



International Committee of the Decorative Laminates Industry

Technical Leaflet

General recommendations for working with decorative laminates

December 13, 2011

Preface

Decorative laminates according to EN 438 are an excellent material for indoor and outdoor surfaces. They can be used either applied to suitable substrates or as self-supporting compact sheets. Decorative laminates meet the stringent requirements for hygiene, fire resistance humidity resistance and mechanical properties. Decorative laminates are available in a variety of colours, patterns and surface textures, providing extensive options for architects and designers. Decorative laminate surfaces are hard and resistant to wear, impact and scratching, making them long lasting, easy to clean and largely resistant to vandalism.

In addition to their physical properties, decorative laminates offer other benefits including quick and easy installation of compact laminate panels, and in renovation applications using dry construction methods, elimination of the need to remove existing wall coverings such as wallpaper, textile coverings, or ceramic tiles. This technical leaflet contains general recommendations for the processing and handling of decorative laminates. In addition to this leaflet there are a number of other documents which provide detailed information about the topics described. This bulletin is intended as an overview for professionals working in the decorative laminates industry.

Our special thanks to Leitz GmbH & Co. KG, Oberkochen, for their support with the revision of chapter 3, as well as to Kleiberit Klebchemie M.G. Becker GmbH & Co. KG, for their support with the revised version of chapter 4.5. They have provided us with valuable information, technical data and drawings.

The leaflet represents the state of knowledge as of December, 2011.

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1. General information

Decorative laminates according to EN 438 are an excellent material for indoor and outdoor surfaces. They can be used either applied to suitable substrates or as self-supporting compact sheets. Decorative laminates meet the stringent requirements for hygiene, fire resistance, humidity resistance and mechanical properties.

Decorative laminates are available in a variety of colours, patterns and surface textures, providing extensive options for architects and designers. Decorative laminate surfaces are hard and resistant to wear, impact and scratching, making them long lasting, easy to clean and largely resistant to vandalism.

In addition to their physical properties, decorative laminates offer other benefits including quick and easy installation of compact laminate panels, and in renovation applications using dry construction methods, elimination of the need to remove existing wall coverings such as wallpaper, textile coverings, or ceramic tiles.

Decorative laminates are composed of paper layers which are impregnated with synthetic resins and fused together under elevated temperature and high pressure. The laminate structure contains a number of core paper layers typically impregnated with phenolic resin, with the number varying depending on the laminate thickness, and a surface layer typically consisting of a decorative paper impregnated with melamine resin. Printed decorative paper may also include a clear overlay paper to enhance abrasion resistance.

Typical structure of decorative laminates (figure 1, figure 2):

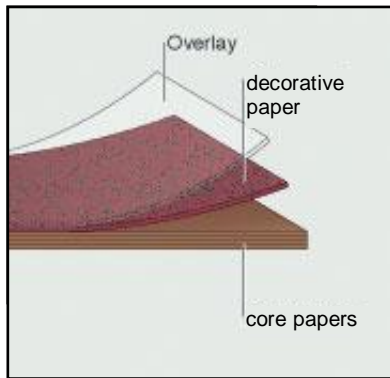


Figure 1: Laminate sheet

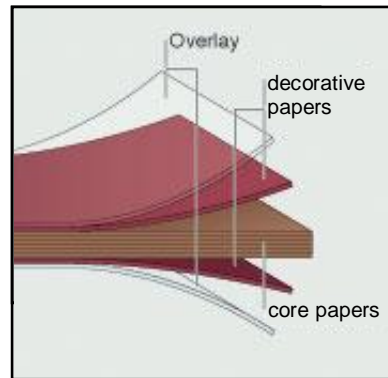


Figure 2: Compact sheet

Decorative laminates are grouped into the following types according to EN 438:

Type S (standard grade)

The characteristic properties of this grade are hard, virtually wear and scratch proof surfaces, high resistance to impact, insensitivity to boiling water and a number of typical household chemicals, as well as a pronounced resistance to dry and humid heat. The back side of decorative laminate is designed to allow defect free bonding to a substrate such as chipboard.

Type P (postforming grade)

This properties of this grade are generally equivalent to type S, but is capable of being postformed at fixed temperature conditions according to the manufacturers specifications.

