FINNISH ThermoWood ASSOCIATION

ThermoWood®
Manual on Surface Treatment

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1. GENERAL

This manual on surface treatment has been produced by the Finnish ThermoWood Association (FTWA).

The document is based on the experiences of ThermoWood® producers and on recommendations given by the manufacturers of coatings. The primary objective of the document is to provide all ThermoWood® users with some general guidelines on the use of finishes as well as feedback on good experiences so that the different properties of thermally modified wood can be put into best possible use. An additional objective is to further expand general awareness and use of ThermoWood®.

The structure, color and moisture of wood are changed as a result of the ThermoWood® process. Instructions given in this document can be applied to the surface treatment of thermally modified pine, spruce, birch, and aspen, which are the most widely-used tree species at the moment.

New substances and methods of surface treatment are developed constantly. This document has been drawn up according to the most up-to-date information available at present.

2. THERMOWOOD SURFACE TREATMENT

2.1. GENERAL

Surface treatment is necessary for both the protection and esthetic value of wood. It efficiently prevents wood from turning into a grayish color and slows down water absorption of the wood. In addition, it also curbs the growth of fungi that produce mold or blue stains. Thermally modified timber can be finished in the same manner as normal wood.

Thermally modified timber sustains its dimensions extremely well. In indoor use, this property can be put into good use, especially in the making of floors, furniture, and fixtures. It is easier to keep a surface clean when it has been finished.

Thermal modification increases the decay resistance of wood to such a degree that in theory, the installation direction of wood in façades should no longer make a relevant improvement to weathering. However, weather does still place a lot of strain on the mechanical durability of wood, and in practice, the installation of sapwood outwards has proved to be an essential and effective solution for improving the weathering abilities of wood.

When coating the surface of thermally modified timber, the following factors should be taken into consideration:

- the absorption of finishes is generally slower, and there are more variations in permeability in different parts of the wood
- in long-term use, there are clearly less cosmetic problems caused by resin, because a great percentage of resin has been removed during the thermal modification process. As a consequence, knots might not necessarily require special treatment when finishing a surface
- the improved dimensional stability of wood decreases peeling and cracking of the coating in changing conditions
- the cell tissue on the surface of thermally modified timber must be opened as usual before treatment in order to ensure and optimize fixing.

Thermal modification slows down the rotting, improves the ability to maintain its dimensions, and creates a dark-brown color on the surface of wood.

In some weather conditions, the color of thermally modified timber fades and turns gray. If the surface of the wood is not finished, it might crack in the same manner as the surface of normal wood. Cracking can, for instance, be triggered by water penetrating the wood through the cross-cut ends. It may also be a result of the ultraviolet radiation of the sun. This tends to produce micro cracks on the surface of wood. UV radiation also causes the color of wood to fade.

Thermally modified timber should be finished like untreated wood in order to prevent the color from fading and the surface from cracking.

Thermally modified timber is suitable material for doors, window frames, indoor upholstery, garden furniture, and other forms of environmental construction.

2.2. THE IMPACT OF SURFACE TREATMENT ON THE WEATHERING ABILITIES OF WOOD

Weather and biological damage are primarily responsible for changes in the consistency of wood. In terms of weather factors, the most adverse effects are created by sunlight and rain water when it is absorbed into the wood. Impurities spread around by the wind can sometimes emphasize existing problems. Ultraviolet radiation of the sun decomposes lignin which is a chemical compound that keeps the cell tissue of a tree together. As a result, the surface of the wood becomes softer, darker in color, and covered with down. In addition, intense sunshine also creates heat waves, especially on dark surfaces. Rainwater, on the other hand, causes movement and cracking when absorbed into the tree. Fungi that decompose the cell tissue of trees create the worst biological damage. Algae as well as fungi that produce mold and blue stains can also constitute cosmetic problems and make surface treatment of the wood more difficult.

Wood can be protected by both structural and chemical methods. The enhanced biological durability of thermally modified timber reduces the need for structural protection in the building of façades. **This manual does not encompass information about structural protection techniques. It is assumed that structural solutions have been realized case-specifically by taking into consideration a particular climate and area and by following regional construction regulations.**

Surface treatment can balance out and reduce the moisture of wood which results in less splitting and cracking. Further precautions involve protecting the wood from rain and sunlight. This minimizes surface erosion (soft spots, down, brittleness, and wearing).

The purity of air and especially the acidity of rainwater in some climates and regions should be taken into consideration during surface treatment.

Environmental conditions cause variations to the durability of paint. Even the direction in which the wood is facing can make a difference.

2.3. THE EFFECTS AND REQUIREMENTS OF DIFFERENT CLIMATE TYPES

Different climates set distinct requirements for the durability of finished wood. Painted wood weathers better in some environments and temperatures than in others. In order to ensure maximum durability in a specific climate, it is essential to combine the right surface treatment products with an appropriate method of treatment.

While assessing the impacts of environmental stress, the following factors should be taken in to account:

