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WTT

Wood Treatment Technology

Thermo-treated wood

Characteristics and specifications

WTT Thermo-treated wood

– characteristics and specifications

General description of WTT thermo-treated wood.

WTT thermo-treated wood characterises various wood species that have been thermally modified/treated in a WTT thermo treatment plant that operates with temperatures in the temperature range 160-180 °C. This treatment dramatically changes the characteristics and properties of the wood.

The WTT thermo-treated wood is produced in a pressurized autoclave which makes it possible to keep the water contained in the wood throughout the process. This accelerates the chemical processes and moreover it takes place at lower temperatures than what can be observed with conventional plants that dry out the wood to 0% water before the temperature is raised.

This publication serves the purpose of describing what the above treatment does to the wood, what the application areas are and how the wood should be handled when taken into use. The below findings are based on extensive in-house tests, a large-scale test course carried out with the University of Freiburg in Germany (2006-2008) and laboratory tests at the Latvian State Institute of Wood Chemistry.

The main purpose of setting up the above tests was to investigate what the high temperatures do the durability of the wood. When being exposed to so high temperatures the wood will change in more ways: The cellulose chains breaks up, the acid in the wood decomposes and the microorganisms present in all natural, untreated wood will be 'killed'. As rot and fungus thrive from exactly those microorganisms, this alone leads to a considerable improved durability of thermo-treated wood compared with untreated wood.
Please see the chart next page to see the durability test results for 9 wood species. As it can be seen, remarkable durability improvements are reached by thermo-treating the wood. Untreated wood typically moves from class 3 and 4 to class 1 and 2 (and thus expected life-time in excess of 25 years).

