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DELIVERABLE D_5.3:

End User Practical Handbook / Guide

31/08/2016

TV4NEWOOD PROJECT

AGREEMENT NUMBER:
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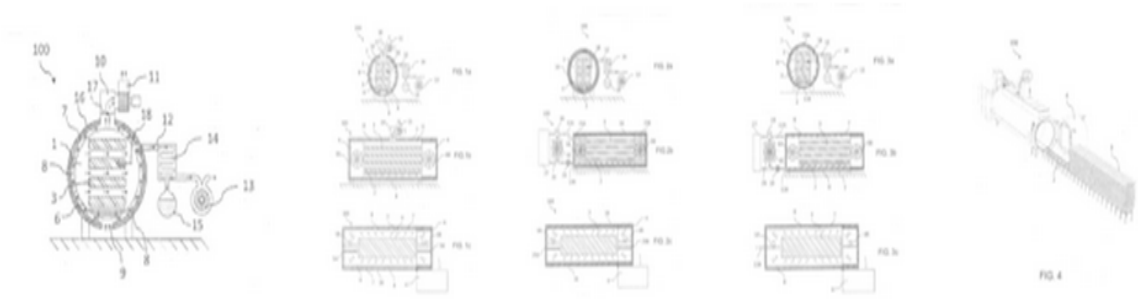

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CONTENT

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Introduction

This handbook has been produced through a close cooperation among the Partners of Tv4newood project.

This handbook is a first edition and collect all information necessarily to produce VacWood®, the innovative wood made with Thermo vacuum process.
Because this is a new product we think that it is very important to offer as much information as possible concerning the product and process so as to raise and maintain the level of knowledge as efficiently as possible.

Therefore, we hope that this handbook will act as a good information source for specifiers, end users in industry, construction companies, timber merchants, etc.

The results have been collected during Tv4newood project with research and tests, experiences of industrial manufacturers, feedback from customers, etc…
The results and experiences presented in this handbook have to be used as a guide for the production of VacWood® wood and for the perfect use of ThermoVacuum system.

One of the aim of the project partners is to update this handbook on a regular basis. As new results and experiences become available, new editions will be published outlining the areas that have been updated.

The ThermoVacuum process is patented by WDE-Maspell and VacWood® is a registered trademark and may be used only by producer of thermo vacuum wood with Wde-Maspell plant
We hope that the readers of this handbook will find it both informative and useful.

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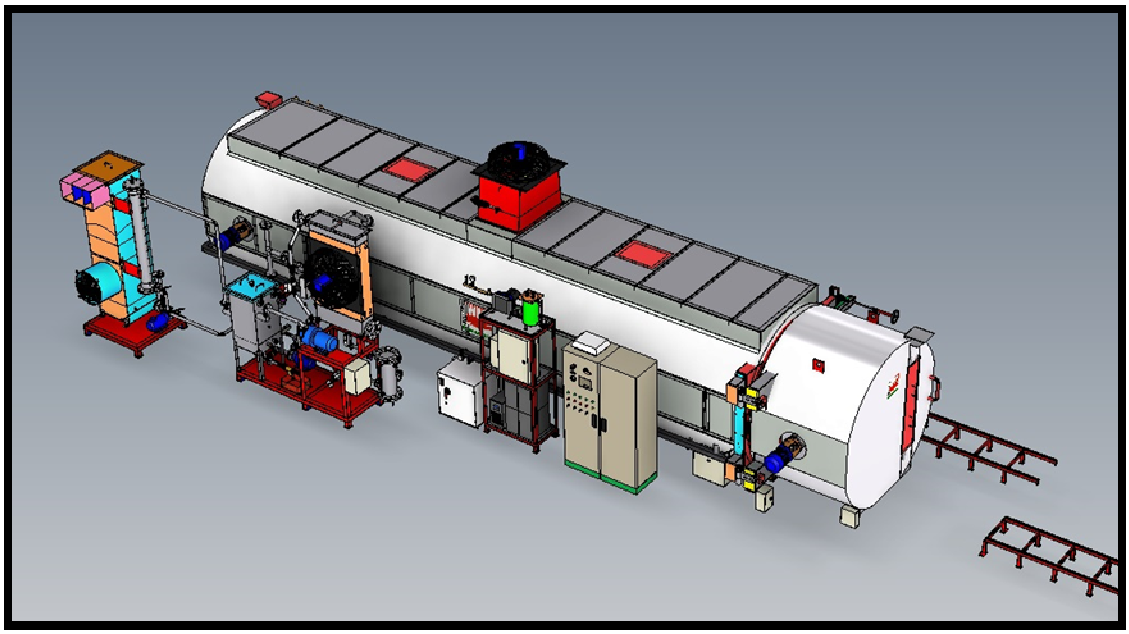
Overview of ThermoVacuum system

The THERMOVACUUM versatile vacuum kiln principally consists of the following elements:

- DRYING AND HEAT-TREATMENT CELL
- WOOD-CHARGING SYSTEM
- WOOD-HEATING SYSTEM
- WOOD-COOLING SYSTEM
- COOLING SYSTEM,
- VACUUM-PUMPING SYSTEM
- ELECTRICAL CABINET
- SAFETY SYSTEM



The machine can operate as a vacuum dryer or as a THERMOVACUUM heat-treatment system for the modification of wood at high temperature.

DRYING FUNCTION.

After loading the wood pile onto cars, connecting the humidity probes to the connector via electrical wires and inserting the temperature probe into the centre of the wood, the operator can push the car into the dryer, remove the bridge from the external rails and close the door using the two small handwheels.

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When this has been done, the operator has to select the drying program on the PLC touch screen, which depends on the type of wood, its thickness and its initial and final moisture (see Section 12), and then the drying cycle can start, which progresses through the following three phases:

- PHASE 1: Preheating to the middle of the wood
- PHASE 2: Drying
- PHASE 3: Cooling and conditioning of the wood.

PREHEATING: During this phase, which can be done either under atmospheric pressure or under partial vacuum, fans circulate the air through the heaters and the woodpile so that the wood is heated to the temperature shown in the drying program selected.

DRYING: After the preheating phase, the vacuum pump withdraws air from the cell until the target vacuum value for the drying process is reached, while heating system (consisting of the fans and the electrical heaters) continues to supply the wood with thermal energy needed to maintain the required temperature and to cause the evaporation of water from the wood.
The combination of vacuum and temperature greatly stimulates the flow of water from the centre to the surface of the wood such that the water, converted into vapour by the effect of vacuum, is withdrawn by the vacuum pump and evacuated to the outside of the drying cell.
During drying, the PLC performs all necessary changes in temperature and pressure inside the cell, depending on the wood moisture content measured by the three probes.
After the moisture content of the wood has reached the desired final value, the dryer switches to the cooling phase.
COOLING: During this phase, the supply of heat is inhibited, but the fans continue to rotate so as to even out the moisture of the various wood planks and to cool them.
At the same time, the cooling fans circulate cold air inside the dryer wall to cool the inner wall of the cell and hence the wood contained within it.
When the temperature inside the cell reaches the value programmed into the PLC, the dryer switches off all components, waiting for the operator to open the door and unload the dry wood.