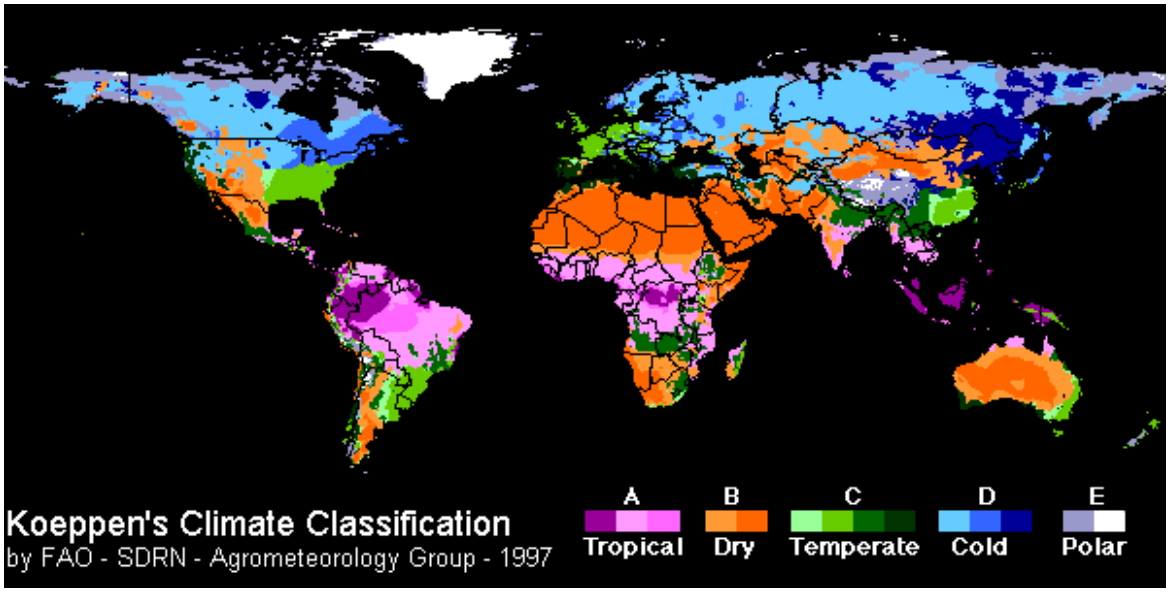
1. how climate affects the weathering abilities of wood and finishes

2. continental/marine climate and its impact on weathering

3. the significance of the local climate
   - the location of the building/the significance of the local environment (sloping rain)
   - which direction the building is facing
   - the significance of the structural particularities of each building

4. possibilities that arise with surface treatment and alternative methods of protection

Climate classification according to Koeppen



The table on environmental stress factor indexes in different climates (below) records the following stress factors and their definitions:

- Moisture refers to the relative humidity of the air and to annual changes in moisture. The table portrays how these affect wood and the method of surface treatment

- Weathering refers to strains caused by a regional climate. It indicates the effects that ultraviolet radiation, sunshine (number of hours per annum), wind, and impurities of the air have on wood and the system of surface treatment. The table also takes into consideration the impact of seasonal changes and extreme weather conditions.

- Precipitation measures the quantity of rain or snow falling to the ground and how these affect wood and the surface treatment system.

- The column ‘organisms’ refers to the total number of organisms that live in a particular climate and that are responsible for decaying wood. The table measures their impact on wood and on the surface treatment system.

Notes

- no impact

\+ a minimal effect

++ a relatively substantial effect

+++ severe stress

Climate type		*Environmental stress to wood and coating*				
		Temperature	*Relative humidity RH*	*Weathering*	*Precipitation*	*Organisms*
Af	Hot and wet year round	++	+++	++	++	+++
Aw	Hot wet summer, hot dry winter	++	++	++	++	++
BSh	Hot year round, unreliable precipitation	++	++	++	++	++
BWh	Hot and dry year round	++	+	+++	+	+
BSk	Hot summer, cool to cold winter, unreliable precipitation	++	++	++	++	++
BWk	Hot summer, cool to cold winter, dry year round	++	+	++	+	+
Cf	Warm to hot wet summer, cool wet winter	++	++	++	++	+++
Cs	Hot dry summer, cool wet winter	++	++	++	++	++
Cw	Warm to hot wet summer, cool dry winter	++	++	++	++	++
Dfa	Hot wet summer, cool to cold wet winter	+++	+++	++	+++	+++
Dfb	Warm wet summer, cold wet winter	++	++	++	++	+
Dfc	Cool to warm summer, very cold winter, some precipitation year round	+++	+	++	++	+
Dfd	Cool to warm summer, very cold winter, some precipitation year round	++	+	++	+	+
Dw	Cool to warm wet summer, cool to cold dry winter	++	+	++	+	+
Et	Cool summer, cold winter, little precipitation	+	-	+	-	-
Ef	Ice cap	+	-	++	-	-
H	Highlands, various local climates	Not ranked				

2.4. PROPERTIES OF WOOD THAT ARE ENHANCED BY SURFACE TREATMENT

THERMALLY MODIFIED TIMBER AS A BASE FOR COATINGS

Thermal modification changes the properties of wood. This should be taken into account when choosing the method of surface treatment. Changes in the structure of wood reflect on surface treatment in the following ways:

- The wood reacts less easily to changes in moisture. This relieves the amount of strain inflicted on the finish
- Almost all resin has been removed from the wood. Knots do not require special treatment in order to prevent the leaking of resin
- The permeability of the surface of wood has changed. By and large, research has indicated a growth in the contact angle of liquids. As a result, the liquids do not spread onto the surface that easily and wood does not wet as much as normal wood. In practice the permeability degreases, but the variation of the individual piece has also been changed.

DECAY RESISTANCE

The surface of wood is finished in order to protect the wood from moisture. Moisture fosters the growth of mold and fungi. Surface treatment prevents the absorption of moisture into wood and thus creates less favorable conditions for fungi to grow in.

The air is full of fungi spores that produce mold, decay, and blue stains. These spores are microscopically small; their diameter is only a few micrometers. They are carried around with air currents, and when they fall down on damp wood, they start to grow a threadlike mycelium of fungus. The moisture and temperature of both the air and the surface, the acidity of the surface, and the amount of dirt on the surface all have an impact on the reproductive abilities of fungi. The most favorable growing conditions for spores and mycelium are when the relative humidity of the air is over 95 % and the temperature is between +20 °C and +30 °C.

Mold and decay are generally caused by excessive moisture in structures, impurities of the air, and by the availability of nutrients in the habitat of a tree.

MOLD AND ALGAE

Damage created by mold, blue stain and algae is primarily esthetical. They stain wood and make painting it more difficult. Mold fungi do not affect the strength properties of wood.

There are several species of mold. One of the most common species is black spot mold which can be clearly distinguished, especially from a light-colored surface, due to its dark color. This fungus grows on the surface of wood and, as mentioned above, only creates esthetical damage.