Type F (fire-retardant grade)

The properties of this grade are generally equivalent to type S, but feature increased resistance to fire.

Note: National and international fire regulations must be followed.

The laminate type designations according to EN 438 are fully described in the technical leaflet "Manufacturing of decorative laminates".

Typical fields of application for decorative laminates

Decorative laminates are versatile and suitable for both indoor and outdoor applications. Examples include:

- furniture and interior finishes
- automotive industry
- commercial construction

A detailed overview of the varied applications can be found in the technical leaflet "Typical applications of decorative laminates".

2. Storage and handling

2.1 Storage

Decorative laminates should be stored so they are protected from moisture, humidity and direct sunlight. The sheets should be placed flat on a suitable horizontal surface (e.g. on a pallet with a backing plate). The stack should be held down with a heavy protective cover plate. If decorative laminates are supplied in film packaging, the film packaging should be re-closed and the cover plate replaced immediately after removing any sheets. If horizontal storage is not feasible, it is recommended that the material be stored at angle of approx. 80° with support over the entire area as well as a counterweight on the ground to prevent sliding (figure 3).

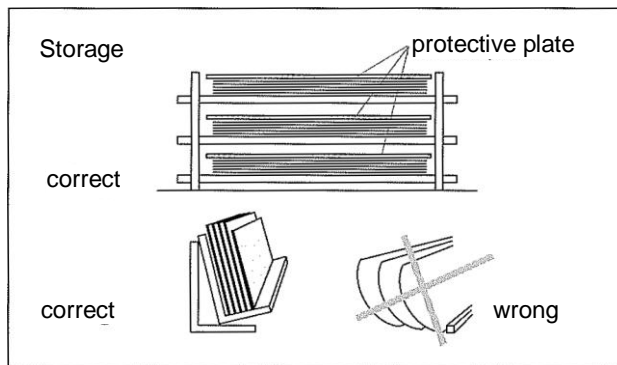


Figure 3: Correct storage of laminate sheets

2.2 Handling

When handling or moving decorative laminates it is important that the sheets be lifted above adjacent sheets to avoid damage that can occur if the sheets are pulled or slid against each other. For larger sizes it is recommended that sheets be carried arched along the longitudinal axis to prevent sagging (figure 4). Individual sheets can also be rolled up for easier handling (roll with the decorative side to the inside, making sure to avoid any side-to-side sliding motions). When moving stacked sheets with transport vehicles, large and sturdy pallets should be used, with the stacked sheets secured to prevent sliding.

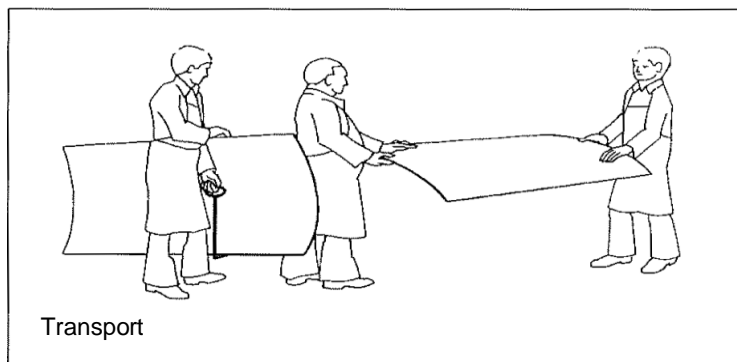


Figure 4: Correct handling of laminate

3. Machining decorative laminates

3.1 General information

All corner cutouts and inner cutouts on composite panels and compact sheets should be rounded (figure 5). The inner radius should be as large as possible: For cutouts up to 250 mm side length the corners must have a minimum radius of 6 mm.

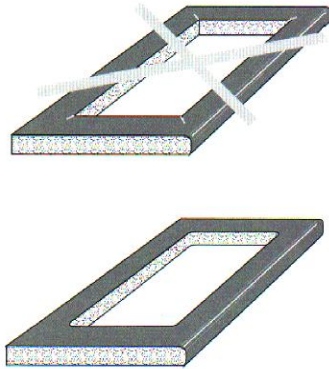


Figure 5: Inner cutout

3.1.1 Tools

The surface of decorative laminate consists of high-quality melamine resins, making it relatively hard. Tool wear will be greater than with most wood based products. Tools with tungsten carbide tipped (TCT) blades have performed adequately, with polycrystalline diamond blades (PCD) providing a more durable option.