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ThermoVacuum Function

After loading the wood pile onto cars and inserting the temperature probe into the wood, the operator can push the car into the dryer, remove the bridge from the external rails and close the door using the two small handwheels.
When this has been done, the operator has to select the most suitable THERMOVACUUM program on the PLC touch screen, taking into account the type of wood, its thickness and its initial and final moisture , and then the heat-treatment cycle can start, which progresses through the following three phases:

- PHASE 1: Preheating to the middle of the wood
- PHASE 2: THERMOVACUUM heat treatment
- PHASE 3: Cooling and conditioning of the wood.

PREHEATING: During this phase, which can be done either under atmospheric pressure or under partial vacuum, fans circulate the air through the heaters and the woodpile so that the wood is heated to the temperature shown in the THERMOVACUUM program selected.

THERMOVACUUM HEAT TREATMENT: After the preheating phase, the vacuum pump withdraws air from the cell until the target vacuum value for the drying process is reached, while heating system (consisting of the fans and the electrical heaters) continues to supply the wood with thermal energy needed to maintain the configured temperature.
The combination of vacuum and temperature causes a thermochemical modification of the woody matter, while any residual vapour and/or gas sucked out by the vacuum pump is condensed and returned to liquid state by the effect of the condenser.
During the treatment, the PLC performs all necessary changes in temperature and pressure inside the cell, depending on the desired end result.
After the time indicated in the program, the system automatically switches to the cooling phase.

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Instruction for using the dryer.

SEQUENCE OF OPERATIONS FOR A DRYING CYCLE.

1. Open the door (1) of the THERMOVACUUM after unscrewing the two handwheels (2) that lock the door.
2. Disconnect the humidity sensors (sensors connectors positioned at the entrance of the cell).

FIGURE 8.1.1

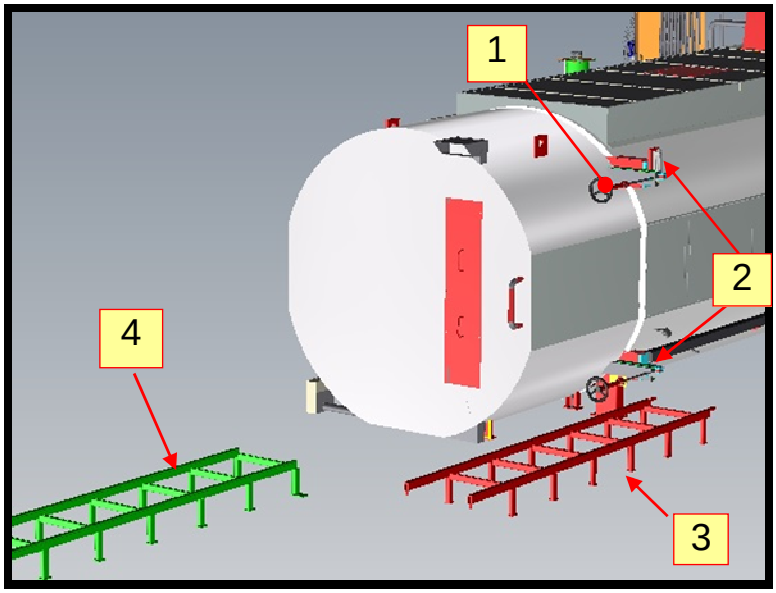
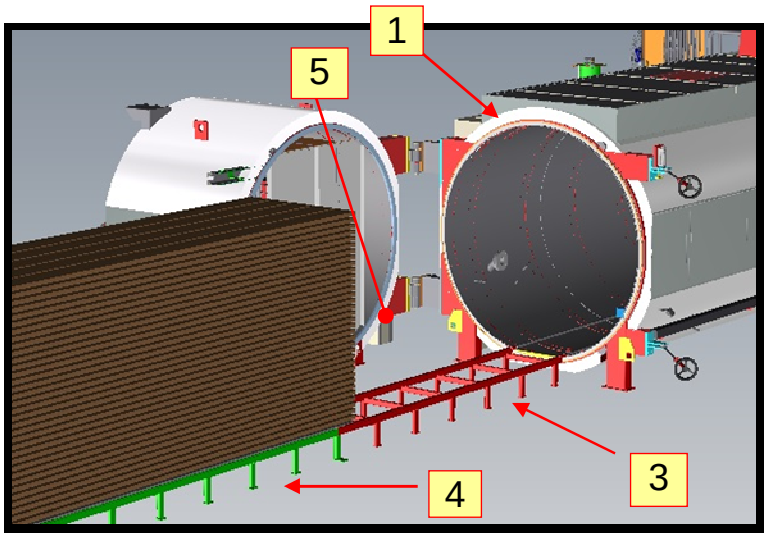


FIGURE 8.1.2



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3. Place the bridge (3) between the cell and the external rails (4).

4. Remove the wood-charging car (5) from the cell.

5. Load the pile of wood for drying onto the cars.

6. Carefully read and use the "PRACTICAL ADVICE FOR DRYING".

7. The wood should be stacked according to the rules for good stacking, i.e.:

   - thickness of the sticks
   - spacing of the sticks
   - alignment of the sticks

8. The quality and speed of drying depend mainly on compliance with these conditions. For this reason, users are advised to follow the rules for good stacking (Items 8-9-10-11-12).

9. Thickness of the sticks:

THICKNESS OF THE WOOD	THICKNESS OF THE STICKS
18–40 mm	20 mm
40–60 mm	20–25 mm
60–90 mm	25–30 mm
>90 mm	30–40 mm

10. The spacing of the sticks depends on the thickness of the wood:

THICKNESS OF THE WOOD	Spacing of the sticks
18–30 mm	50 cm
30–50 mm	70 cm
50–80 mm	100 cm
>80 mm	120 cm

11. To avoid deformations of the wood, the sticks must be vertically aligned.
12. To avoid deformations of the wood, the sticks must be vertically aligned.
13. To avoid cracking at the bottom of the planks, the stick must be placed starting at the start of the stack of wood.
14. To avoid staining the wood, the sticks must be of a white wood.
15. Check that the type, thickness and initial moisture content of the wood to be dried complies with the values in Table 11.1, Section 11.