Mold fungi obtain nutrients from their habitat. Their primary nutrition on the surface of wood consists of water-soluble sugars and other organic matter in the wood. Thermal modification changes the structure of wood, and as a result, there are less suitable nutrients for the mold fungi to feed on. In addition, the acidic nature of thermally modified wood reduces the successful growth of mold.

Moisture and adequate warmth are prerequisites for the survival of mold and algae. Growth already begins in a temperature of +5 °C and accelerates as the temperature rises. The growth rate reaches its peak between +20 °C and +25 °C. When temperatures rise over +40 °C, growth stops almost entirely. A porous surface absorbs more moisture than a smooth one and thus also gets moldy more easily. Cracks in wood that absorb moisture and attract dirt are usually ideal spots for mold growth. From such places, mold gradually spreads into the environment.

Blue stain can be seen especially in wood that has not been painted. They grow into the wood and somewhat affect the wood itself; however they do not weaken the durability of wood, like decaying fungi. Both the mycelium and the spores are capable of staining. If one paints over the blue stains, the fungus can grow through the layer of paint.

Mold is caused by the surrounding vegetation and by other environmental and climatic factors. Even the direction in which the structures are facing can make a difference.

In order to prevent the growth of mold and fungi, it is essential to keep the moisture of wood below the levels required by fungi for reproduction.

PERMANENCE OF THE COLOR

Ultraviolet radiation of the sun changes the color of unfinished wood quickly. Visible changes can be detected already after a few weeks. Ultraviolet radiation decomposes lignin which (as mentioned at the top of page 4) is a chemical compound that keeps the cell tissue of a tree together. A longer period of exposure to UV radiation results in the decomposition of cellulose which is a common material in plant cell walls. Consequently, the surface of wood becomes softer and weaker. In a year, 0,01- 0,1 mm of an unfinished wooden surface turns gray and rougher.

A wooden surface affected by UV radiation is a poor base for surface treatment; thus it must be removed carefully. If this procedure is not done, paint and other coatings that protect wood will not stick to the surface properly and therefore will not last as long as they should. A new surface treatment will have to be performed prematurely.

The color of thermally modified, unfinished timber changes significantly in a short period of time as a result of ultraviolet radiation of the sun. Pigmented translucent wood stains protect thermally modified wood from UV radiation

better than transparent substances. The end result is also very similar to the original color of thermally modified wood. On terraces, it is not recommended to use varnish or any kind of wood preservative that creates a thick film on the surface because this coating might start to peel off due to changes in moisture.

Opaque paint gives thermally modified wood the best protection. The more pigment the finish contains, the longer it lasts. The only disadvantage with opaque paint is the fact that when the natural color of wood is covered, it is more laborious and time-consuming to carry out maintenance treatments.

The need for maintenance treatments is determined by the manufacturer's guidelines and recommendations. At the latest, a treatment must be performed when the finish starts to wear off and the first visible signs of weathering and environmental stress appear on the wood. The durability of a treatment varies according to two factors: the end use of the finished good and the coating that is used to protect the wood. Some wood stains have a more long-lasting effect than others. Treatment intervals can range from a few months to several years.

DIMENSIONAL STABILITY AND THE PREVENTION OF CRACKING

When unprotected wood gets wet and dries up again, it cracks. This is caused by the considerable, temporary differences in the moisture of the surface and the inner parts of the wood. Cracking can, for instance, be triggered by water penetrating the wood through the cross-cut ends.

By coating the surface of façades and other wooden structures exposed to the rain, it is possible to reduce changes in moisture and thus reduce cracking. It is also advisable to seal the cross-cut ends of thermally modified timber carefully.

MOISTURE RESISTANCE

The purpose of surface coating is to slow down the process of moisture penetrating wood from the outside.

Thermally modified timber does not absorb moisture from the air in the same manner as normal wood, and thus changes in its moisture take place more gradually. In addition, compared to normal wood, thermally modified wood has considerably lower equilibrium moisture content (level of moisture in a specific humidity).

As far as temporary differences in the moisture of wood are concerned, it is important to observe if the wood absorbs the moisture directly from the air or whether drops of water actually permeate the wood.

Thermal modification changes the cell structure of wood. The density of solid matter decreases significantly in comparison to normal wood. Yet the dimensions of the piece of wood do not diminish proportionately. As a

consequence, there is more “air” inside the wood. The implication of this is that water can move faster along the length of the wood than it can in untreated wood. The capillary movement of water along the length of the wood causes the ends to swell more than the middle, and in time cracks can be detected at the ends.

The principal solution for improving the water repellence of wood is to structurally prevent moisture from entering the wood through intersections. Secondarily, a finish should be used to protect the ends which are primarily exposed to moisture.

THE GROWTH OF ALGAE (PARTICULARLY IN A MARINE CLIMATE)

Algae can usually be found on surfaces that are in the close proximity of exuberant vegetation.

Algae are not funguses. Like all plants, they contain chlorophyll and use the sun energy to convert water and carbon dioxide into sugar that they can then use as a nutriment. Algae do not depend on obtaining nutriments from their environment. Green growth that appears on walls is usually a form of algae.

Algae can be removed from thermally modified wood mechanically by brushing and washing it off. Growth can also be curbed by applying a coating on the wood.

2.5. ESSENTIAL REQUIREMENTS FOR FINISHES

Finishing thermally modified wood is very similar to finishing normal kiln-dried wood. This means that any requirements that have been set for standard wood protection in a specific climate can usually be applied to thermally modified wood as well.

All stages of thermal modification are ecological, and the finished goods are safe, hygienic, and ecological, both in use and after. The manufacturers of ThermoWood® products insist that the use of thermally modified wood and all its applications are harmless for people, animals, plants, and the whole environment.

