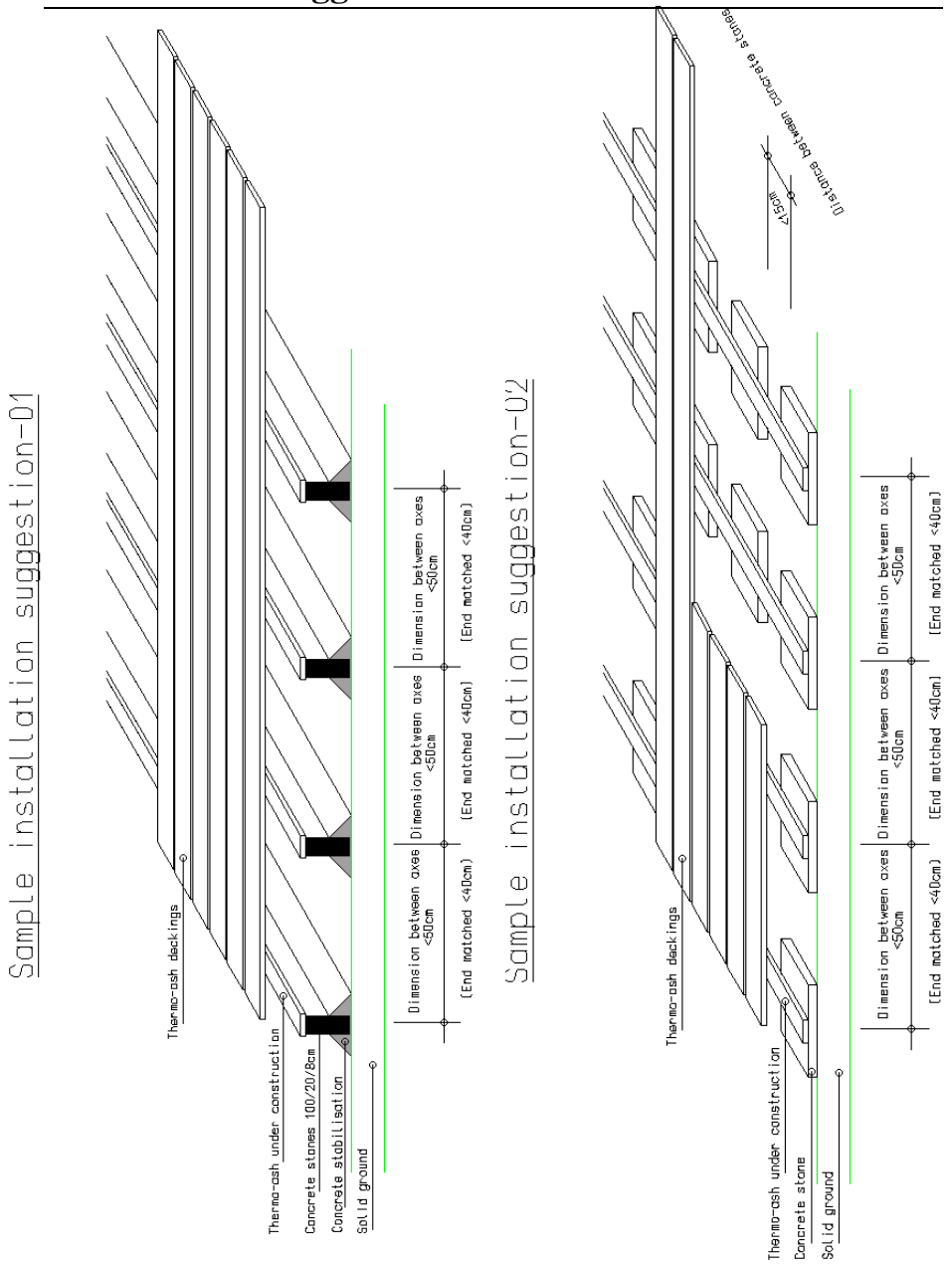
3. Surface cracks
   Surface cracks are inevitable. The surface of a correctly installed decking board is always swelling and shrinking more than its core. Surface cracks are a consequence of shrinkage, and appear with some boards stronger and others less or not at all. Regular oiling may minimize the appearance of surface cracks.