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16. Do not forget to place the sensors for humidity measurement inside the wood (see Section 11.4).
17. Push the cars (5) into the dryer, remove the bridge (3) and close the door (1) by turning the handwheels.
18. Switch on the power for the cabinet at the main switch and select the drying program on the PLC touch screen (on the electrical cabinet) or computer (if the machine has one) according to the type and thickness of the wood (see details in Section 11-12).
19. Set the value of desired final moisture content (FMC; see Example 3 in Section 8.4.3).
20. The selectors for the vacuum pump (21), heating (22) and shutter with double turbine (23) must be in the ON position (see Figure 8.2.1).
21. The drying process consists of three phases:
    - PREHEATING
    - DRYING
    - COOLING

    After all data has been entered, the PLC executes the drying cycle automatically.
22. In the first preheating phase (PH0), the PLC takes the wood to the programmed drying temperature, during which time only the heating system can operate (possibly with the application of a pre-vacuum).
23. The preheating phase consists of two periods:
    - The first period of increasing temperature according to a configuration chosen by the operator;
    - The second period of heating to the inside, according to the time determined by the operator (typically 1 hour for each centimetre of thickness of the wood).
24. During the following drying stages (from PH1 to PH8), the PLC controls the vacuum pump to reach the programmed vacuum value and activates the fans so as to maintain the set temperature. Depending on the amount of moisture in the wood, the PLC changes the value of the pressure and temperature inside the cell according to the phases of the drying program.
25. When the moisture content of the wood reaches the desired value (FMC), the microprocessor enters the final cooling stage (PH9). During this phase, the heating system of the dryer is stopped while the fans turn and the vacuum is maintained at the same value as in the previous phase. The cooling time is determined by the operator according to the thickness of the wood, the final temperature and the external temperature to avoid exposing the timber to thermal shock.
26. After the initial programming, all drying stages are automatically defined by the PLC.
27. After the period of cooling and conditioning the wood, the dryer stops and the door can be opened to remove the car with dry wood.
28. To open the door, the air-inlet ball valve (6) located in the door of the dryer must be opened (Fig. 8.1.1).
29. If connected to an external computer, we recommend sending us the different "data" detected apart from the drying curve.
30. The corrections in successive cycles will be made on the basis of the first results until the ideal cycle is achieved (depending on the wood type and local conditions of heating and stacking).

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31. If monitoring only with the PLC, we advise you to collect data three times per day during the first cycles.

SEQUENCE OF OPERATIONS FOR A THERMOVACUUM CYCLE.

1. Open the door (1) of the THERMOVACUUM after unscrewing the two handwheels (2) that lock the door.
2. Disconnect the humidity sensors (sensors connectors positioned at the entrance of the cell).

FIGURE 8.2.1

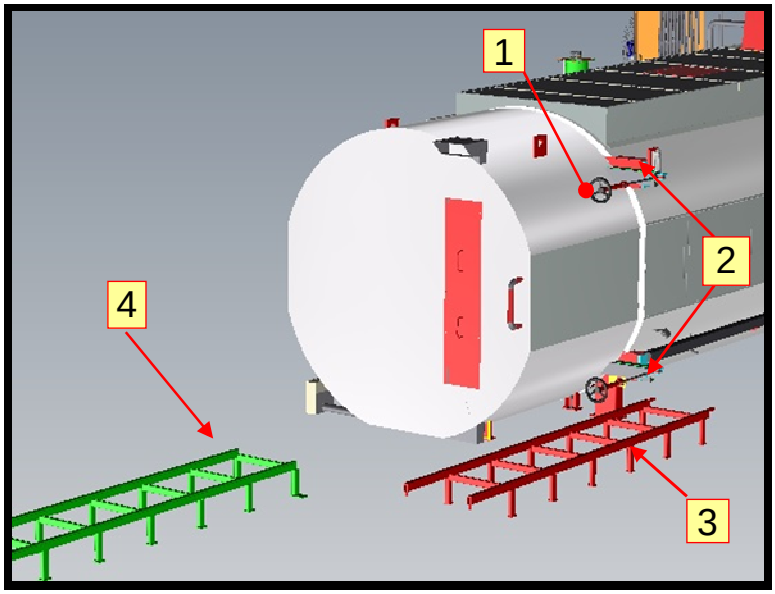
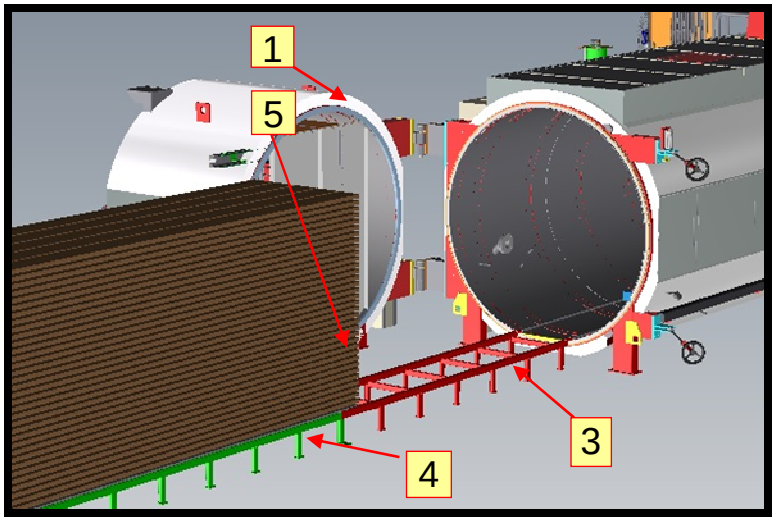


FIGURE 8.2.2



3. Place the bridge (3) between the cell and the external rails (4).
4. Remove the wood-charging car (5) from the cell.
5. Load the pile of wood for drying onto the cars.
6. Carefully read and use the "PRACTICAL ADVICE FOR DRYING" in Section 11.
7. The wood should be stacked according to the rules for good stacking, i.e.:
    - thickness of the sticks
    - spacing of the sticks
    - alignment of the sticks
8. The quality and speed of drying depend mainly on compliance with these conditions.
   For this reason, users are advised to follow the rules for good stacking (Items 8-9-10-11-12).
9. Thickness of the sticks:

THICKNESS OF THE WOOD	THICKNESS OF THE STICKS
18–40 mm	20 mm
40–60 mm	20–25 mm
60–90 mm	25–30 mm
>90 mm	30–40 mm

10. The spacing of the sticks depends on the thickness of the wood:

THICKNESS OF THE WOOD	Spacing of the sticks
18–30 mm	50 cm
30–50 mm	70 cm
50–80 mm	100 cm
>80 mm	120 cm

11. To avoid deformations of the wood, the sticks must be vertically aligned.
12. To avoid cracking at the bottom of the planks, the stick must be placed starting at the start of the stack of wood.
13. To avoid staining the wood, the sticks must be of a white wood.
14. Check that the initial wood moisture content is close to "zero".
15. The piles of wood must be placed in the chamber so as to avoid empty spaces where air and/or gas can easily pass without being forced through the piles of wood. This is of fundamental importance to achieve adequate drying, to prevent temperature differences between the wooden planks during thermal treatment and, finally, for cooling all of the wood, even in the centre of the stack, at the end of cycle to avoid a wood fire when the cell door is opened (read Section 14 carefully).
16. Do not forget to place the sensors for measuring temperature at the centre of the wood.