With ThermoWood®, it is recommended to use coatings that

- Meet the standards set out in the current and prospective (from 2007 onwards) legislation of the EU
- (outside the EU) at least meet national requirements
- Allow for the ThermoWood® product to be disposed of safely by burning. A finish that contains toxic substances that could dissolve from the ashes into the environment should not be used
- Do not exceed the indoors limits for VOC emissions

Oils

- water-dilutable
- must be well absorbed into thermally modified wood
- should form a water-repellent coat on the surface of wood

Paints

- standard requirements for primers
- standard requirements for paints

Varnishes (Especially Floor Varnishes)

- water-dilutable
- the wooden surface should be sanded to improve the fixing of the lacquer
- primer is flexible and durable
- before the top coats of varnish are applied, the wood is sanded again. This allows for the varnish to stick to the surface more firmly.
- the top coats of varnish protect the wood from wear in everyday use

Fixation

- preparation of the surface before surface treatment (opening of the cell tissue)

  The cell tissue should be opened so that finishes, such as paint, would stick to the surface firmly. This can be done by sanding, brushing, or fine-sawing the surface. The best results are achieved when the basic impregnant treatment is performed in an industrial environment.

Cleanliness of the Surface

- Surfaces must be clean. Impurities and dirt are removed already during the industrial process by planing, brushing, and sanding.

- The air is full of fungi spores that produce mold and decay. An effective finish should contain substances that prevent or reduce mold growth. Due to the considerable impact of weather conditions, one should always select a coating that takes regional climatic factors into account.

Treatment Conditions and the Moisture of Wood

- Seasonal changes in weather conditions (temperature, precipitation, length of the day, strength of the sun's radiation etc.) are quite substantial in many regions. The manufacturers of finishes have the most accurate knowledge of which product is most suitable for a specific climate and region.

- The hydroscopic properties of thermally modified wood are different to those of normal wood. Thermally modified wood absorbs moisture more gradually. It is, therefore, important to pay special attention to the absorption of the finish.

- Thermally modified wood reacts less to environmental and climatic effects than most normal tree species. Thus, it is less susceptible to swelling and shrinking but it is still advisable to use an elastic finish.

Porosity

- In order to maximize the lifespan of the wood and coating, it is necessary to select a finish that is breathable. The finish should create a porous film on the surface of the wood. This would then allow water and moisture to evaporate in different weather conditions.

Surface treatment requirements according to end use

- The properties of thermally modified wood are versatile. With the thermal modification classes, it is possible to highlight which qualities are particularly important with regard to a specific end use.

- The main emphasis in the Thermo-S treatment is the dimensional stability of wood and its ability to tolerate moisture. ThermoWood® that is modified to Thermo-S class is very well-suited for making floors, for instance.

  Floors

  Floor materials require specific surface treatment, for example varnishing, waxing, or oiling. The best method can be found by consulting the manufacturers of finishes.

  Saunas and Damp Areas

  Due to its hydrophobic (water and moisture repellent) properties, thermally modified wood is an excellent material for damp areas. It should be paired with a finish that emphasizes breathable, fixation, and odorless surface treatment.

  Outdoor Use

  A lot is demanded of finishes in outdoor use. Suitable substances must take into consideration and comply with practically all of the requirements set out below:
  - regional weather and environmental conditions
  - fixation
  - breathable
  - changes in the moisture of wood
  - elasticity

- ecological requirements

3. WATER- AND OIL-BASED FINISHES

Finishes are classified according to their water permeability and the quality/ durability of the cover that they provide. The following are examples of different classifications: pigmented wood stains, opaque wood stains, red ocher, opaque paints, dispersion paints, latex paints, oil paints, alkyd oil paints, and polyurethane paints. Follow-up inspections take into consideration which products and method of treatment have originally been used and how these have managed to offer protection against moisture, weathering (UV radiation), rain, and living organisms.

3.1. TRANSPARENT WOOD OILS AND WOOD STAINS

Transparent wood oils and wood stains do not prevent the color of thermally modified wood from fading in the sunlight. It is recommended to carry out surface treatment with such products that curb mold growth.

Maintenance treatments should be performed at least once or twice a year. Transparent finishes are ideal for this purpose. If, for instance, thermally modified garden furniture is kept under a cover away from direct sunlight and rain, transparent finishes provide a very good protection.

3.2. PIGMENTED TRANSLUCENT WOOD STAINS

Pigmented translucent wood stains protect thermally modified wood more effectively than transparent finishes. They also retain a color very similar to the natural color of wood after thermal modification. Varnishes or wood stains that form a film on the surface of the wood are not recommended for use on terrace floors. The film tends to peel due to changes in moisture.

3.3. OPAQUE PAINT

Opaque paint gives thermally modified wood the best protection, but the original color and properties of the wood do not stand out as conspicuously as before. Experts recommend that the wood should be treated with one layer of opaque paint before assembly but the finishing touch should only be provided after assembly. If a vegetable oil –based finish is applied on wood that is exposed to a whole range of different weather conditions, it is wise to select a

product that prevents or reduces mold growth. It is essential to the surface treatment of thermally modified wood to follow the instructions given out by the manufacturers of coatings.

3.4. MAINTENANCE TREATMENTS

It is worthwhile to check the condition of wooden surfaces annually. A defect or damage in the wood is usually a sign of structural weakness and this is a matter that should be addressed immediately. The extent of maintenance treatments varies greatly. Sometimes it is sufficient to simply wash the surface, if it is severely soiled or slightly moldy but the finish is still intact.

TREATMENT INTERVALS

Buildings, structures, and building materials that are primarily outdoors are very vulnerable to the effects of weathering and environmental stress. It is difficult to give generally applicable guidelines about when an outdoor surface requires another surface treatment.

It is usually suggested that a surface that has been protected with a translucent wood stain should be treated again in 2-5 years' time while treatment intervals for opaque products range from 8-12 years. However, even the direction in which the building is facing can make a huge difference to that assumption. Weather conditions can strain one wall of a building to such an extent that the supposed durability of the finish diminishes by several years. The other walls still remain solid for the estimated time frame. Before a new finish is applied, it is important to do the necessary preparations thoroughly, because they can have a critical impact on the final outcome.