<u>Survey of durability classes</u>

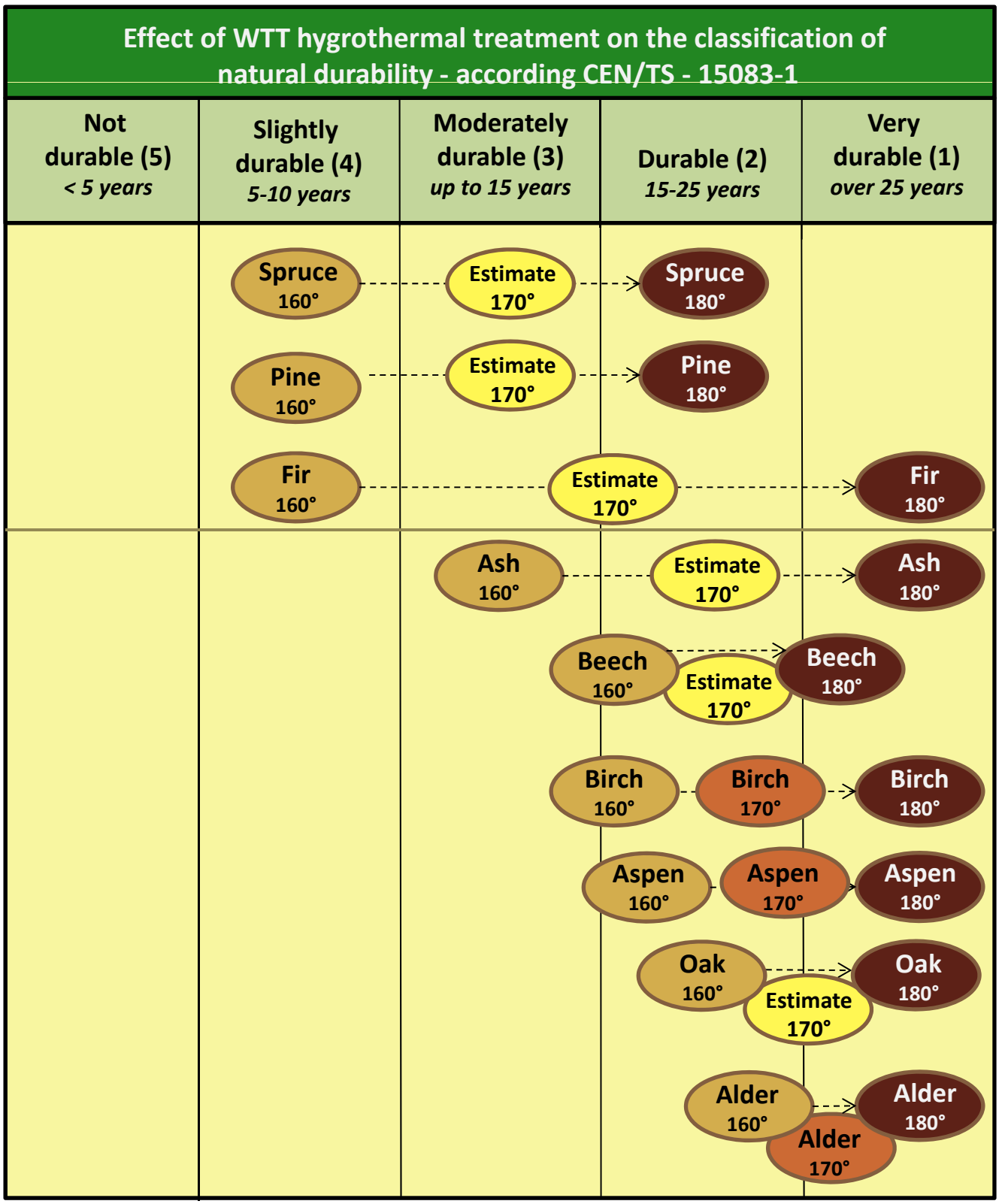
<u>Softwood</u>

WTT 170 °C equals Thermowood – S 190 °C
WTT 180 °C equals Thermowood – D 212 °C

<u>Hardwood</u>

WTT 160 °C equals Thermowood – S 185 °C
WTT 170 °C equals Thermowood – D 200 °C

Biological durability of WTT thermo-treated wood



Sources: "Hygrothermal Modification of Wood by the WTT process" - University of Freiburg, 2009 (spruce, pine, fir, ash, beech, oak - yellow: estimate at 170°C)

" Effect of one stage heat treatment process to the dimensional stability of hardwood" - Latvian State Institute of Wood Chemistry - 2012 (birch, aspen, alder - 170°C tested)

Apart from the improved durability of the wood, there are other characteristics of WTT thermo-treated wood to notice. Below you will find the main headlines and some of them will be explained further subsequently.

- The thermo treatment takes place **without the use of chemicals** what so ever. Only a little water is needed to start the process. The rest of the process takes place via the gradual heating up of the plant in the pressurized vessel (normally up to 7-9 bars). The heating up of the wood will **liberate the moisture** in the wood which then creates a steam environment in the plant that will ensure a **uniform coloration and a lenient/even treatment** of the wood. The wood is therefore absolutely environment-friendly and does not form any threat to the surrounding areas and/or humans and animals

- The wood needs to be **pre-dried to about 12-14% MC** prior to the heat treatment. A particular aspect of the WTT process is that the wood is not entirely dried down to 0% in the treatment. On the opposite, a **residual moisture content of 6-8%** is still present in the wood after the treatment. This has as consequence that subsequent **conditioning of the wood is not needed**

- The **computer-controlled manufacturing process** ensures the uniform treatment of the wood and the very nice dark colouring of the wood. Thermo-treated wood can thus be an **alternative/supplement to tropical wood** species

- The wood obtains improved dimensional stability as the torsion and bending tendencies in the wood is very much reduced

- Considerable improvement in resistance against attack from rot and fungus

- Improved insulation properties

Application areas:

Application areas for are numerous:

All areas within garden and landscape installations
Façades and balconies
Doors and windows
Playground equipment
Noise barriers, canal systems, jetties etc.
Industrial construction, cooling towers, bridges
Saunas, swimming pool areas
Laminated wood, floor boards, parquet
Furniture, kitchens and bathrooms

In relation to the durability classes and thus application areas mentioned earlier, the following breakdown can be used:

Durability class 3 acc. to the EN 113 standard:

WTT thermo-treated softwood (170 °C)	WTT thermo-treated hardwood (160 °C)
- Furniture - Building components - Furnishing in dry conditions - Door and window parts - Sauna benches - Fixtures in dry conditions - Flooring, indoor	- Furniture, including garden furniture - Furnishing - Flooring, indoor - Fixtures - Sauna (construction structures)

Durability class 2 acc. to the EN 113 standard:

WTT thermo-treated softwood (180 °C)	WTT thermo-treated hardwood (170 °C)*
- Garden furniture - Sauna furnishing - Bathroom furnishing - Cladding - Terraces - Doors, external - Shutters	- Furniture, including garden furniture - Furnishing - Terraces - Fixtures - Sauna (construction structures)

* Same application areas as in hardwood treated at 160 °C; only the higher temperatures will result in darker colours of the wood

Physical properties of WTT thermo-treated wood

Brinell hardness

Softwood			
Brinell hardness N/mm2 - average values			
	Untreated	WTT - 160 °C	WTT - 180 °C
Pine	55	50	51
Spruce	43	37	42
Fir	44	43	49

Source : Universitet Freiburg im Breisgau - February 2010

Hardwood			
Brinell hardness N/mm2 - average values			
	Untreated	WTT - 160 °C	WTT - 180 °C
Beech	76	70	76
Ash	78	75	82
Oak	55	42	