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17. Push the cars (5) into the dryer, remove the bridge (3) and close the door (1) by turning the handwheels (2).
18. Turn on the power of the electrical cabinet at the main switch and select the heat-treatment program on the PLC touch screen according to the type and thickness of the loaded wood and the desired final characteristics.
19. The vacuum pump (18) and heating (19) selectors must be in the YES position, while the antifreeze (20) selector should remain in position NO (see Figure 8.2.1).
20. A complete heat-treatment cycle consists of three phases:

- PREHEATING THE WOOD
- HEAT TREATMENT OF THE WOOD
- COOLING THE WOOD

After all data has been entered, the PLC system executes the heat-treatment cycle automatically.

21. In the first preheating phase (PH0), the PLC takes the wood to the programmed treatment temperature, during which time only the heating system can operate (possibly with the application of a pre-vacuum).
22. The preheating phase consists of two periods:

- The first period of increasing temperature according to a configuration chosen by the operator;
- The second period of heating to the inside, according to the time determined by the operator (typically 1 hour for each centimetre of thickness of the wood).

23. During the following treatment stages (from PH1 to PH3), the PLC system controls the vacuum pump to reach the programmed vacuum value and activates the fans so as to maintain the set temperature. The PLC system alters the values of pressure and temperature within the cell according to the duration of the different phases stored in the program.
24. At the end of the time for Phase 3, the PLC system switches to the final cooling stage. During this phase, the heating system of the dryer is stopped, while the fans in the cell and the cooling fan of the double wall keep turning and the vacuum is maintained at the same value as in the previous stage. The duration of cooling is determined by the PLC, which completes the cycle when the air temperature within the cell reaches 80°C.
25. After the initial programming, all treatment stages are automatically defined by the PLC.
26. After the period of cooling and conditioning the wood, the dryer stops and the door can be opened to remove the car with dry wood.
27. To open the door, it is necessary to wait until the air pressure within the cell reaches the ambient pressure by use of the pneumatic vacuum release valve (6), (Fig. 8.1.1) and the opening safety system (Fig. 8.1.2) allows the door to open.
28. If connected to an external computer, we recommend sending us the different "data" detected apart from the drying curve.

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29. The corrections in successive cycles will be made on the basis of the first results until the ideal cycle is achieved (depending on the wood type and local conditions of heating and stacking).
30. If monitoring only with the PLC, we advise you to collect data three times per day during the first cycles.

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Pratical Advice for drying

WOOD FAMILIES

The different species of wood can be divided into three families:

- **FAMILY A:** very hard wood
- **FAMILY B:** hardwood
- **FAMILY C:** softwood

Each of these 3 families of wood has drying limits with regard to the thickness and initial moisture, according to Table 11.1.

TABLE 11.1

	THICKNESS OF THE WOOD	MAX. INITIAL MOISTURE CONTENT
FAMILY A:	20–30 mm	32–35%
	30–50 mm	30–32%
	>50 mm	25–30%
FAMILY B:	20–40 mm	40–50%
	40–60 mm	35–40%
	>60 mm	30–35%
FAMILY C:	20–60 mm	green
	>60 mm	50–60%

- ***UNIFORMITY OF THE WOOD LOAD***

To avoid differences in final moisture content of the wood and/or other defects, you must load the dryer with homogeneous wood, i.e., of the same type, the same thickness and the same initial moisture content.

- ***STACKING AND STORING WOOD***

The quality and speed of drying depend mainly on compliance with the rules for good stacking, i.e.:

a. thickness of the sticks
b. spacing of the sticks
c. alignment of the sticks

For this reason, we recommend the user to observe the following rules:

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a) Thickness of the sticks:

THICKNESS OF THE WOOD	THICKNESS OF THE STICKS
18–40 mm	20 mm
40–60 mm	20–25 mm
60–90 mm	25–30 mm
>90 mm	30–40 mm

b) The spacing of the sticks depends on the thickness of the wood:

18–30 mm	=>	50 cm
30–50 mm	=>	70 cm
50–80 mm	=>	100 cm
>80 mm	=>	120 cm

c) To avoid deformations of the wood, the sticks must be vertically aligned.

d) To avoid cracking at the bottom of the planks, the stick must be placed starting at the start of the stack of wood.

LOADING THE STACKS OF WOOD INTO THE DRYING CHAMBER.

- ***How to load the stacks without voids.***

The piles of wood must be placed in the chamber so as to avoid empty spaces where air and/or gas can easily pass without being forced through the piles of wood. This is of fundamental importance to achieve adequate drying, to prevent temperature differences between the wooden planks during thermal treatment and, finally, for cooling all of the wood, even in the centre of the stack, at the end of cycle to avoid a wood fire when the cell door is opened.

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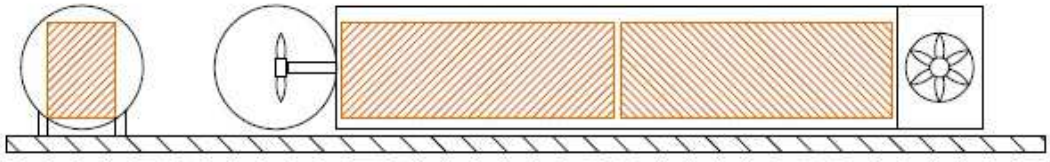