3.1.2 Procedure

Machining of unbonded sheets should be carried out on a flat, solid surface. Avoid any vibration of the sheet. Sharp blades and smoothly running tools are essential for producing defect free machined edges. Breaking, splintering or bowing of the decorative side are the result of incorrect machining or improper tools. Any grooves created during machining can lead to the formation of cracks.

3.1.3 Base

Whenever a decorative surface has to be moved over the bearing surface for machining or vice versa, it is recommended to use a guide or base (e.g. chipboard) to move along with the decorative laminate. For machine tools it is also possible to use flat bearing surfaces with grooves, in order to keep the contact area with the decorative laminate as small as possible. No base is required for tables with air cushion supports.

3.2 Decorative laminates with and without substrates, cutting

3.2.1 Portable circular saws

Use a guide or stop bar to obtain straight cuts. Cutting must be performed with the laminate decorative side down to avoid chipping on the visible edge. Note the blade projection for portable circular saws with a plunge function (figure 6).

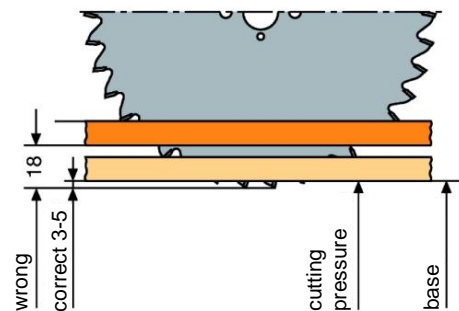


Figure 6: Correct blade projection for portable circular saws with plunge function (source: Leitz GmbH & Co. KG)

3.2.2 Compass saws

Compass saws are suitable only for rough cutting. Cutting must be performed with the laminate decorative side down to avoid chipping on the visible edge. A clean base (e.g. felt base) should be used to protect the visible decorative side from scratching.

3.2.3 Splitting with fixed circular saws and sliding table saws

The following should be observed for obtaining acceptable results:

- decorative side face up
- the quality of the cut edge depends on the height adjustment of the saw blade as well as the items mentioned below. The ideal height depends on the thickness of the decorative laminate and the circular saw blade (figure 7).

The decorative laminate should be placed flat on the cutting table and held down firmly in the region near the saw blade. A hold-down clamp or pressure bar should be used to prevent vibration of the laminate while being cut. Additional factors which can influence the quality of the cut edge include:

- blade height
- quality and condition of machine and circular saw blade
- tooth shape
- number of teeth
- cutting speed
- feed speed
- control of material vibration during cutting

Decorative laminates can also be cut in stacks.

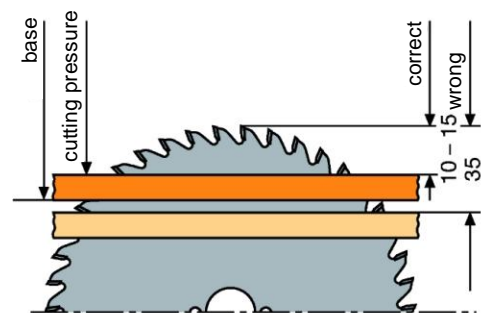


Figure 7: Correct saw blade projection for fixed circular saws and sliding table saws (source: Leitz GmbH & Co. KG)

The following tooth shapes are standard:

Flat top is the simplest tooth shape. It features ease of use and can be easily sharpened (figure 8).

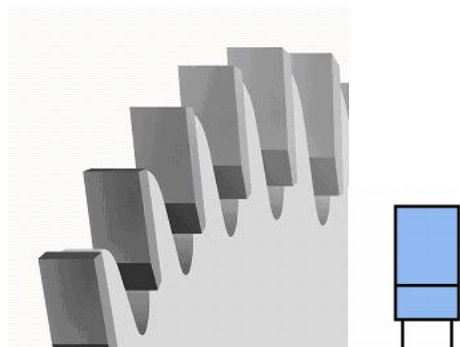


Figure 8: Flat tooth (source: Leitz GmbH & Co. KG)

Alternate top bevel (WZ) is the universal tooth shape for trimming and separating cuts. The tooth configuration results in a lower power consumption of the machine. The pull cut of the alternate top bevel provides excellent quality at the entry side. This blade can be easily sharpened (figure 9).