REMOVING THE PREVIOUS FINISH

An old but intact finish does not need to be removed, it is merely enough to take off the dust and dirt. It is possible to use a brush to clean the rough, external surfaces of a building. Brushing removes dust and dirt that has stuck onto the wood and breaks the film that the previous finish created. This enables the new layer of finish to stick on much better. If one wishes to brush off an old layer of translucent wood stain with a wire brush, it is wise to move along the length of the wood grains.

If the old surface is entirely dilapidated or if there are several layers of paint on it, the finish/paint must be removed completely. Methods of removal vary according to the type of finish/paint that was used and according to the size and shape of the surface. The most typical method to remove paint off wooden surfaces is mechanical scraping.

Moldy surfaces should be washed with a hypochlorite solution, for example, before they can be repainted. The surface should then be rinsed thoroughly with clean water and left to dry before the new surface treatment.

4. SURFACE TREATMENT INSTRUCTIONS FOR DIFFERENT APPLICATIONS

Thermal modification improves the decay resistance and dimensional stability of wood and gives the surface its distinctive dark-brown color. Weather conditions make the color fade, and when unfinished, the surface might even crack. Cracking can, for instance, be triggered by water penetrating the wood through the cross-cut ends.

Thermally modified wood should always be treated with a pigmented finish if one wants to prevent the surface from cracking and the color from fading as a result of UV radiation. Generally, the pigmented finish slightly darkens the color of thermally modified wood.

In outdoor use, thermally modified wood is suitable material for windows, doors, claddings, terrace floors, garden furniture, and for other forms of environmental construction. For the construction of any of the above, thermally modified wood should be paired with a finish that is also intended for outdoor use. In addition, the wood should never come into contact with the ground or water.

In indoor use, it is possible to profit from the dimensional stability of thermally modified wood, especially in the making of upholstery and furniture. A suitable finish would also be intended for indoor use. It is easier to keep a surface clean when it has been finished.

Thermally modified wood can be finished in the same manner as normal wood. Instructions and recommendations (such as priming before painting and the protection of cross-cut ends) given for the surface treatment of normal wood thus apply to thermally modified wood as well. The finish should first be tested on a sample piece or small area in order to ensure the right outcome.

It is generally a good idea to treat the products once before assembly and once after so that the fixing points will also be protected. It is very important to protect the cross-cut ends, especially in outdoor use.

The more pigment the finish contains, the longer the treatment intervals are. Future treatments should always be performed with exactly the same finish that was used originally.

It is essential to the surface treatment of thermally modified wood to follow the instructions given out by the manufacturers of finishes. Recommendations about protection and desired conditions for treatment should also be taken into consideration. The surface should always be clean before a coating is applied.

The following instructions might be helpful in selecting the right finish. They are categorized according to the end use of thermally modified wood.

4.1. OUTDOOR FURNITURE

Outdoor furniture made of thermally modified wood can be treated with pigmented oil, wood stain, varnish, or opaque paint. It is wise to select a tinted product for the treatment of garden furniture, because color-free oils, translucent wood stains, or varnishes do not provide adequate protection against UV radiation. Oiled wood repels water and dirt. A follow-up treatment should be performed once or twice a year, and immediately when the surface absorbs water incredibly quickly. Oil is always the best choice for finishing a previously oiled surface.

4.2. PATIOS AND TERRACES

Translucent wood stains or oils that have been pigmented to match the natural color of ThermoWood® are well-suited for treating terrace boards made of thermally modified pine or spruce. It is crucial to seal and finish the ends of terrace boards to prevent moisture absorption. In order for the color to be as even as possible, one should only apply very thin layers of pigmented oil or wood stain. One should never allow the product to build up in puddles on the surface.

Oiled terraces must be treated annually. Oils are designed to repel water and dirt. Another treatment should be carried out as soon as the wood shows the first signs of serious moisture absorption. Oil is always the best choice for finishing a previously oiled surface.

Varnishes or wood stains that form a film on the surface of the wood should not be used on terrace floors. The film tends to peel due to changes in moisture.

4.3. SAUNAS

It is not necessary to finish ThermoWood® panels and seats of saunas. However, the finishing can be made like in saunas that are made of normal wood. The surfaces that are finished with products prepared for saunas are easier to keep clean. In case of finishing, it is recommended that cut surfaces of boards are carefully finished with the same substance as panels and seats.

The panels and seats of saunas can also be finished with absolute pure paraffin oil.

4.4. INDOOR UPHOLSTERY

Inside, it is not essential to protect thermally modified wood. Upholstery made of thermally modified pine, spruce, or deciduous trees can be finished with ordinary, non-specialist substances that are simply designed for indoor use. Possible methods of surface treatment include varnish, wax, and oil.

4.5. FLOORS

Floorboards made of thermally modified pine, spruce, or deciduous trees can be coated with finishes that have been designed for normal wood. Suitable methods of surface treatment include varnish, wax, and oil. These substances should always be used in accordance with the instructions given by their manufacturer. Equal attention should be paid to the instructions at the time of maintenance and follow-up treatments.

4.6. CLADDINGS

Outdoor panels made of thermally modified spruce or pine can be treated with normal finishes that are suitable for outdoor surfaces. Pigmented coatings protect the surface of wood from the aging effects of the sun. ThermoWood® is best matched with pigmented, translucent wood stains that are similar in color to its natural look. It is very important to remember to treat the ends of the panels as well.

The quality of the wooden surface before treatment tends to have an impact on the durability of the finish. If a surface is left rough like after planing, paint, for instance, does not stick onto it as well as it would onto a fine-sawn surface. Improved durability can be achieved by removing all dirt, dust, and loose bits of wood off the surface before treatment.

4.7. INDUSTRIAL SURFACE TREATMENT

Industrial surface treatment must always be performed according to guidelines given by the manufacturer of the finish.