Fig. A — ***NOTE:*** **The stacks are well loaded!**

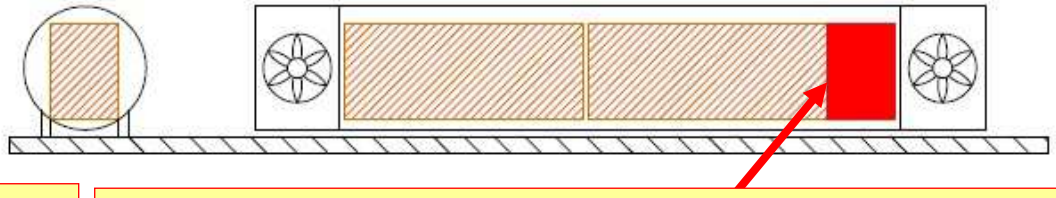

Fig. B — ***ATTENTION:*** You need to fill the voids with other woods

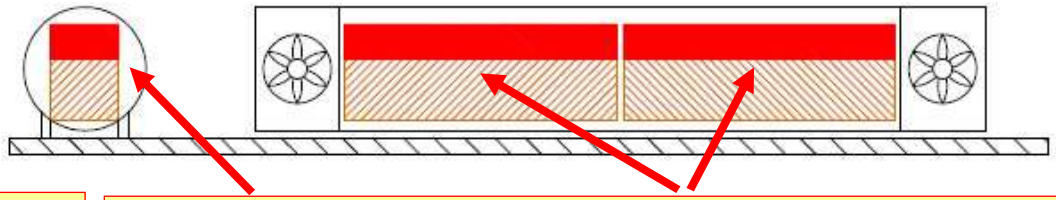

Fig. C — ***ATTENTION:*** You need to fill the voids with other woods

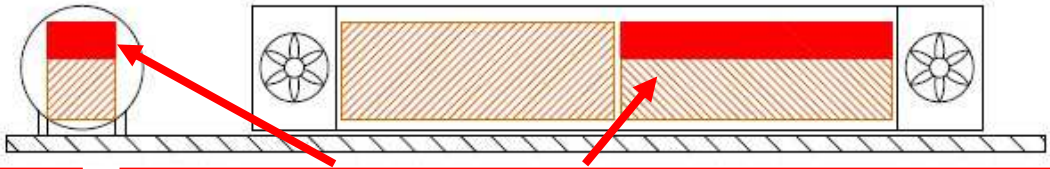

Fig. D — ***ATTENTION:*** You need to fill the voids with other woods

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- ***How to charge the stacks for the best reading of the cell temperature.***

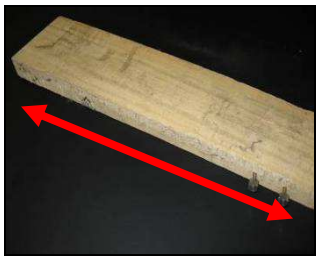
As the air-temperature sensors are placed at the sides of the cell near the door, it is necessary that the first stack is placed as close as possible to the mouth of the machine (see Fig. B).

- ***POSITIONING OF THE MOISTURE SENSORS.***

The 3 moisture sensors (each consisting of two nails) must be placed in the middle of a stack of wood in 3 different boards chosen as indicators of drying because they are the dampest and most difficult to dry.

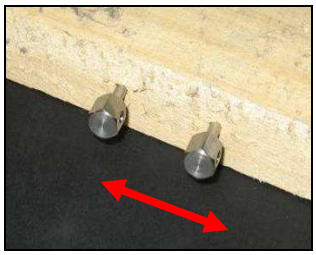
The nails must be positioned on the **side edges** of the boards in 4-mm-diameter holes with a gap of 40 mm between the two nails.

The minimum distance between the sensors and the ends of the boards is 40 centimetres.



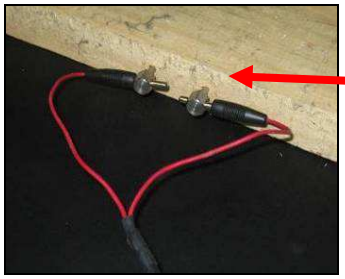
ATTENTION

The minimum distance between the sensors and the ends of the boards is 40 centimetres.



ATTENTION

- The gap between the nails is 40 mm.
- The diameter of the holes is 4 mm.
- Position the axes of the mounting holes of the banana jacks horizontally to avoid interference with the wood.



ATTENTION

Position the banana jacks with the axes horizontal.
The positioning of the electrical cables of the moisture sensors must be done carefully to avoid faults and/or cuts.

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VACWOOD® wood innovation

The manufacturing of VacWood® relies on the use of high temperatures in a under vacuum environment, without any chemical additives. This process improves many wood features:

- Resistance to biological agents,
- The resistance to atmospheric agents,
- The dimensional stability
- The 'thermal insulation
- A pleasant odour of the product
- The mechanical strength, very close to that of a natural wood
- The reduced moisture content and wettability
- The uniform colour for the entire thickness of the wood
- The compatibility with the environment of a 100% natural product and free of pollutants

The Thermovacuum process has other positives features:

- Very low energy consumption

- Emission of VOC - volatile organic compound – very close to that of natural wood

- No leakage into the surrounding environment

The wood treatment process, patented by WDE Maspell, take place in a single machine for all process stages.

The three stages are:

DRYING:

The wood is properly dried until it contains an extremely low moisture content, close to 0%, using a vacuum drying process within a superheated steam atmosphere in order to guarantee the quickest and most effective drying, without stressing the woody matter.

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HIGH TEMPERATURE:

During the thermal vacuum treatment stage, the temperature is raised up between 170°C and 210°C, depending on wood type and expected result; wood stays in this condition for between two to four hours.

Thanks to the continuous extraction of the internal atmosphere by an innovative vacuum pump system, the emissions of the gases produced by the wood are condensed, diluted and stored without any risk to the environment.

The cooling period follows, whereby an air-air heat exchanger is used, down to a temperature of 90°C, without the addition of coolants or direct contact with the atmosphere.

CONDITIONING

Starting from the pre-existing under-vacuum values, the conditioning stage consists of increasing the pressure within the cell using the steam produced by atmospheric pressure. This process allows the wood, which is practically anhydrous, to regain an equilibrium moisture content of approximately 4%, thereby avoiding the stress of atmospheric contact.

TREATMENT CATEGORIES AND WOOD SPECIES

Currently the VacWood® brand applies to 7 wood species: SILVER FIR, SPRUCE, MARITIME PINE, ASH, BEECH, POPLAR and OAK

There are three treatment categories, which have been designed to guarantee the performance of the wood in line with the chemical and physical changes achieved due to the rising temperature that is applied. Each category foreseen a different treatment for various wood thickness, up to 22 mm and 33 mm.

VacWood® – C (COLOUR)

The maximum treatment temperature is 170°C, which guarantees that the wood becomes a darker colour compared to untreated wood, giving it a more attractive appearance and evening out the colouration in raw material which features differences between sapwood and heartwood.

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VacWood® – S (STABILITY)

The maximum treatment temperature is 190°C in order to achieve an even darker colour and greater dimensional stability. Ideal for uses that require the wood to be immobile (ex. flooring, internal doors and windows).