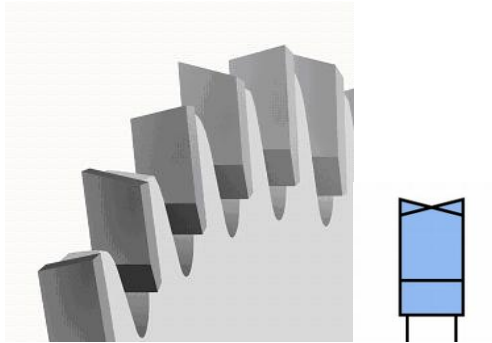


Figure 9: Alternate top bevel (source: Leitz GmbH & Co. KG)

Trapezoidal / flat tooth (TZ/FZ) is a combination where the trapezoidal tooth carries out the pre-chipping and guides the saw blade. It achieves a better cut quality than the alternate top bevel. This blade can be easily sharpened (figure 10).

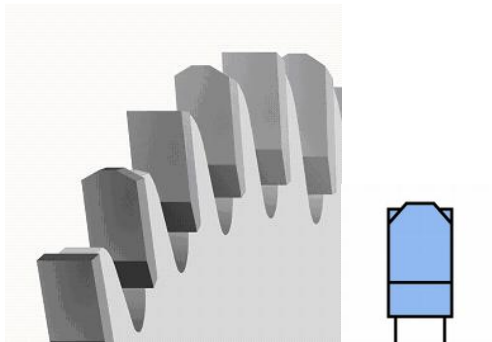


Figure 10: Trapezoidal / flat tooth (source: Leitz GmbH & Co. KG)

Top tooth / hollow tooth (DZ/HZ) is a combination where the high bevel tooth carries out the pre-chipping and guides the saw blade. The double-sided bevel angle resulting from the hollow grind of the hollow tooth ensures the best possible edge quality, better than the trapezoidal/flat tooth, while retaining high tool life. Proper projection of the saw blade can achieve an optimum upper and lower edge. Particularly suitable for machines without a scoring unit. Sharpening this blade must be performed by a specially qualified company (figure 11).

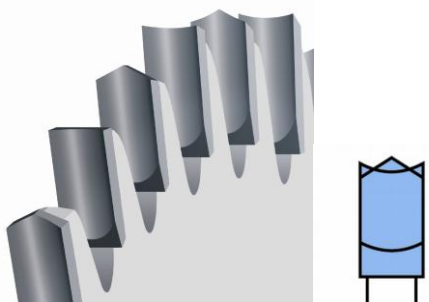


Figure 11: Top tooth/hollow tooth (source: Leitz GmbH & Co. KG)