4. End cracks
   The capillary effect at the ends of a wooden board is always stronger than in the flat areas. Consequently shakes are forming more likely at the ends, which can be minimized by applying waxes that inhibit water uptake. Especially boards with top side tongue & groove necessarily require the application of such waxes, also for durability reasons.

<u>Colour differences, deformation, and dimensional stability:</u>

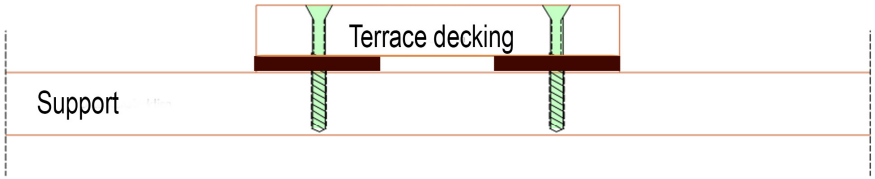
Colour differences between single decking boards depend on different growth areas. Deformation respectively “working” of thermo-wood is a lot weaker than for untreated wood, however may also be seen rarely with thermo-wood, especially if conditions at site are difficult (ventilation, North/South exposition, general deck set-up…). Dimensional stability (swelling & shrinking) is for thermos-wood better than for untreated wood, but also depending on raw material and growth, entrapments and knots.

4. Installation suggestions



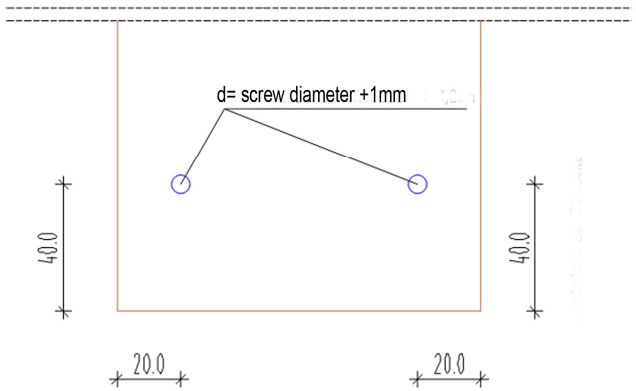
5. Fixation possibilities

Visible fixation with stainless stell screws:



CROSS SECTION

Hole diameter d= (screw diameter + 1mm)
Adaptation screw head conus (countersink)



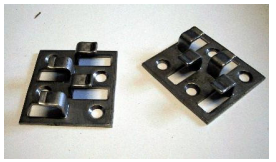
TOP VIEW

Bore hole table *	
Screw diameter	Screw hole
3,0mm 3,5mm 4,0mm 4,5mm	4,0mm 4,5mm 5,0mm 5,5mm

Invisible fixation options:

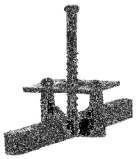
We recommend for boards with horizontal side groove:

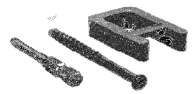
Stainless steel clip:
Contact:
Brenstol OÜ
Peterburi Tee 44
EE-11415 Tallinn
www.brenstol.ee



This clip requires an additional elevation, to increase the distance between decking and support up to 5 mm.

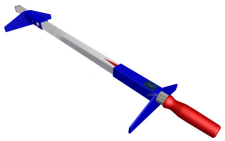
Gecko clip:
Contact:
Brenstol OÜ
Peterburi Tee 44
EE-11415 Tallinn
www.brenstol.ee





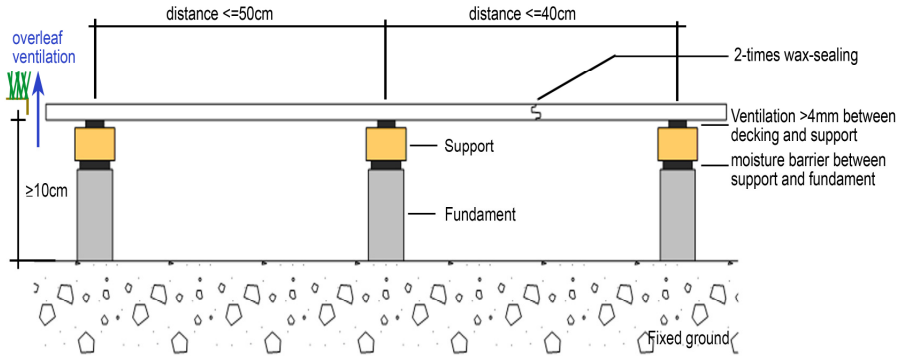
We recommend for boards with hollow side groove:

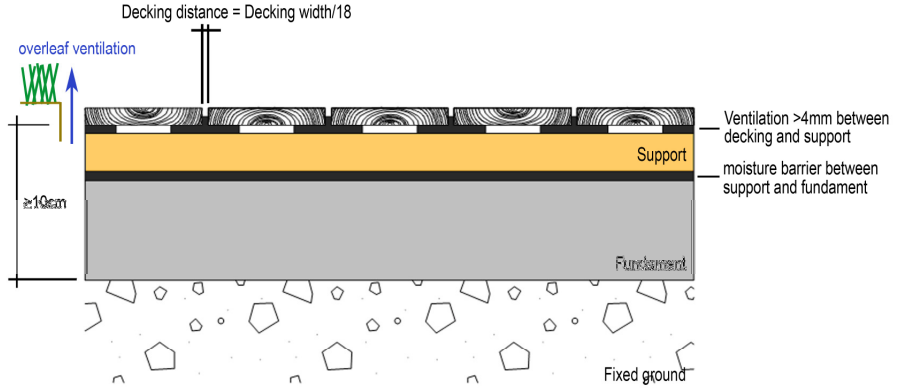
SenoFix-Clip
Contact:
Brenstol OÜ
Peterburi Tee 44
EE-11415 Tallinn
www.brenstol.ee

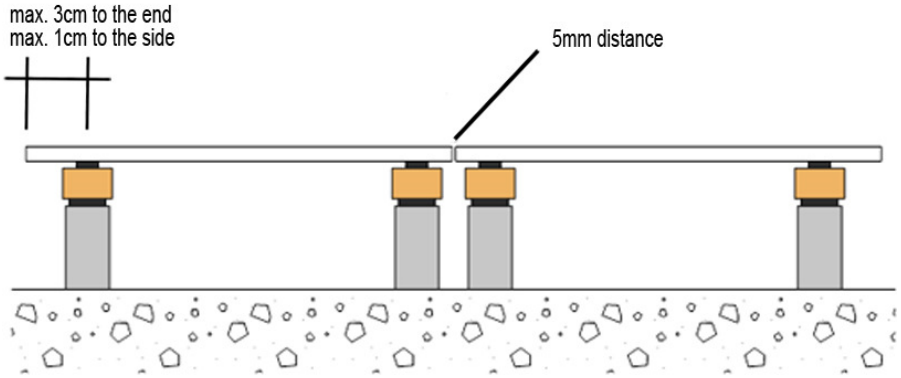


Teni®-Clip
Contact:
Brenstol OÜ
Peterburi Tee 44
EE-11415 Tallinn
www.brenstol.ee

6. Technical drawings terrace construction







7. Terrace oil

Thermory Thermo-Wood oil dark:
Contact:
Brenstol OÜ
Peterburi Tee 44
11415 Tallinn
Estonia

This type of oil is in general applied for thermo-ash and thermo-hickory.

Thermory Thermo-Wood Oil light:
Contact:
Brenstol OÜ
Peterburi Tee 44
11415 Tallinn
Estonia

This type of oil is in general applied for thermo-pine and thermo-spruce.

Thermory Top side sealer:
Contact:
Brenstol OÜ
Peterburi Tee 44
11415 Tallinn
Estonia

The top side sealer is recommended for all decking boards and support beams to cover the ends. It is a must for decking boards that have top side tongue & groove.

8. Physical properties: Example Thermo-Ash

TEST REPORT

No. 239 2007-07-05

Product description: Heat treated (215 ºC) ash wood 20x135x1000 mm
Reason for test: Test mandate of 2007-05-22
Test target: Determination of physical and mechanical properties of terrace deckings

Test methods.