Paint sticks on to thermally modified wood better if the surface is straight-planed, or in the case of springwood, if the surface is brushed. The surface must also be cleaned from all dirt, dust, and loose bits of wood before treatment. As a general rule, regardless of whether the wood is thermally modified or normal, one should always pay close attention to achieving the right conditions for surface treatment, such as the right temperature and moisture of the wood.

Oil-based finishes can be applied on ThermoWood® just as well as on normal wood. The benefits remain the same regardless of wood type. When using water-dilutable substances, however, one should always take into consideration that ThermoWood® absorbs water a lot more slowly than normal wood. Therefore, water-dilutable substances only work well when they dry slowly and have enough time to be absorbed.

UV-hardening paints and varnishes, as well as oils and waxes, have given good test results.

A fine-sawn ThermoWood surface can often absorb a primer better than a normal wooden surface.

5. RECOMMENDATIONS FROM THE MANUFACTURERS

5.1. TEKNOS

On the basis of research, we can recommend the following substances for the industrial surface treatment of heat-modified wood:

Terrace Boards

Oil Treatment
1 x Aquagrund 100 tinted to e.g. the natural color of thermally modified wood (TM-4532/99)
30-50 % of Teknol wood oil is mixed into the translucent Aquagrund color to give it a water repellent quality.

Oiled ThermoWood® must be treated with wood oil annually.

Outdoor Upholstery

Translucent Treatment
1 x Aquagrund 100 tinted to, for instance, hazel (TM-1701) or the natural color of thermally modified wood (TM-4532/99)

One treatment provides sufficient protection during transportation, storage, and assembly, but the wooden panels must be treated with a pigmented wood stain, for example Kuulto-Visa, within one year's time after the initial treatment.

1 x Aquagrund 100 tinted
1-2 x Aquatop 292 Varnish (tinted with 5 % of Aquagrund 100)

This method of treatment is suitable for finished goods.

Opaque Treatment
Primer: 1 x Teknol 881
The top coat of paint should be applied on the construction site one year after assembly, at the latest. Acrylic and oil paints are appropriate for this purpose.

Windows and Doors

Translucent Treatment
1 x Aquagrund 100 tinted to e.g. the natural color of thermally modified wood (TM 4532/99)
1-2 x Aquatop 292 Varnish (tinted with 5 % of Aquagrund 100)

Opaque Treatment
1 x Aquaprimer 290
1 x Aquatop 260 (paint)

Sauna Doors and Panels

These should be left untreated or alternatively, they can be treated with Sauna-Natura.

5.2. AKZO NOBEL

OK 21/08/2001

THE SURFACE TREATMENT OF THERMALLY MODIFIED CLADDING BOARDS

We recommend the following methods for thermally modified wood:

INDUSTRIAL PRODUCTS

Water Products

1. Basic treatment	Uppopohja VO	562-2606	transparent
OR alternatively			
1A. Basic treatment	Teollisuuskuullote VO	828-xxxx	transparent or tinted
2. Surface	Teollisuuskuullote VO	828-xxxx	tinted
OR alternatively			
2A. Surface	Superkryl	1983-9000	tinted

Solvents

3. Basic treatment	Uppopohja	980-9800	clear
4. Surface	Teollisuuskuullote	980-xxxx	tinted

The methods mentioned above are intended for industrial use and for the spray, rinse or dip technique. It is also possible to apply these finishes with a paintbrush, apart from Superkryl 1983-9000, which must be sprayed on the wood to create a thick, protective film.

COMMERCIAL PRODUCTS

Solvents

5. Basic treatment	Pinotex Base	982-1011	clear
6. Surface	Pinotex Classic	80-xxxx	tinted

PLEASE NOTE THE FOLLOWING:

We recommend that the surface of wood is treated prior to releasing the product for commercial use. This will prevent the color from fading and turning gray and protect the wood against any other strains before and after assembly.

At least the top coat of finish must contain some pigment in order to provide sufficient protection against UV radiation. A product intended for outdoor use should not be treated only with transparent finishes. It is possible to select the desired color from a variety of shades, including options that are very similar to the natural dark-brown color of thermally modified wood.

No specific guarantees can be given to the products because the manufacturer is unable to perform the treatment himself or even oversee the appropriate use of the products. The condition of surfaces should be checked at least every 1-2 years and where necessary, maintenance treatments should be carried out using the same products. The need for repairs and follow-up treatments varies greatly depending on local weather conditions.

AKZO NOBEL INDUSTRIAL COATINGS OY
Osmo Kinnanen

5.3. TIKKURILA

Instructions for painting new ThermoWood® surfaces outside

Outdoor Cladding Boards

Translucent treatment

- Prime with Valtti primer
- Treat the boards twice with tinted Valtti Akvacolor or with Valtti Color or 1-2 times with Valtti Color Satin.

Opaque Treatment

Pre-treatment

- Prime with Valtti primer.
- Protect all the nails and other parts that are likely to corrode with Rostex Super anti-corrosive primer.

Surface treatment

- a matte surface: treat twice with Pika-Teho
- a semi-matte surface: treat twice with Ultra, Vinha, or ValttiTeho
- a semi-glossy surface: treat twice with Teho Oil Paint

Window Frames and Front Doors (The External Surfaces)

Translucent Treatment

- Prime with Valtti primer
- Treat 1-2 times with tinted Valtti Akvacolor, Valtti Color, Valtti Color Satin, or Valtti Color Extra.

Opaque treatment

Pre-treatment

- Prime with Valtti primer.
- Protect all the nails and other parts that are likely to corrode with Rostex Super anti-corrosive primer.
- Prime with Teho Oil Paint or Teho Window Paint that has been diluted with 10% of Valtti primer.

Surface treatment

- Apply a layer of undiluted Teho Oil Paint on the surface for a semi-glossy look or Teho Window Paint for a hard glossy look.

OR

- After priming, apply two layers of ValttiTeho or Vinha paint only on the external surface in order to create a semi-matte surface.