3.2.4 Cutting and feed speeds

Speed diagram, maximum operating speed, recommended operating speed

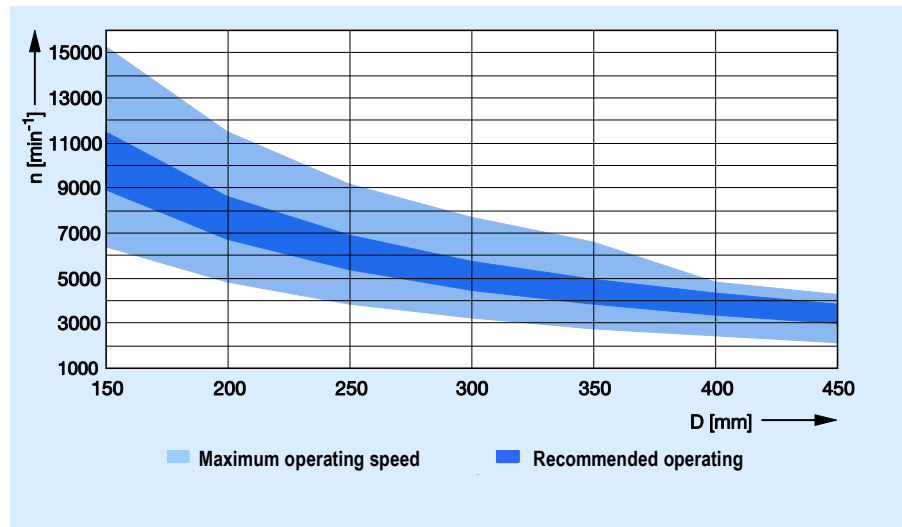


Figure 12: Speed n as a function of circular saw blade diameter D (source: Leitz GmbH & Co. KG)

The feed speed v_f for mechanical feed is calculated using the following formula:

$$v_f = n Z f_z / 1000$$

where:

Z: number of teeth

n: speed

f_z : tooth feed

Recommended for decorative laminates: $f_z = 0.03 - 0.06$ mm

Cutting height diagram

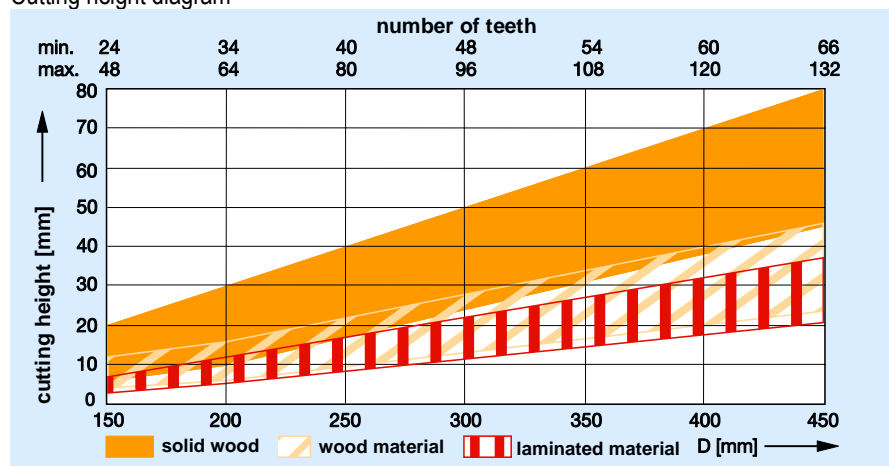


Figure 13: Cutting height as a function of circular saw blade diameter D (source: Leitz GmbH & Co. KG)

3.3 Decorative laminates, on one or two sides on substrates; treatment of cutting edges and profiling

3.3.1 Manual edge treatment

3.3.1.1 File, sandpaper, scraper

Files are suitable for finishing the laminate edges. Always file from the decorative side towards the substrate. Fine files, sandpaper (100 - 150 grit) or scrapers provide good results for breaking edges. Milled edges should be finished in the following manner: Lightly break sharp and slightly sharp edges with sandpaper; smooth the edges with a scraper; break edges again with fine sandpaper; then carefully remove any dislodged sanding particles.

3.3.1.2 Plane

Manual planes may be used for edge treatment as well. Metal planes with high speed steel (HSS) blades are recommended so the contact surface does not wear out when sliding along the edge of the sheet. The cutting angle of the blade should be approximately 15°.

3.3.2 Edge treatment with hand-held routers

Hand-held routers are used primarily for trimming protruding sheet edges. The hand-held router must be covered with a non-abrasive material to protect the surface during sliding. Dirt particles and milling shavings should be carefully removed.

Diameter of milling cutter:	approx. 10 - 25 mm
Speed:	20,000 rpm
Cutting speed:	10 - 25 m/s

Milling cutters with single or double flute tungsten carbide tipped blades are recommended. For larger diameters these tools are also available with reversible plates. Height-adjustable milling cutters with axially parallel blades are preferable because they allow more efficient use of the tool. Edges are broken afterwards (see section 3.3.1.1). The sheet should only protrude as much as required (2 - 3 mm) to avoid unnecessary strain on the tool. Stronger motors are required for longer cutting periods and particularly for continuous cutting operations.