Source : Universitet Freiburg im Breisgau - February 2010

Bending modulus of elasticity

Softwood			
Bending modulus of elasticity (MOE) N/mm2 - average values			
	Untreated	WTT - 160 °C	WTT - 180 °C
Pine	12.200	11.900	10.300
Spruce	11.100	9.000	11.300
Fir	8.500	9.500	9.500

Source : Universitet Freiburg im Breisgau - February 2010

Hardwood			
Bending modulus of elasticity (MOE) N/mm2 - average values			
	Untreated	WTT - 160 °C	WTT - 180 °C
Beech	13.000	13.500	13.900
Ash	13.900	13.600	13.300
Oak	10.500	10.400	

Source : Universitet Freiburg im Breisgau - February 2010

Bending strength

Softwood			
Bending strength N/mm2 - average values			
	Untreated	WTT - 160 °C	WTT - 180 °C
Pine	100	70	73
Spruce	80	50	60
Fir	78	62	50

Source : Universitet Freiburg im Breisgau - February 2010

Hardwood			
Bending strength N/mm2 - average values			
	Untreated	WTT - 160 °C	WTT - 180 °C
Beech	121	80	87
Ash	130	90	77
Oak	102	93	

Source : Universitet Freiburg im Breisgau - February 2010

Impact bending

Softwood			
Impact bending test KJ/mm2 - average values			
	Untreated	WTT - 160 °C	WTT - 180 °C
Pine	53	40	45
Spruce	45	30	40
Fir	39	30	29

Source : Universitet Freiburg im Breisgau - February 2010

Hardwood			
Impact bending test KJ/mm2 - average values			
	Untreated	WTT - 160 °C	WTT - 180 °C
Beech	115	70	50
Ash	90	70	38
Oak	93	70	

Source : Universitet Freiburg im Breisgau - February 2010

Reduction of swelling/shrinking

Softwood		
Reduction of swelling/shrinking ASE-Index (%) - average values		
	WTT - 160 °C	WTT - 180 °C
Pine	-40	-52
Spruce	-32	-43
Fir	-30	-45

Source : Universitet Freiburg im Breisgau - February 2010

Hardwood		
Reduction of swelling/shrinking ASE-Index (%) - average values		
	WTT - 160 °C	WTT - 180 °C
Beech	-45	-62
Ash	-45	-62
Oak	-43	-47

Source : Universitet Freiburg im Breisgau - February 2010

Weight loss and change in density

Softwood				
Weight loss and change in density				
		Oven-dry density Kg/m3	Bulk density Kg/m3	SA %
Pine	Untreated	536	562	
	WTT - 160 °C	516	539	2
	WTT - 180 °C	519	533	1
Spruce	Untreated	536	562	
	WTT - 160 °C	516	539	1
	WTT - 180 °C	519	533	0
Fir	Untreated	536	562	
	WTT - 160 °C	516	539	9
	WTT - 180 °C	519	533	9

Source : Universitet Freiburg im Breisgau - February 2010

Hardwood				
Weight loss and change in density				
		Oven-dry density Kg/m3	Bulk density Kg/m3	SA %
Beech	Untreated	704	730	
	WTT - 160 °C	652	670	2
	WTT - 180 °C	618	630	1
Ash	Untreated	665	690	
	WTT - 160 °C	631	648	1
	WTT - 180 °C	602	619	0
Oak	Untreated	639	712	
	WTT - 160 °C	575	600	9
	WTT - 180 °C	540	560	9

Source : Universitet Freiburg im Breisgau - February 2010

Equilibrium moisture content

Equilibrium moisture content of the wood (% moisture content)					
	50%	65%	80%	90%	Atm. moisture
Untreated	10%	14%	18%	25%	Wood moisture
WTT - 160 °C	6%	8%	12%	15%	Wood moisture
WTT - 180 °C	6%	7%	10%	13%	Wood moisture

Source : Universitet Freiburg im Breisgau - February 2010

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Test protocol

EN 113 (CEN/TS 15083-1)
Hard- and softwoods

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Testing institute	Albert-Ludwig-University Freiburg, Institute for Forest Utilization and Work Science and Institute for Forest Botany and Tree Physiology, Chair of Forest Botany
Cooperation partner	Ets. Röthlisberger SA, Rue de la Gare 28 CH-2855 Glovelier, Schwitzerland; WTT A/S, Jyllandsvej 9, DK 7330 Brande, Denmark

Preliminary note

This report documents the results of an investigation into the resistance of hygrothermally modified wood to wood-decaying Basidiomyceten. It was carried out as part of the research project Thermowood modified by the WTT process. The study was conducted in accordance with the EN113 German standard. The analysis of the results and the preliminary classification of the wood samples into natural durability classes were undertaken concurrently in keeping with the EN113/EN350 and CEN/TS 15083-1 standards respectively. The validity of CEN/TS 15083-1 expired in June 2008. As yet it (CEN/TS) has not been converted to European standards. Thus the results presented here must be interpreted in relation to EN113. The classification of the natural durability of the wood samples was undertaken in laboratory trials, and the results need to be confirmed under field conditions.