VacWood® – D (DURABILITY)

The maximum treatment temperature is 210°C in order to achieve an even darker colour and an improvement in durability class, which is defined as the resistance capacity of the woody matter against biodegradation (fungus, mould) and is linked to classes of risk that determine the particular exposure conditions (outdoors, in contact with ground, etc.) in which we can use the wood. This, therefore, opens up the option of using species that undergo rapid biodegradation in environments that were previously risky for them, thereby allowing less valuable forest resources to be used, yet ones which grow quicker, in an exponential way.

The physical properties of VacWood® include

Loss of mass is the best indicator and guarantee of treatment intensity and is closely linked to thermal degradation, which indicates the way in which the wood is changing its chemical structure via the partial evaporation of certain components.

Equilibrium moisture content and dimensional stability

The variation in the equilibrium moisture content of VacWood® correlates to the exposure temperature. Its value decreases, while maintaining this feature over time, in a range between 4% and 8%.

Colour The colour of VacWood® changes throughout the three treatment categories described previously. The higher the exposure temperature, the darker the wood becomes. The colour acquired by wood is uniform throughout its surface, inside and outside.

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Working with VAcwood® product certification

Subject and Definition

(1) Certification of product described in this document is the procedure needed to guarantee minimum performance quality and homogeneity requirements for thermally modified timber (TMT) produced by a VacWood® Producer. The Certification VacWood® Mark certifies the compliance with specific requirements of selected properties of TMT, which are tested by defined test methods developed during TV4Newood project.

(2) Subject of the Certification VacWood® Mark is thermally modified timber, according to the TERMOVUOTO technology. General definition of TV modified Timber is similar to the ones given in CEN/TS 15679:2007 for TMT (Thermally Modified Timber).

(3) According to CEN/TS 15679:2007, TMT is timber in which the chemical composition of wood substance (wood cell wall) and its physical properties are modified by exposure to both high temperatures – typically in the range between 160 °C - 230 °C – and condition of reduced oxygen availability. The wood is modified in such a way that at least some of the basic characteristics (properties) are permanently and throughout altered compared to untreated wood. TMT is generally characterised by darker colours, higher dimensional stability, lower equilibrium moisture content and increased resistance against wood-destroying fungi compared to untreated wood. Due to the thermal treatment, wood strength is generally decreasing with increasing treatment intensity. The properties of TMT can vary depending on the wood species, process type, treatment level and specific process conditions.

(4) VacWood® is a special case of TMT produced only with ThermoVacuum technology and following the ThermoVacuum process. The process is classified as dry process in an open system. The oxygen is substituted by vacuum and the heat transfer from the system to the wood is based on convection. The VacWood® is generally characterised by low ML (Mass Loss) and absence of odour.

(5) The Certification VacWood® basically refers to a specific VacWood® set defined by wood species, grading, manufacturer (plant facility), and process/temperature conditions (treatment level see § 4 point (5), which is usually available as a semi-finished product.

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(6) The Certification VacWood® guarantees the minimum performance and quality requirements and the expected level (within a given range of tolerance) of the modified technological properties (**MTP**) of the modified wood as determined in the D.4.3 Results of Laboratory Tests (**MEE, ASE, DL*, MOR, MOE**, **hardness, durability**). The **MTP** shall be valued in terms of variation with respect to an expected average value and range of variability.

Awarding and content

The Certification VacWood®Mark is awarded to products:

- which conform to the definition of VacWood® according to § 1;
- which essential properties have been tested according to recognised standards and test methods as defined in D.4.3 and D.2.10 Laboratory data sheet for each essence;
- which fulfill the requirements of the specifications as defined in D2.5 Manual for the standard production of treated wood for the certification procedure (§ 4 and § 6);
- which fulfill the criteria for wood quality and property values that are declared by the producer and have to be kept within defined ranges of tolerance.

(7) The mass loss (**ML**) is the main mandatory feature measured as proof of certification since it is easy to measure with reliable preciseness. It is stated (D. 4.3) that ML is the main indicator of the modification intensity since it is strongly correlated with all the modified technological properties (**MTP**), excepted durability and **Tpr** (maximum process temperature). **ML** is correlated to the **Tpr** but also with other process parameters such as **t** (exposure time to a given **Tpr**) in a way that a given **M**L can be achieved by the producer by various combinations of process parameters. Accordingly, the producers can independently manage the process parameters to reach a defined result (in term of Mass Loss) in the framework of only general guidelines and prescriptions. Only for **VacWood® – D** the observance of the **Tpr** is prescribed.

(8) The expected average **MTP** (and the range of expected variations) are certified on the base of the measured **ML** (and measured variation of **ML**). For VacWood®, **Tpr** record is needed as additional proof of certification.

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Classes of treatment and wood species

(9) Currently the VacWood® brand applies to the following wood species: **Silver Fir** (*Abies alba*), **Spruce** (*Picea abies*), **Maritime Pine** (*Pinus pinaster*), **Ash** (*Fraxinus* spp.), **Beech** (*Fagus sylvatica*), **Poplar** (*Populus* sp.) and **Oak** (*Quercus petrae*). All of the above species are expected to originate from Europe and are identified by the botanical name and the average basic density as indicated in the D.2.10. Genus *Populus* is expected to originate from France but the species are not identified. Correct identification of the treated wood species and provenience is important since the same commercial name often includes a variety of wood species from several proveniences, which may demand individual approach in the choice of technological parameters to avoid significant differences between the attended results.

(10) The quality of raw material is a fundamental prerequisite to produce a final certifiable product. The quality requirements of to the timber to be treated by TVW are deemed as fulfilled if:

- the sawn wood is free of pith
- at least 80 % of the assessed set are free of inner cracks

the set are used by at least 80 % of their length, i. e. they are free from end-to-end drying cracks in at least 80 % of their length (except micro-cracks).

(11) There are three treatment categories, which have been designed to guarantee the performance of the modified wood according to specific end uses and in line with the chemical and physical changes achieved due to different modification intensity applied. Each category foresees individual treatment for set thickness up to 33 mm.

VacWood® – C (COLOUR)
mainly for interior use. The thermal modification is intended to control the colour changes. No imposed property limits except ML, MC (Moisture Content) and in particular case, those relevant for a given end-use (e.g. hardness for flooring). Certification requisites: ML must range from low (around 2% depending on wood species) to severe. MC must be not lower than 4%. Certified MTP are according to the measured ML.

VacWood® – S (STABILITY)
for interior and exterior use, even in moderately wet conditions (hazard class 2 according to EN 335-1). A high dimensional stability (ASE) and low hygroscopicity (MEE) are crucial factors for final use (e.g. facades, external

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joineries, flooring, internal doors and windows). Imposed limits for ML, EMC, ASE, MC and those relevant for a given end-use.
Certification requisites: ML must range from moderate (around 6-8% depending on wood species) to severe and to achieve minimum MEE > 35%. MC must be not lower than 4%. Certified MTP are according to the measured ML.