3.3.3 Edge treatment with stationary machines

3.3.3.1 Table milling machines

Router and cutting heads with interchangeable tungsten carbide tipped blades have proven to be effective on table routers. Parallel tools are used:

- a) with axially parallel blades for sheets covered on one or both sides
- b) with diagonal blades on one side for sheets covered on one side
- c) with diagonal blades on both sides for sheets covered on both sides

When milling decorative laminates up to approximately 5 mm thickness, the preferred speed is 12,000 rpm with a tool diameter of around 100 mm, which is equivalent to a cutting speed of 60 m/s. (Do not exceed the maximum allowed speed of the tool!). Lower tool speeds are recommended for bonded sheets (approx. 3,000 - 6,000 rpm, equivalent to cutting speed of 15 - 30 m/s). The tool life for each height setting often differs greatly depending on tool location and type, required cutting quality, and types of substrates. For large amounts of cutting, it may be beneficial to use tools with polycrystalline diamond cutters.

3.3.3.2 Bench routers

Bench routers can be used with single or double flute tungsten carbide tipped cutters, also with interchangeable blades, at an ideal cutting speed of 10 – 15 m/s. This tool is also used for cutouts (section 3.5). Substrates covered on one side can be guided with vertical routers on a template along the follower. Substrates covered on both sides, as well as loose decorative laminates, can only be milled properly using a fixture. An allowance of 2 mm per edge is sufficient in most cases. For curved edges it is often advisable to pre-cut to the approximate shape to avoid excessive milling.

3.3.3.3 Planers

Feed speed:	5 - 15 m/min
Cutting speed:	12 - 15 m/s
Rotation:	3,000 rpm

This machine has limited suitability due to the short tool life of standard blades. Tungsten carbide tipped blades should be used for larger quantities.

3.3.3.4 Edge-banding machines

Edge-banding machines play an important role in machining decorative laminates. With feed speeds of 10 to 32 m/min they are recommended particularly for custom manufacturing and for short runs. These machines are designed for one-sided machining and typically have an optional panel sizing section with jointing cutters and an edge banding section. Edge finishing consists of a cutting unit, a pre-milling unit, a profiling or alternatively an external milling unit, as well as scraper, grinding or polishing units for the edge finish. Jointing tools with polycrystalline diamond cutters (PCD) are recommended for machining the workpiece edges.

3.3.3.5 Double-end profilers

Double-end profilers consist of two parallel edge-banding machines which can be independently moved using an adjusting system. The projected maximum feed speeds depend primarily on the type of edging tape with approximate feed speeds of:

- 20 m/min for solid wood banding and sophisticated soft forming edges,
- 40 to 60 m/min for plastic edges (1 to 3 mm thickness),
- 12 m/min for thin edges (melamine paper edges with 0.3 to 0.4 mm thickness).

Panel sizing is generally carried out with cutting machines (standard tool diameter is 250 mm at a speed of 6000 rpm, using polycrystalline diamond cutters (PCD).

3.3.4 Profiling workpiece edges

Profiling of workpiece edges, as required for postforming or softforming processes, should be carried out with tools described in sections 3.3.2 (hand-held router), 3.3.3.1 (bench milling machine) and 3.3.3.5 (double-end profiler).

3.4 Decorative laminates, composite panels covered on one or both sides

3.4.1 Drilling tools

3.4.1.1 Spiral drills

When drilling decorative laminates, special drill bits are recommended. The recommend tools are spiral drills with a point angle of 60° to 80° (compared to the 120° point angle typically used to drill metals) (figure 14). The laminate spiral drills also have a steep pitch (steep spiral) with large chip space (wide grooves). High speed steel (HSS) drills are recommended for hand-held tools, and tungsten carbide (TCT) drills for machines with mechanical feed. The recommended rotational speed is 1,500 - 3,500 rpm.

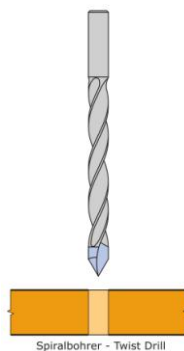


Figure 14: Spiral drill for decorative laminates (source: Leitz GmbH & Co. KG)

3.4.1.2 Multi-diameter drills / step drills

Multi-diameter or step drills are suitable for stepped boreholes with different diameters (figure 15).