Material and test conditions

Standards used for testing and classification of the natural durability class:	EN 113: Wood preservatives – Test method for determining the protective effectiveness against wood destroying basidiomycetes – Determination of the toxic values; German version EN 113:1996 CEN/TS 15083-1: Durability of wood and wood based products – Determination of the natural durability of solid wood against wood destroying fungi, test methods Part 1: Basidiomycetes; German version CEN/TS 15083-1:2005 EN 350-1: Durability of wood and wood based products – Natural durability of solid wood – Part 1: Guide to the principles of testing and classification of the ntural durability of wood; German version EN 350-1:1994 CEN/TS 15679: Thermal Modified Timber – Definitions and characteristics; German version CEN/TS 15679:2007
Species and stem zones in accordance with EN 350-1:	European beech (*Fagus sylvatica*): heart- and sapwood; European ash (*Fraxinus excelsior*): heart-, transition- and sapwood; Oak (*Quercus spec.*); heart-, transition wood, Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), White fir (*Abies alba*): heart- and sapwood
Number and origin of the trees:	Bottom stems (each 3, ash 2 stems); Switzerland (canton Jura); amplitude 400-600 NN; kiln dried (60-62°C, one week)
Characterisation of wood:	60 % of the oak boards shown decayed sapwood, beech without red heartwood, ash with little heartwood (olive green)
Tested wood product:	Standard test samples of hygrothermally treated (WTT technique) and untreated control samples of same species
Tested treatment variants:	Kiln dried wood (u= 12 % ± 2) of following variants:

variant	0	untreated controls
variant	160°C	treated with 160°C or 180°C
variant	180°C	

Sampling / weathering:	According to EN 350-1 and EN 84
Sterilisation method:	Ionizing gamma radiation
Test period:	March 08 to April 09

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Test protocol

EN 113 (CEN/TS 15083-1)

Hard- and softwoods

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Test duration:	16 weeks
Deviations from the standard:	The required angle of the tree rings to the broad surfaces from 90±15° could be observed only for about 80% of the test specimens. Required number of trees after EN113 = 3, according to CEN / TS 15083-1 = 5; investigated trees: spruce, pine, fir, beech and oak = 3, ash = 2; in each experimental vessel were added three (untreated, 160° C, 180° C) instead of 2 specimens as specified in EN 113.
Report prepared by:	Andrea Tausch, Denny Ohnesorge
Date:	11. May 2009

Test fungi:

scientific name	strain number	tested with
Coniophora puteana	BAM Ebw. 15[1] / (DSM 3085))	HW and SW
Gloeophyllum trabeum	BAM Ebw. 109[3]/ (DSM 3087)	HW and SW
Serpula lacrymans	BAM Ebw. 315	HW and SW
Coriolus versicolor	CTB 863 A[2]/ (DSM 3087)	HW
Poria placenta	EMPA 229	SW

[1]obtained as EMPA 62, [2]: obtained as EMPA 159, [3]: obtained as EMPA 100; HW = hardwoods, SW = softwoods

Method

The table below presents the investigation results for the resistance of hygrothermally modified wood to wood-decaying Basidiomyceten after a 16-week incubation period for each tree species. Both the uncorrected percentage weight loss (from CEN/TS 15083-1) and the corrected weight loss (from EN 113) are presented in relation to the initial dry weight of the wood samples. When, at the end of the trial, an increase in the oven dry weight of a sample was measured, this value was recorded as a 0% weight loss in the analysis. In contrast to CEN/TS 15083-1, the weight loss determined (WL_{uncorr}) was corrected with a correction factor (WL_{corr}) in accordance with EN 113. The correction factor represents a weight change that cannot be attributed to the trial fungus. Its determination was based on the separate control wood samples. Furthermore, in accordance with CEN/TS 15679, sample wood with abnormal moisture content (moisture content u < 25% and u > 80%) was not eliminated as prescribed in EN 113.

Classification of natural durability

The following table shows the classification of the natural durability of the wood samples tested, determined in accordance with the standards CEN/TS 15083-1 and EN 350-1. The classification adopting CEN/TS 15083-1 was carried out using the limiting values in Appendix E of the technical specifications. These were obtained from the highest median weight loss of the fungi tested. As this is merely a preliminary assessment, the following results are also preliminary. The classification of the natural durability to fungal infection following EN 350-1 was conducted on the basis of the trial fungi that caused the highest average weight loss (WL_{corr}) in wood samples. The classification was performed with an x-value, which was derived from ratio of the mean percentage weight loss of the wood species tested and the mean weight loss of reference wood species. Beech wood served as a reference wood species for hardwoods, and pine sapwood as the reference wood species for softwoods.