The humidity of all samples was determined in a drying kiln at temperatures between 103 and 105 °C till a constant mass was achieved. Density, bending strength and surface hardness were measured at equilibrium moisture level of 4,6% in the laboratory. For obtaining the equilibrium moisture in exterior conditions the samples were exposed to a relative humidity of 85% till a constant mass was achieved.

The surface hardness was measured in accordance with EN 1534 by applying a certification stamp of 10 mm in diameter.

Test results.

Moisture level at (normal) laboratory conditions

Sample No.	1	2	3	4	5	6	**Average**
Moisture level, %	4,4	4,7	4,7	4,5	4,7	4,7	**4,6**

Density

Sample No.	1	2	3	4	5	6	**Average**
Density, kg/m^3	597	598	582	580	608	575	**590**

Equilibrium moisture at average exterior conditions

Sample No.	1	2	3	4	5	6	**Average**
Moisture level, %	7,7	8,0	7,9	7,8	7,9	8,1	**7,9**

Bending strength

Sample No.	1	2	3	4	5	**Average**
Bending strength, N/mm^2	110,0	102,3	89.2	100,4	83,5	
Sample No.	6	7	8	9	10	
Bending strength, N/mm^2	82,1	112,0	94,4	99,0	93,1	**96,6**

Surface hardness

No.	d1	d2	d	HB (N/mm^2)
1-20	4,9 – 7,3	5,1 – 7,6	5,00 – 7,45	19,1 – 47,5
Average				**29,4**

9. Resistance/Thermo-Ash

REPORT -NO. 85963/1 dated 17.03.2008

Date received:	08.10.2007	BRENSTOL OÜ
Date of tests:	09.11.2007	PETERBURI TEE 44
Date of issue:	17.03.2008	11415 TALLINN
Sample name:	Decking board	ESTONIA
	Thermo-ash 215 °C	CONTACT: Mr. Meelis Kajandu

Technical Report

Determination of the durability of solid wood against wood-destroying basidiomycetes.

Test method:	according to CEN/TS 15083-1/2005, except for sampling and preparation of wood test specimens, which were provided by the customer.
Test material:	heat treated ash (fraxinus)
Reference timber:	Fagus sylvatica
Test fungi:	Coniophora puteana DSM 3085; Coriolus versicolor SM3086
Ageing procedure:	none
Sterilization:	by gamma radiation
Date of exposure to fungi:	09/11/2007
Date removed from fungi, test duration:	10/03/2008, 4 months

Test results
Mean percentage mass loss of reference timber:
with Coniophora puteana: 33%
with Coriolus versicolor: 30%
test valid

Moisture content of test specimen after exposure to fungi
with Coniophora puteana: Ø 18%, min 9%, max 24%
with Coriolus versicolor: Ø 31%, min 16%, max 57%
Mean percentage mass loss of test specimens
with Coniophora puteana: 1%
with Coriolus versicolor: 1,4%

Median percentage mass loss of test specimens
with Coniophora puteana: 1%
with Coriolus versicolor: 1%
Provisional durability rating according to CEN/TS 15083-1/2005, Annex D:

Class 1 - very durable - median percentage mass loss ≤ 5%

Note: the test method was applied to treated timber

Head of Department
Dott. Franco Bulian

Managing Director
Dott. Andrea Giavon

10. Resistance/Thermo-Walnut

REPORT -NO. 112556/1 dated 24.06.2010

Date received:	21.01.2010	BRENSTOL OÜ
Date of tests:	01.02.2010	PETERBURI TEE 44
Date of issue:	24.06.2010	11415 TALLINN
Sample name:	Decking board	ESTONIA
	Thermo- Hickory 215 °C	CONTACT: Mr. Meelis Kajandu

Technical Report

Determination of the durability of solid wood against wood-destroying basidiomycetes.