VacWood® – D (DURABILITY)
for exterior use (hazard class 3 according to EN 335-1: wet conditions above ground). When at least durability class 3 (i.e. resistance against biodegradation according to the EN 350-1) is needed (e.g. decking, cladding, fences, and other items exposed above ground). Imposed limits for ML, MC, Tpr (maximum process temperature), durability and those relevant for a given end-use.
Certification requisites: ML must range from high (8-10 % depending on wood species) to severe. Tpr must be not lower than 212 °C. MC must be not lower than 3% and Certified MTP are according to the ML.

Vacwood® producers: procedures for the release of the Vacwood® mark

As described below, today VacWood® Mark is applicable by VacWood® Producers only on 7 wood species: Silver Fir, Spruce, Maritime Pine, Ash, Beech, Poplar and Oak.
VacWood® Producer can be enabled to produce one or more wood species.
VacWood® Producer is only the Subject that has a plant authorized producing VacWood®.
An initial "qualification visit" is due by the Certification Body to the VacWood® Producer.
The "qualification visit" will focus on the treated wood species and the procedures through which the treatment takes place (prescription), and also the guarantee of "repeatability" of treatments over time.

The result of the "qualification visit" will be send to VacWood® Techincal Committee.
In its initial phase the VacWood® Techincal Committee will be composed by: one member of WDE-Maspell, one member of CNR-IVALSA, one member of Conlegno.

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The release of VacWood® Mark to a VacWood® Producer will only happen by unanimous decision of all members of VacWood® Techincal Committee.

Conlegno takes care of the sending of the VacWood® License, and will also handle the management, promotion and protection of VacWood® Mark.

The VacWood® Mark with the initials of the State and progressive order as shown below

VacWood

IT - 001

must be applied to focus on each single element on which the treatment has taken place.

The VacWood® Producer shall have the obligation to keep records in a register of "loading and unloading treated wood".
In these records it should also be indicated, in addition to quantity and treated species, also the clients to which the product has been sold.
Such records may be requested at any time and viewed by the independent Certification Body.

The VacWood® Brand could be used by the VacWood® Producer also for marketing and/or promotional information (eg. brochures, fairs, etc ...).

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Vacwood® producers: procedures for the audits for the maintenance of the Vacwood® mark

The VacWood® Producer might be at any times verified by the independent Certification Body.
For the maintenance of the VacWood® Mark it is mandatory at least one planned audit yearly.
The controls will focus on: cubic meters treated, wood species, the "prescription", the loading and unloading registers, storage mode, etc ...
As an indication see the ANNEX 2 below.
The result of the "maintenance visit" will be send to the VacWood® Techincal Committee.
Following evaluation by the VacWood® "Technical Committee", Conlegno will notify to the VacWood® Producers the outcome of the audit and in case of failure to maintain the mark, the Certification Body will be in charge of the withdrawal of the VacWood® Mark.

ANNEX 1: Qualification visit check list

Qualification visit is carried out by one Inspector of the Certification Body. It takes place at the production site and lasts from the charge operation of the plant with raw material until the end of the reference thermal process (usually 2-3 days).
During the visit the inspector will check the conformity of the following elements:

1. **Production registers;**
2. **Plant and equipment**: entirety and functionality of the plant with special regards to the measuring system (temperature and pressure probes), control and recording system, safety devices, anti pollution devices and procedures;
3. Pre and post **production facilities** (storerooms, logistic, quality grading procedure...);
4. **Product conformity**: 30 boards among different species and class are sampled from the stock before the treatment. A sample 1 m long is cut from the selected boards. Samples are cut in two sub-samples and properly labelled. The weight of each sub-sample is measured and recorded. Half of the matched sub-samples are charged (equally distributed in the stack volume) in the stack. After the reference thermal treatment, the weight of each sub-sample is measured and recorded again. Data are collected together with the process diagram. A visual grading is performed by the Inspector together with the producer on the whole treated stack. All the

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samples are then transported to the Certification Laboratory where the **MC** and **ML** is calculated. At the Laboratory other parameters such as colour and NIR spectra are measured as well as visual qualitative parameters (internal checks, cracks, warpings). The examined samples are stored at the laboratory as references material. The results of all the above mentioned laboratory tests are ready within 3 days from the arrival of the material at the laboratory.

5. Extra laboratory tests on one ore more modified technological properties (**MTP**) can be measured on the reference laboratory in case of justified cause.

The same procedure as descibed above must be repeated for each species/class. It is possible to treat two or more species during a single reference thermal treatment.

ANNEX 2: Maintenence visit check list

Maintenence visit is focused on the constancy and repeatibility of production over time. Accordingly, **ML** and **MC** must be measured on material produced on a new reference thermal treatment. In order to keep low time and costs of the visit the preparation and weight of samples before the thermal treatment can be performed autonomosly by the producer. In this case the producer must be equipped with a certified balance. As alternative the certified balance can be provided by the Certification Body. In case of autonomous procedure the producer must ship the sample and transfer results to the laboratory.

In order to measure the variations of temperature, each producer should have in the plant certified probes. As alternative the certified probes can be provided as a service by WDE-Maspell.

Special attention must be also focused on the entirety and functionality of the safety and anti-pollution devices.

ANNEX 3: Procedure for new wood species and/or new MTP VacWood® certification

In the case that the producer want to:

- ✓ certify a new wood species;
- ✓ certify a higher thickness;
- ✓ certify a new Modified Technological properties not specified at the point 6 of §1 (example thermal conducivity for joinery end-use);
- ✓ verify or improve the certified MTP
- ✓ develop new products

new laboratory tests are required.

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In this case a new reference thermal treatment must be performed as described in ANNEX 1.
In addition an extra sampling of material (matched treated/untreated) from reference thermal treatment must be delivered to the laboratory for thr tests.

Alternatively the reference thermal treatment can be performed on small scale on the Piolot plant at IVALSA. In this last case the trasfereability of results is guaranteed and hence the qualification visit can be avoided.

After the conclusion of the tests the producers can achieve the new certification, and the new results become properties of the VacWood® mark which can extend the certification to other VacWood® producers.