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Results for beech wood

beech wood				CEN/TS 15083-1			EN 113 / EN 350-1			
test fungi	treatment	stem zone	ρ_0 [kg/m³]	n	WL_{uncorr} [%]	s [%]	n	K [%]	WL_{corr} [%]	s [%]
Coniophora puteana	control	heart	729	19	36,1	3,3	19	0,7	35,4	3,3
		transition	696	10	33,4	4,2	10	0,7	32,6	4,2
		sap	685	30	37,3	7,6	30	0,7	36,5	7,6
	160°C	heart	599	19	13,6	6,9	19	3,7	9,9	6,9
		transition	654	12	18,7	3,2	12	3,7	15,0	3,2
		sap	616	27	7,8	2,8	27	3,7	4,0	2,8
	180°C	heart	615	19	2,4	2,3	19	2,1	0,7	2,1
		transition	631	28	1,4	0,5	28	2,1	0,0	0,1
		sap	628	10	2,4	1,1	10	2,1	0,6	0,6
Gloeophyllum trabeum	control	heart	739	15	29,9	1,2	15	0,7	29,2	1,2
		sap	660	15	31,9	5,6	15	0,7	31,1	5,6
	160°C	heart	649	15	7,2	5,0	15	3,7	4,5	3,5
		sap	600	15	4,4	1,5	15	3,7	0,9	1,3
	180°C	heart	640	15	1,7	0,6	15	2,1	0,1	0,2
		sap	601	15	2,4	1,3	15	2,1	0,5	1,2
Coriolus versicolor	control	heart	727	15	33,6	2,9	15	0,7	32,8	2,9
		sap	664	18	35,9	10,5	18	0,7	35,2	10,5
	160°C	heart	653	15	9,2	2,3	15	3,7	5,5	2,3
		sap	604	18	11,0	2,2	18	3,7	7,3	2,2
	180°C	heart	649	15	5,8	1,6	15	2,1	3,7	1,6
		sap	601	18	6,0	1,1	18	2,1	3,9	1,1
Serpula lacrymans	control	heart	734	15	3,2	5,4	15	0,7	2,5	5,4
		sap	680	15	7,7	12,9	15	0,7	7,5	12,7
	160°C	heart	659	15	6,8	5,2	15	3,7	3,5	4,8
		sap	588	15	0,9	1,2	14	3,7	0,0	0,0
	180°C	heart	643	15	1,9	0,7	15	2,1	0,2	0,3
		sap	620	15	3,8	1,5	15	2,1	1,7	1,4

Classification of natural durability

			CEN/TS 15083-1		EN 113 / EN 350-1		
species	treatment	zones	median WL [%]	DC	WL_{corr} [%]	x-value	DC
European beech	control	all [a]	36,9	5	35,5	1,00	5
	160°C	all	10,9	3*	8,2	0,23	2
	180°C	all	6,1	2*	3,8	0,11	1

*deviations in classification between the two standards; [a] reference species; DC = Code durability class:
1 = very durable, 2 = durable, 3 = less durable, 4 = little durable, 5 = not durable