Transparent or tinted varnish

- Prime with Valtti primer.
- For the lacquer, apply 1-2 layers of glossy Unica Super which has been diluted with approximately 20-40 % of white spirit 1050.

- For the top coat, use pure glossy or semi-glossy Unica Super varnish or alternatively dilute it with up to 20 % of white spirit 1050. Apply 1-2 coats as necessary.
  OR
- Use tinted semi-matte Unica Super, which has been diluted with approximately 5-10 % of white spirit, as the lacquer.
- For the top coat, simply apply 1-2 layers of semi-matte Unica Super.

Terrace floors, banisters, and outdoor furniture

Translucent treatment

- Prime with Valtti primer.
- Treat 1-2 times with tinted Valtti Akvacolor or Valtti Color.

Wood oil treatment

- Prime with Valtti primer.
- Spread 1-2 coats of Valtti Wood Oil or Valtti Wood Oil Akva on the surface.
- Wipe off the excess oil that has not been absorbed.

Before using any of these products, always read detailed instructions from the label and/or the product description inside the packet.

Further information and instructions on how to use these products can be obtained from the Tikkurila paint helpline, tel. +358 10 860 8600

5.4. SADOLIN & SIKKENS

SOLVENT-BASED PRODUCTS

Terrace boards

RECOMMENDED FINISHES FROM SADOLIN

Sadolin Classic: 2 treatments *(VOC classification very high)*
Sadolin Supercoat: 1 treatment *(VOC classification moderate)*
Sadolin Advanced: 1 treatment *(VOC classification moderate)*

RECOMMENDED FINISHES FROM SIKKENS

Sikkens Cetol HLS: 2 treatments *(VOC classification very high)*
Sikkens Cetol Novatech: 1 treatment *(VOC emissions are high but only 310 g/liter.)*

Depending on weather conditions and the particularities of the terrace, maintenance treatments may be required annually.

Claddings

RECOMMENDED FINISHES FROM SADOLIN

Sadolin Supercoat: 2 treatments *(VOC classification moderate)*
Sadolin Advanced: 1 treatment *(VOC classification moderate)*

Opaque Coatings
Sadolin Superdec: 2 treatments *(VOC classification low)*

The estimated life span of all these Sadolin finishes is 5-10 years depending on weather conditions, the particularities of the structure being treated, and the success of the initial surface treatment.

RECOMMENDED FINISHES FROM SIKKENS

Sikkens Cetol HLS: 3 treatments *(VOC classification very high)*
The estimated life span of this finish is 5-8 years depending on weather conditions and the particularities of the structure being treated.

Sikkens Cetol Novatech: 2 treatments *(VOC emissions are high but only 310 g/liter.)*

Opaque coatings
Sikkens Cetol BL Opaque: 2 treatments *(VOC classification low)*

The estimated life span of this finish is 5-10 years depending on weather conditions and the particularities of the structure being treated.

WATER-SOLUBLE PRODUCTS

RECOMMENDED FINISHES FROM SADOLIN

Sadolin Quick Drying Woodstain: 2 treatments *(VOC classification low)*
Sadolin "In the Garden" Smooth Timber Protection: 2 treatments *(VOC classification low)*

RECOMMENDED FINISHES FROM SIKKENS

Sikkens Cetol BL21 Plus: 2 treatments *(VOC classification moderate, 96 g/liter)*
Depending on weather conditions and the particularities of the structure being treated, maintenance treatments may be required annually.

Claddings

RECOMMENDED FINISHES FROM SADOLIN

Sadolin Quick Drying Woodstain: 2 treatments *(VOC classification low)*

Opaque coatings
Sadolin Superdec: 2 treatments *(VOC classification low)*
The estimated life span of this finish is 5-10 years depending on weather conditions and the particularities of the structure being treated.

RECOMMENDED FINISHES FROM SIKKENS

Sikkens Cetol BL 21: 1 base treatment followed by 2 treatments with Sikkens Cetol BL31 *(VOC classification moderate, 96 g/liter)*
The estimated life span of this method of surface treatment is 5-8 years depending on weather conditions and the particularities of the structure being treated.

Opaque coatings
Sikkens Cetol BL Opaque: 2 treatments *(VOC classification low)*
The estimated life span of this finish is 5-10 years depending on weather conditions and the particularities of the structure being treated.

Sprays for Outdoor claddings

SIKKENS JOINERY

Sikkens Cetol WP560: 1 treatment
Sikkens Cetol WF755: Treat the surface to a depth of 250-300 micrometers.

Both products are water-soluble, and their VOC classifications are low. Their estimated lifespan is 5-10 years depending on weather conditions and the particularities of the structure being treated.

6. FAQ

Frequently asked questions with their answers:

1. Can different tree species be modified thermally?

Nordic tree species, such as pine, spruce, birch, and aspen are suitable for thermal modification. In addition, at least a few hardwood species, for example beech, oak, and ash, can also be modified thermally.

2. How long does the ThermoWood effect last?

Although there is no long-term evidence of the durability of the ThermoWood effect, because the product is new, tests have indicated that the decay resistance of thermally modified wood is far better than that of normal coniferous trees or of several corresponding tropical deciduous trees. Great dimensional stability also increases the lifespan of ThermoWood products. Several other factors, such as frequent follow-ups for surface treatment, damage control, and general maintenance, can help keep thermally modified wood in good condition. Following the instructions in this manual also increases the expected lifetime of the product.

3. What guarantees does the product have?

The guarantee should be determined on the basis of the ThermoWood end product and its uses. It is difficult to give a general guarantee for ThermoWood itself. The conditions that ThermoWood is subject to when used in damp rooms inside, such as saunas, are very different to conditions outside. Sauna boards must, therefore, have a different kind of guarantee than, for instance, garden furniture.

Although thermally modified wood itself does not have any specific guarantees, several independent research institutes have obtained consistent results on the biological durability of the product. According to their tests, thermally modified wood is clearly more durable than normal, untreated wood.