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Table of expected ML and MTP for each species and category

		category		
		VacWood® – C	**VacWood® – S**	**VacWood® – S**
Spruce and Fir	***ML*** [%]	**1±0,1**	**2,1±0,2**	**6±0,6**
	DL*	-11±2	-20±3,7	-43±7,8
	MEE [%]	-10,9±4,4	-19,8±4,4	-30±4,4
	ASE r [%]	13±11,3	27,1±11,3	23,8±11,3
	ASE t [%]	13,7±11,3	48,6±11,3	44±11,3
	MOR [%]			
	Durability [class]	5	5	3
Maritime pine	***ML*** [%]	**1,9±0,5**	**3,4±0,9**	**5,2±0,8**
	DL*	-21,7±0,8	-27,2±1,2	-30,6±1,4
	MEE [%]	25,5±0,9	31,8±1,2	37,2±1,1
	ASE r [%]	31,7±4,4	31,9±4,8	38,7±6,5
	ASE t [%]	31,6±4,2	37,4±5,5	41,3±6,4
	MOR [%]	/	/	
	Durability [class]	/	/	
Ash	***ML*** [%]	**3,5±0,4**	**5,5±0,6**	**12,8±1,3**
	DL*	-18,6±2,37	-25,5±2,85	-37,5±2,41
	MEE [%]	29,8±1,9	41,2±3,6	50,2±1,3
	ASE r [%]	17,9±4,76	43,1±21,09	60,3±18,06
	ASE t [%]	23,1±4,5	33,3±8,1	59,1±8,9
	MOR [%]			
	Durability [class]	5	5	3
Beech	***ML*** [%]	**2,2±0,2**	**3,6±0,4**	**10,5±1,1**
	DL*	-20,4±2,50	-27,1±3,37	38±2,07
	MEE [%]	24,7±0,5	33,7±6,6	48,6±15,6
	ASE r [%]	0,6±	12,8±2,61	50,1±7,06
	ASE t [%]	20,8±2,1	26,5±2,7	58,4±6,9
	MOR [%]	n.d.	n.d.	
	Durability [class]	5	5	3
Poplar	***ML*** [%]	**3.0±0,5**	**5,6±0,6**	**8,1±0,4**
	DL*	-20±0,5	-27,1±0,7	-29,6±1,4
	MEE [%]	32,1±2	39,1±2,6	44,2±3,2
	ASE r [%]	30,3±6,4	41,3±10,4	44,4±10,8
	ASE t [%]	36,1±5,3	44,6±7,9	51,3±10,2
	MOR [%]	/	/	
	Durability [class]	5	/	0
Oak	***ML*** [%]	**0,9±0,1**	**1,5±0,2**	**2,4±0,2**
	DL*	-12±2,1	-17±3,0	-22±3,9
	MEE [%]	19,5±1,3		/
	ASE r [%]	36,5±11,08		/
	ASE t [%]	16,6±2,9		/
	MOR [%]	n.d.	n.d.	/
	Durability [class]	3	0	/

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Use of VacWood®

WORKING WITH VACWOOD®
VacWood® may be sawed and worked just in the same way as untreated wood.
Important: Working on VacWood® requires a bit more attention because the ThermoVacuum treated wood, compared to the raw one, tends to break more easily;
Very important: VacWood® in general and VacWood® wood planks shall be transported with a good protection in order to avoid any damage for example on the corners.

Sawing:
Any kind of tools can be used: saw, drill, plane etc; with very low efforts, the result is a smooth surface, ready to be transformed.
Important: Dust generation must be taken into account when working on VacWood®
VacWood® dust has a slightly smaller particle size than normal softwoods because that wood is particularly dry and can bother;
Important recommendation: please remember to saw VacWood® only if a good extraction system is working or in open air; please use always protective mask and glasses.

Planing:
Mechanical planing is easy and the final result more than acceptable even without sanding or smoothing the surfaces.
Important recommendation: please regulate the planing machine for hardwood species; the planing machine may crack the borders. The raw material after thermal processing may be convex and therefore the feed rollers should be adjusted accordingly to prevent the boards from splitting.
A normal hand planer may also be used, a bigger amount of dust may arise from this operation, therefore it is always advisable to use a protective mask and glasses.

Milling:
If VacWood® is intended to be milled, the blades should be in good and sharp condition to ensure good end results otherwise tearing may occur. A bigger chance of tearing may happen when the wood is milled across the grain. Highest risk of tearing normally happens at the start or at the end of the operation.
Important recommendation: processing must be pre-planned carefully: the best results are obtained when there is sufficient solid wood material behind the blade. The light, fine-grained saw dust is readily extracted with no adhesion to the cutter blades. Further due to

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the fine-grained saw dust, it is recommended to use a respiratory protection mask and glasses.

Sanding

Sanding is generally not needed when working on VacWood® because after planning the surface is usually already very smooth and does not need further treatment. However, if sanding need to be done, its required the same procedure as normal untreated wood. Moreover, thanks to the absence of resin, sanding papers generally last much longer than with normal wood. Attention must be paid to the thin dust which arises from the operation; it is recommended to use a respiratory protection mask and glasses.

Jointing

Nailing and screwing: The best results are reached with the use of pneumatic nailers; attention must be paid to the correct pressure and the nailer's drive length; nails should be fixed 1 cm deep.
The use of a standard hammer is not advisable because the wood might crack; the use of stainless steel nails is preferred in order to reduce the risk of discoloration of the wood because of the presence of rust.
A good result is offered also by galvanised nails especially when a topcoat is applied to the cladding; To prevent splitting, small oval-headed nails would be the most suitable.
Should screws be used, these ones need to be carefully screwed at the level of the wood's surface. Pre-drilling and countersinking is essential, just as when working with hardwood. Stainless steels screws with countersunk heads are most suitable in outdoor usage or other humid environments. For the best holding strength, coarse-thread screws perform best. Self-tapping screws can be used with VacWood® without pre-drilling.

Gluing: VacWood® has a lower capacity of absorbing water;
Please note that: the waterbased glue need to be pressed for more time.
For polyurethanes or resin-based adhesive the humidity of VacWood® need to be increase; VacWood® for special gluing need to be prepared before; please communicate the final use always to the producer.

Surface treatment

When used outdoors, VacWood® shall be treated with a protective paint because UV radiation from sunlight and weathering may affect the wood's colour and cause small cracks.
Discoloration may be avoided by treating the wood with pigment-base paint; the most suitable one is a transparent paint where brown pigments are added so that it very much looks like the original wood colour.

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Protective paints must in any case be applied on a regular base; pigment containing transparent surface treatment has a doubled or tripled maintenance interval in comparison to a treatment product without pigments.

Health and safety

Being a chemicals-free product, there are no big risks in working with VacWood® except the ones arising from the small dust, which may be in bigger amount compared to the normal untreated wood because of its higher dryness and lack of resin. Therefore the use of a protective mask when working, especially when sawing, planning and milling is highly recommended.

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