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Results for ash wood

ash wood				CEN/TS 15083-1			EN 113 / EN 350-1			
test fungi	treatment	stem zone	ρ_0 [kg/m³]	n	WL_{uncorr} [%]	s [%]	n	K [%]	WL_{corr} [%]	s [%]
Coniophora puteana	control	heart	651	14	28,0	3,5	14	1,6	26,5	3,5
		sap	639	15	29,9	2,1	15	1,6	28,3	2,1
	160°C	heart	622	14	4,6	4,0	14	4,4	1,6	2,8
		sap	567	14	6,6	2,0	14	4,4	2,2	1,9
	180°C	heart	607	9	1,2	0,7	9	2,6	0,0	0,0
		transition	562	5	1,6	0,6	5	2,6	0,0	0,0
		sap	575	6	1,4	0,8	6	2,6	0,0	0,0
Gloeophyllum trabeum	control	heart	679	10	27,0	4,5	10	1,6	25,4	4,5
		transition	659	10	28,0	1,7	10	1,6	26,5	1,7
		sap	646	10	21,3	4,6	10	1,6	19,7	4,6
	160°C	heart	662	10	6,3	1,1	10	4,4	1,8	1,1
		transition	581	10	6,5	0,7	10	4,4	2,1	0,7
		sap	598	10	7,5	1,4	10	4,4	3,0	1,4
	180°C	heart	622	10	2,2	0,7	10	2,6	0,2	0,3
		transition	576	10	2,6	0,2	10	2,6	0,1	0,2
		sap	571	10	2,7	0,5	10	2,6	0,3	0,3
Coriolus versicolor	control	heart	699	10	31,5	1,7	10	1,6	29,9	1,7
		transition	655	10	33,0	1,3	10	1,6	31,5	1,3
		sap	663	10	32,5	1,1	10	1,6	30,9	1,1
	160°C	heart	654	10	9,4	1,9	10	4,4	5,0	1,9
		transition	592	10	11,3	2,1	10	4,4	6,8	2,1
		sap	591	10	13,1	1,4	10	4,4	8,6	1,4
	180°C	heart	607	10	4,6	1,5	10	2,6	2,1	1,5
		transition	579	10	4,7	1,0	10	2,6	2,2	1,0
		sap	590	10	4,1	0,9	10	2,6	1,5	0,9
Serpula lacrymans	control	heart	700	10	0,8	0,6	10	1,6	0,0	0,0
		transition	652	10	2,5	0,3	10	1,6	1,0	0,3
		sap	661	10	3,2	0,2	10	1,6	1,6	0,2
	160°C	heart	633	10	4,8	0,3	10	4,4	0,4	0,3
		transition	591	10	4,9	0,8	10	4,4	0,6	0,6
		sap	575	10	5,8	0,7	10	4,4	1,3	0,7
	180°C	heart	612	10	2,1	0,6	10	2,6	0,1	0,3
		transition	575	10	2,3	0,1	10	2,6	0,0	0,0
		sap	592	10	2,2	0,2	10	2,6	0,0	0,0

Classification of natural durability

			CEN/TS 15083-1		EN 113 / EN 350-1		
species[a]	treatment	zones	median WL [%]	DC	WL_{corr} [%]	x-value	DC
ash	control	heart	32,0	5*	29,9	0,84	4
		transition	32,8	5*	31,5	0,89	4
		sap	32,4	5*	30,9	0,87	4
	160°C	heart	9,2	2*	5,0	0,14	1
		transition	10,6	3*	6,8	0,19	2
		sap	13,0	3*	8,6	0,24	2
	180°C	heart	4,3	1	2,1	0,06	1
		transition	4,3	1	2,2	0,06	1
		sap	4,0	1	1,5	0,04	1

*deviations in classification between the two standards; [a] reference species beech; DC = Code durability class:
1 = very durable, 2 = durable, 3 = less durable, 4 = little durable, 5 = not durable

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Results for oak wood

oak wood				CEN/TS 15083-1			EN 113 / EN 350-1			
test fungi	treatment	stem zone	ρ_0 [kg/m³]	n	WL_{uncorr} [%]	s [%]	n	K [%]	WL_{corr} [%]	s [%]
Coniophora puteana	control	heart	629	30	9,6	4,5	30	2,9	6,7	4,5
		transition	580	30	6,8	2,2	30	2,9	3,9	2,2
	160°C	heart	577	30	11,9	6,9	30	2,7	9,2	6,9
		transition	492	30	5,6	3,8	30	2,7	3,0	3,7
	180°C	heart	587	16	3,5	1,0	16	2,2	1,4	0,9
		transition	533	25	3,3	1,1	25	2,2	1,3	0,9
Gloeophyllum trabeum	control	heart	669	14	4,2	5,2	14	2,9	1,8	5,0
		transition	552	15	2,6	0,5	15	2,9	0,1	0,2
	160°C	heart	607	14	7,0	2,5	14	2,7	4,3	2,5
		transition	493	15	4,7	1,0	15	2,7	2,0	1,0
	180°C	heart	668	4	5,1	5,5	4	2,2	3,5	4,9
		transition	531	9	2,8	0,6	9	2,2	0,6	0,5
Coriolus versicolor	control	heart	672	15	28,6	9,3	15	2,9	25,7	9,3
		transition	553	10	28,7	6,5	10	2,9	25,8	6,5
	160°C	heart	623	14	7,4	1,6	14	2,7	4,7	1,6
		transition	466	10	9,5	2,6	10	2,7	6,8	2,6
	180°C	heart	657	4	3,2	1,0	4	2,2	1,1	0,9
		transition	533	10	3,9	1,7	10	2,2	1,7	1,7
Serpula lacrymans	control	heart	658	13	2,1	0,5	13	2,9	0,0	0,0
		transition	563	20	2,4	0,7	20	2,9	0,1	0,2
	160°C	heart	609	13	5,0	1,8	13	2,7	2,3	1,8
		transition	478	20	3,4	1,3	20	2,7	0,9	1,2
	180°C	heart	628	4	2,5	1,1	4	2,2	0,6	0,9
		transition	518	8	3,1	1,8	8	2,2	1,3	1,3