Test method:	according to CEN/TS 15083-1/2005, except for sampling and preparation of wood test specimens, which were provided by the customer.
Test material:	heat treated hickory
Reference timber:	Fagus sylvatica
Test fungi:	Coniophora puteana DSM 3085; Coriolus versicolor SM3086
Ageing procedure:	none
Sterilization:	by gamma radiation
Date of exposure to fungi:	01/03/2010
Date removed from fungi, test duration:	22/06/2010, 4 months

Test results

Mean percentage mass loss of reference timber:

with Coniophora puteana:	37%
with Coriolus versicolor:	30%

test valid

Moisture content of test specimen after exposure to fungi

with Coniophora puteana:	Ø 25%, min 9%, max 49%
with Coriolus versicolor:	Ø 20%, min 10%, max 32%

Mean percentage mass loss of test specimens

with Coniophora puteana:	1,2%
with Coriolus versicolor:	0,4%

Median percentage mass loss of test specimens

with Coniophora puteana:	0,6%
with Coriolus versicolor:	0,4%

Provisional durability rating according to CEN/TS 15083-1/2005, Annex D:

Class 1 - very durable - median percentage mass loss ≤ 5%

Note: the test method was applied to treated timber

Head of Department
Dott. Franco Bulian

Managing Director
Dott. Andrea Giavon

10. Resistance/Thermo-Spruce

REPORT -NO. 132648/1 dated 06.03.2012

Date received:	29.09.2011	BRENSTOL OÜ
Date of tests:	29.09.2011	PETERBURI TEE 44
Date of issue:	06.03.2012	11415 TALLINN
Sample name:	Nordic Spruce 215°C	ESTONIA
		CONTACT: Mr. Meelis Kajandu

Technical Report

Determination of the durability of solid wood against wood-destroying basidiomycetes.

Test method:	according to CEN/TS 15083-1/2005, except for sampling and preparation of wood test specimens, which were provided by the customer.
Test material:	heat treated Nordic Spruce
Reference timber:	Pinus Sylvestris (scots pine sapwood)
Test fungi:	Coniophora puteana DSM3085; Poria placenta DSM3088
Ageing procedure:	none
Sterilization:	by gamma radiation
Date of exposure to fungi:	27/10/2011
Date removed from fungi, test duration:	27/02/2012, 4 months

Test results

Mean percentage mass loss of reference timber:

with Coniophora puteana:	29,8%
with Poria placenta:	20,3%

test valid

Moisture content of test specimen after exposure to fungi

with Coniophora puteana:	Ø 21,4%, min 8,2%, max 56,6%
with Poria placenta:	Ø 29%, min 7,4%, max 88,3%

Median percentage mass loss of test specimens

with Coniophora puteana:	2,9%
with Poria placenta:	5,2%

Provisional durability rating according to CEN/TS 15083-1/2005, Annex D:

Class 1 - very durable - median percentage mass loss ≤ 5%

Note: the test method was applied to treated timber

Managing Director
Dott. Andrea Giavon

10. Resistance/Thermo-Pine

REPORT -NO. 132647/1 dated 06.03.2012

Date received:	29.09.2011	BRENSTOL OÜ
Date of tests:	29.09.2011	PETERBURI TEE 44
Date of issue:	06.03.2012	11415 TALLINN
Sample name:	Nordic Pine 215°C	ESTONIA
		CONTACT: Mr. Meelis Kajandu

Technical Report

Determination of the durability of solid wood against wood-destroying basidiomycetes.

Test method:	according to CEN/TS 15083-1/2005, except for sampling and preparation of wood test specimens, which were provided by the customer.
Test material:	heat treated Nordic Pine
Reference timber:	Pinus Sylvestris (scots pine sapwood)
Test fungi:	Coniophora puteana DSM3085; Poria placenta DSM3088
Ageing procedure:	none
Sterilization:	by gamma radiation
Date of exposure to fungi:	27/10/2011
Date removed from fungi, test duration:	27/02/2012, 4 months

Test results
Mean percentage mass loss of reference timber:

with Coniophora puteana:	29,8%
with Poria placenta:	20,3%

test valid

Moisture content of test specimen after exposure to fungi

with Coniophora puteana:	Ø 33,7%, min 12,1%, max 96,4%
with Poria placenta:	Ø 26,5%, min 12,7%, max 39,9%

Median percentage mass loss of test specimens

with Coniophora puteana:	5,9%
with Poria placenta:	6,8%

Provisional durability rating according to CEN/TS 15083-1/2005, Annex D:

Class 1 - very durable - median percentage mass loss ≤ 5%

Note: the test method was applied to treated timber

Managing Director
Dott. Andrea Giavon

10. Energybalance terrace deckings

Rank	Wood Species	Cumulated Energy Demand Sawn Timber KD 15%	Transports till Arrival in EU Region		Energy Demand Transportation*)	Processing		Usage	ENERGY DEMAND PER YEAR
		kWh/kg	Ship (km)	Truck (km)	kWh/kg	Description	kWh/kg	Jahre	kWh/kg
1	Ipe South America	1,83	*10.000*	*1.000*	0,68	*Planing*	0,4	30	0,097
2	Robinia Central Europe	1,83	*0*	*1.000*	0,36	*Planing*	0,4	25	0,104
3	Thermo-Ash Central Europe	1,83	*0*	*1.000*	0,36	*Thermo treatment, Planing*	1,00	30	0,106
4	Thermo-Ash North America	1,83	*6.000*	*1.000*	0,55	*Thermo treatment, Planing*	1,00	30	0,113
5	Oak Central Europe	1,83	*0*	*1.000*	0,36	*Planing*	0,4	20	0,130
6	Thermo-Ash Eastern Europe	1,83	*0*	*3.000*	1,08	*Thermo treatment, Planing*	1,00	30	0,130
7	Oak North America	1,83	*6.000*	*1.000*	0,55	*Planing*	0,4	20	0,139
8	WPC Central Europe	2,50	*0*	*1.000*	0,36	*Extrusion*	1,7	30	0,152
9	Larch Central Europe	1,23	*0*	*1.000*	0,36	*Planing*	0,4	13	0,153
10	Douglas Fir Central Europe	1,23	*0*	*1.000*	0,36	*Planing*	0,4	13	0,153
11	Bangkirai Indonesia	1,83	*15.000*	*1.000*	0,84	*Planing*	0,4	20	0,154
12	WPC North America	2,50	*6.000*	*1.000*	0,55	*Extrusion*	1,7	30	0,158
13	Oak Eastern Europe	1,83	*0*	*3.000*	1,08	*Planing*	0,4	20	0,166
14	Douglas Fir North America	1,23	*6.000*	*1.000*	0,55	*Planing*	0,4	13	0,168
15	Pine impregnated Central Europe	1,23	*0*	*1.000*	0,36	*Impregantion, Planing*	1,00	13	0,199
16	Pine impregnated Eastern Europe	1,23	*0*	*3.000*	1,08	*Impregantion, Planing*	1,00	13	0,255
17	Larch Siberia	1,23	*0*	*6.000*	2,16	*Planing*	0,4	13	0,292

***) Ship 0,000032 kWh/kg*km; Truck 0,00036 kWh/kg*km**

ASSUMPTIONS:
1) The terrace deckings are not coated during usage. If coating would be considered, thermo-ash would perform better due to its reduced swelling & shrinking behavior. Coatings stay longer on surfaces that show low movement. Reduced consumption of paints reduces also the energy demand for the production of these paints and thereby contributes directly to the energy balance of terrace deckings.

2) It is assumed that 1 kg of each wood species covers about the same area. In most cases this is not true due to different densities of wood species. If different densities would be respected, the heavier species would perform worse due to the additional energy consumption from transportation.

3) As truck we assume a modern trailer truck corresponding to EU norms of the year 2010. One can assume that truck transports outside the EU area come with higher energy demands due to poor vehicle technology and road infrastructure. If this issue would be precisely accounted for, a species like Siberian Larch would perform worse.

4) For impregnated pine the energy demand for producing the impregnation agent hasn't been considered. If this aspect would be considered as well, impregnated pine would perform worse.

5) For WPC products the plastics content is assumed to be 50%. The wood content is not accounted for at all. Most WPC products bear a higher plastics content than 50%, which would lead to a worse energy balance than described here.

6) For all transports we assume the transport of finished products. In reality, most tropical hardwoods as well as most wood species from Eastern Europe and Russia are transported in fresh undried condition. North American and Central European wood species are shipped usually in dry state. If this aspect would be considered, fluctuations of up to 50% could occur for the energy demand for transportation.

DATA SOURCES:
Data are taken from the ProBas database maintained by German Federal Institute for the Environment (Umweltbundesamt) and the German Ökoinstitut. Other data is taken from the European Plastics Manufacturer's Association (APME), verified by Umweltbundesamt, respectively are calculated from these data sources.