Long-term experiments have been used in the past to test the decay resistance and weathering abilities of thermally modified wood. These will continue to be used in the future in order to provide more accurate information.

4. Why is ThermoWood so durable even though resin and other extract substances have been removed?

The durability of ThermoWood derives from changes that take place in the chemical compounds of wood. The hemicelluloses (sugar compounds) of wood are decomposed, and thus fungi have no nutrients to feed on. In order to prosper and decay wood, fungi need the right temperature (at least 5 ºC), the right moisture of wood (over 20 %), and sugars. The moisture of thermally modified wood remains well below 20 % when the structures are in contact with the ground or even if the relative humidity of the air is 90 %. This prevents or at least significantly slows down the growth of fungi. In addition,

regular surface treatments with wood oil reduce the absorption of moisture into thermally modified wood.

5. Are any chemicals added during thermal modification?

No chemical additives are used during the ThermoWood process. Thermal modification operates entirely on energy and steam. At the end of its lifespan, ThermoWood can thus be put into alternative use or disposed of in the same manner as normal wood.

6. Can ThermoWood be used in contact with the ground?

Research has shown that ThermoWood does not decay even if it is in contact with the ground. Continuous contact with the ground or water does, however, produce chemical reactions that cause thermally modified wood to lose some of its strength. These mechanisms are not yet fully known, and further research is required. Thus, it is not recommended to subject ThermoWood to constant contact with damp ground.

7. What kind of surface treatment is required for outdoor use?

ThermoWood can be used outside without any surface treatment, but the appearance results are the same as with normal wood. The surface turns gray and starts to crack. The latest research and experience suggest that it is wise to treat the surface of thermally modified wood material as well as any coniferous or deciduous trees and hardwoods. Coatings protect wood from the adverse effects of UV radiation and problems caused by variations in moisture (cracking, changes in color etc.). The same products that are used on normal wood are suitable for ThermoWood. The right method of treatment can be determined according to the end use of the product. If a customer expects the product to ressemble the original dark-brown color of ThermoWood, the product should be treated with a translucent wood stain or oil that contains a dash of brown pigment.

If one wants to create a long-lasting surface, paint provides a good solution. The wood should first be primed. This should then be succeeded by the application of a few coats of paint. Lack of resin and minimal reactions to weather conditions allow the paint to stick to the surface of the ThermoWood.

8. Is the smell of ThermoWood harmful?

Tests have proved that ThermoWood does not emit any harmful substances or smells. However, some people might not be very fond of its smell.

9. Does the smell disappear over time?

If the surface of the ThermoWood product is finished, the smell disappears and does not come back. If, on the other hand, the product is used without surface treatment, the smell eventually disappears anyway and it cannot be perceived unless one sniffs the wood from a very close distance.

10. Is it possible to glue ThermoWood?

Practical experience has shown that all types of glue can be used on ThermoWood. If one wishes to use water-soluble glues, such as PVAc glue, it

is necessary to take into consideration that thermally modified wood absorbs water more slowly than normal wood. One must thus allow more time for the glue to dry. Especially in the case of PVAc glue, it is essential to always follow the manufacturer's guidelines on the appropriate use of the product.

11. Can ThermoWood be used in structures?

So far, the durability and strength of ThermoWood has mainly been tested on small, flawless sample pieces. In the future, tests must be extended to larger sample pieces as well as knotted wood. The impact of different types of knots and the number of knots must be examined. Due to insufficient information, at present we **DO NOT** recommend using ThermoWood in supporting structures.

12. How do the properties of heat-modified wood affect surface treatment?

A low equilibrium moisture content paired with the slow absorption of moisture increases the dimensional stability of wood. Moreover, heat-modified coniferous wood material does not contain any resin. This has all been removed from the wood during the heat-treatment process. Both of these properties allow for paint to stick to the surface better.

13. How can one prevent the color from fading?

If one wishes to preserve the natural dark-brown color of heat-modified wood, the wood should first be treated with a primer and then once or twice with a pigmented wood oil or wood stain. The same treatment should be carried out at regular intervals (usually every 1-2 years) depending on changes in the color. Several manufacturers of wood oils have specified the length of treatment intervals with respect to their products.

14. What kind of impact does UV radiation have?

The sun's UV radiation is incredibly strong on the surface of all types of wood. Treating wood with a pigmented wood oil or wood stain helps reduce the damaging effects of UV radiation.

15. How frequently do maintenance treatments need to be performed?

According to the most up-to-date information available at present, it is recommended to treat the surface of a terrace, for instance, every 1-2 years if the terrace has been oiled and one wish to preserve the original dark-brown color. In addition to preventing the color from fading, follow-up treatments protect the wood from water and thus cracking. However, wood oils and wood stains should not be spread on planed surfaces on the south- and west side of a house that are often exposed to sunlight. Translucent finishes can create a film on the surface of wood which can then start to peel in the sunlight. The length of treatment intervals varies greatly depending on how much the wood is subjected to rain and sunlight. Painted surfaces tend to last for a longer time.

16. How does moisture penetrate heat-treated wood and how does it leave?

As in the case of normal wood, water is primarily absorbed through the cross-cut ends of thermally modified wood as well. In order to prevent the absorption of water, it is therefore recommended to treat the cross-cut ends several times with wood oil or a wood stain. As a general rule, once a film has formed on the edge of the wood, one can rest assured that a sufficient number of treatments has been performed.

In comparison to normal wood, thermally modified wood absorbs remarkably less moisture in the form of water vapor. The hydroscopic equilibrium moisture content of thermally modified wood is 30-50 % lower than that of any other kind of wood, including impregnated wood. In a temperature of approximately 20 ºC when the relative humidity of the air is 60-70 %, the equilibrium moisture content of thermally modified wood is about 6-7 %. If the relative humidity rises to 80 %, the equilibrium moisture content of the wood is still only about 8 %. This considerably reduces movement caused by moisture and any damage that results from it.