Classification of natural durability

			CEN/TS 15083-1		EN 113 / EN 350-1		
species[a]	treatment	zones	median WL [%]	DC	WL_{corr} [%]	x-value	DC
oak	control	heart	32,6	5*	25,7	0,72	4
		transition	28,8	4	25,8	0,73	4
	160°C	heart	9,5	2	9,2	0,26	2
		transition	9,7	2	6,8	0,19	2
	180°C	heart	3,9	1	3,5	0,10	1
		transition	3,6	1	1,4	0,04	1

*deviations in classification between the two standards; [a] reference species beech; DC = Code durability class:
1 = very durable, 2 = durable, 3 = less durable, 4 = little durable, 5 = not durable

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Test protocol

EN 113 (CEN/TS 15083-1)

Hard- and softwoods

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Results for pine wood

pine				CEN/TS 15083-1			EN 113 / EN 350-1			
test fungi	treatment	stem zone	ρ_0 [kg/m³]	n	WL_{uncorr} [%]	s [%]	n	K [%]	WL_{corr} [%]	s [%]
Coniophora puteana	control [a]	heart	556	15	27,5	5,8	15	1,5	26,0	5,8
		sap	552	15	29,1	4,4	15	1,5	27,6	4,4
	160°C	heart	474	18	22,6	6,1	18	5,4	17,2	6,1
		sap	508	15	24,6	4,6	15	5,4	19,2	4,6
	180°C	heart	438	19	3,5	3,1	19	2,6	1,5	2,6
		sap	504	15	3,0	1,9	15	2,6	0,8	1,5
Gloeophyllum trabeum	control [a]	heart	512	15	8,3	9,7	15	1,5	7,0	9,5
		sap	556	15	21,2	2,3	15	1,5	19,6	2,3
	160°C	heart	484	15	24,2	3,3	15	5,4	18,8	3,3
		sap	491	20	21,5	3,3	20	5,4	16,1	3,3
	180°C	heart	408	10	3,5	1,4	10	2,6	1,2	1,1
		sap	505	15	3,1	0,7	15	2,6	0,5	0,7
Poria placenta	control [a]	heart	485	15	24,2	8,3	15	1,5	22,8	7,9
		sap	601	10	24,5	3,0	10	1,5	23,0	3,0
	160°C	heart	481	15	24,6	8,2	15	5,4	19,3	8,2
		sap	570	10	21,6	3,6	10	5,4	16,2	3,6
	180°C	heart	427	10	7,0	3,8	10	2,6	4,5	3,7
		sap	507	15	7,6	3,1	15	2,6	4,9	3,1
Serpula lacrymans	control [a]	heart	502	15	15,6	13,2	15	1,5	14,3	12,8
		sap	600	10	31,3	15,9	10	1,5	29,8	15,9
	160°C	heart	475	15	10,5	8,3	15	5,4	5,6	7,9
		sap	569	10	6,4	2,0	10	5,4	1,3	1,8
	180°C	heart	421	10	1,7	1,3	10	2,6	0,2	0,4
		sap	511	15	2,9	0,6	15	2,6	0,4	0,5

Classification of natural durability

			CEN/TS 15083-1		EN 113 / EN 350-1		
species[a]	treatment	zones	median WL [%]	DC	WL_{corr} [%]	x-value	DC
pine	control	heart	27,3	4	26,0	0,87	4
		sap [a]	39,1	5	29,8	1,00	5
	160°C	heart	24,4	4	19,3	0,65	4
		sap	25,6	4	19,2	0,64	4
	180°C	heart	7,9	2*	4,5	0,15	1
		sap	8,5	2	4,9	0,17	2

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Test protocol

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Results for spruce wood

spruce				CEN/TS 15083-1			EN 113 / EN 350-1			
test fungi	treatment	stem zone	ρ_0 [kg/m³]	n	WL_{uncorr} [%]	s [%]	n	K [%]	WL_{corr} [%]	s [%]
Coniophora puteana	control	heart	396	29	32,1	4,2	29	0,9	31,2	4,2
		sap	469	30	35,2	7,9	30	0,9	34,3	7,9
	160°C	heart	389	24	25,3	4,4	24	4,3	21,0	4,4
		sap	456	27	20,7	6,2	27	4,3	16,4	6,2
	180°C	heart	358	27	2,8	2,0	27	3,1	0,7	1,1
		sap	456	30	1,5	1,7	30	3,1	0,3	1,1
Gloeophyllum trabeum	control	heart	402	15	32,4	3,3	15	0,9	31,5	3,3
		sap	477	15	31,4	2,3	15	0,9	30,5	2,3
	160°C	heart	368	15	23,9	4,8	15	4,3	19,6	4,8
		sap	475	15	17,3	5,4	15	4,3	13,0	5,4
	180°C	heart	351	15	5,5	2,6	15	3,1	2,6	2,5
		sap	476	15	3,7	1,8	15	3,1	1,0	1,4
Poria placenta	control	heart	412	13	26,0	5,7	13	0,9	25,1	5,7
		sap	475	19	26,0	4,1	19	0,9	25,2	4,1
	160°C	heart	367	13	24,7	5,0	13	4,3	20,4	5,0
		sap	463	19	25,2	4,8	19	4,3	20,9	4,8
	180°C	heart	343	10	13,9	4,9	10	3,1	10,8	4,9
		sap	458	19	8,8	3,4	19	3,1	5,7	3,4
Serpula lacrymans	control	heart	409	15	35,6	9,8	15	0,9	34,7	9,8
		sap	483	15	33,4	14,6	15	0,9	32,6	14,4
	160°C	heart	371	15	21,1	6,8	15	4,3	16,8	6,8
		sap	464	15	16,3	9,3	15	4,3	12,0	9,3
	180°C	heart	340	15	6,4	12,0	15	3,1	3,7	11,9
		sap	464	15	2,7	1,1	15	3,1	0,3	0,4

Classification of natural durability

			CEN/TS 15083-1		EN 113 / EN 350-1		
species[a]	treatment	zones	median WL [%]	DC	WL_{corr} [%]	x-value	DC
spruce	control	heart	38,9	5	34,7	1,16	5
		sap	39,2	5	34,3	1,15	5
	160°C	heart	25,3	4	21,0	0,70	4
		sap	24,5	4	20,9	0,70	4
	180°C	heart	13,3	3	10,8	0,36	3
		sap	8,9	2	5,7	0,19	2

*deviations in classification between the two standards; [a] reference species pine sapwood; DC = Code durability class:
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Test protocol

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Results for fir wood

test fungi	fir treatment	stem zone	ρ_0 [kg/m³]	CEN/TS 15083-1 n	WL_{uncorr} [%]	s [%]	EN 113 / EN 350-1 n	K [%]	WL_{corr} [%]	s [%]
Coniophora puteana	control	heart	448	6	34,7	3,8	6	1,5	33,2	3,8
		sap	439	12	40,5	3,6	12	1,5	39,0	3,6
	160°C	heart	389	15	15,5	5,0	15	2,3	13,1	5,0
		sap	418	11	11,4	8,0	11	2,3	9,1	8,0
	180°C	heart	364	14	1,3	3,2	14	1,9	0,8	2,8
		sap	419	15	1,1	0,8	15	1,9	0,1	0,2
Gloeophyllum trabeum	control	heart	444	11	17,2	9,4	11	1,5	15,7	9,4
		sap	433	14	13,3	12,7	14	1,5	11,9	12,6
	160°C	heart	389	11	11,7	5,2	11	2,3	9,4	5,2
		sap	418	14	6,3	5,2	14	2,3	4,0	5,1
	180°C	heart	351	11	1,8	0,3	11	1,9	0,1	0,1
		sap	416	13	2,6	0,6	13	1,9	0,7	0,6
Poria placenta	control	heart	426	8	33,4	4,1	8	1,5	31,9	4,1
		sap	423	17	30,6	4,8	17	1,5	29,1	4,8
	160°C	heart	384	8	24,8	5,0	8	2,3	22,5	5,0
		sap	413	14	18,2	6,2	14	2,3	15,8	6,2
	180°C	heart	373	8	2,1	0,9	8	1,9	0,4	0,7
		sap	409	12	2,9	2,2	12	1,9	1,4	1,9
Serpula lacrymans	control	heart	426	8	7,6	18,7	8	1,5	6,7	18,4
		sap	434	15	3,3	7,7	15	1,5	2,2	7,6
	160°C	heart	379	8	5,2	5,9	8	2,3	2,9	5,9
		sap	405	15	2,9	1,1	15	2,3	0,7	0,9
	180°C	heart	363	8	1,6	0,2	8	1,9	0,0	0,0
		sap	396	15	2,7	1,0	15	1,9	0,9	0,8

Classification of natural durability

species[a]	treatment	zones	CEN/TS 15083-1 median WL [%]	DC	EN 113 / EN 350-1 WL_{corr} [%]	x-value	DC
fir	control	heart	34,4	5	33,2	1,11	5
		sap	40,9	5	39,0	1,31	5
	160°C	heart	24,0	4	22,5	0,75	4
		sap	18,8	4*	15,8	0,53	3
	180°C	heart	1,9	1	0,8	0,03	1
		sap	2,5	1	1,4	0,05	1

*deviations in classification between the two standards; [a] reference species pine sapwood; DC = Code durability class:
1 = very durable, 2 = durable, 3 = less durable, 4 = little durable, 5 = not durable