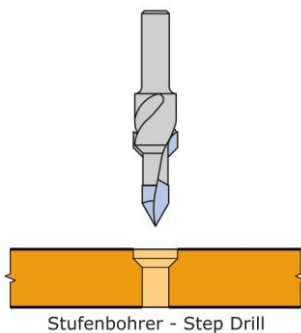


Figure 15: Multi-diameter/step drill (source: Leitz GmbH & Co. KG)

3.4.1.3 Cylindrical drills

Cylindrical drills are suitable for boreholes with larger diameters (figure 16).

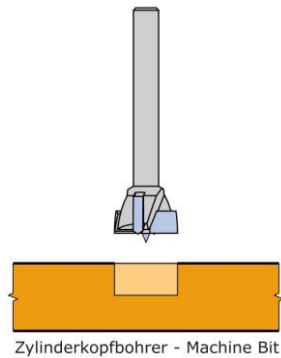


Figure 16: Cylindrical drill (source: Leitz GmbH & Co. KG)

3.4.1.4 Hole saws

Hole saws with a pilot drill can be used and so-called adjustable hole saws with a pilot drill can be used for even larger diameters (figure 17). For the latter version the hole should be cut from both sides, if possible. Alternatively, larger cutouts can be made using a router with a template.

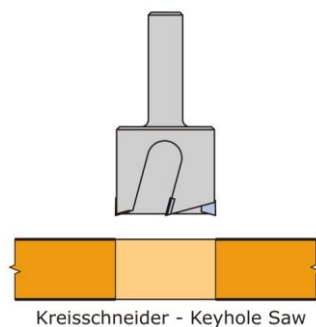


Figure 17: Hole saw (source: Leitz GmbH & Co. KG)

3.4.2 Drilling technique

The depth penetration rate of the drill has to be adjusted to avoid damaging the decorative laminate. The cutting speed for HS drills is approx. 0.8 m/s, for TST drills up to 1.6 m/s. A feed of 0.02 - 0.05 mm/rev is considered suitable, i.e. for every 1000 revolutions the drill penetrates between 20 mm and 50 mm per minute.

Using a hardwood or laminate base can prevent buckling of the material at the exit point of the drill. For large scale production, even better results can be achieved with drill gauges which have drill bushings on both sides and allow tight clamping of the workpiece. Speeds should be reduced by half for countersinking.

3.5 Technical tables

3.5.1 Tool data

The following table provides guidelines for machining decorative laminates with and without substrates such as solid wood boards, veneer laminated wood, plywood, OSB (oriented strand board), epoxy resin bonded chipboard and fibreboard.

Process	Machine	Cutting speed (m/s)	Speed (rpm)	Feed (m/min)
Sheet cutting	Sheet cutting saws	60 - 100	approx. 3,000 - 6,000	approx. 10 - 30
Cutting to size	Bench, panel and hand-held circular saw, MC*	30 - 100	approx. 3,000 - 6,000	up to approx. 10
Machining	Double-end profiler, pre-scoring, cutting and chipping	40 - 60	approx. 6,000	approx. 6 - 60
Milling edges	Bench milling machine or edge-treatment unit, MC*	40 - 60	up to 12,000	approx. 6 - 24
Milling edges	Hand-held router	10 - 25	approx. 12,000 - 27,000	approx. 3 - 8
Grooves	Circular table saw, bench milling machine, MC*	40 - 100	approx. 3,000 - 6,000	approx. 3 - 10
Grooves	Double-end profiler	40 - 60	approx. 6,000 - 9,000	approx. 6 - 24
Grooves	Milling machine, hand-held router, MC*	10 - 25	approx. 12,000 - 27,000	approx. 3 - 8
Drilling	Drilling machine, dowel machine, MC*		approx. 3,000 - 6,000	approx. 0.5 - 3

* MC: CNC machining centre

3.5.2 Cutting speed as a function of rotational speed and tool diameter

The curves in figure 18 show cutting speeds in m/s, determined using rotational speed and tool diameter. If tool diameter and cutting speed are given, the required rotational speed can be determined from the graph. Similarly, the tool diameter can be determined if rotational speed and cutting speed are given.

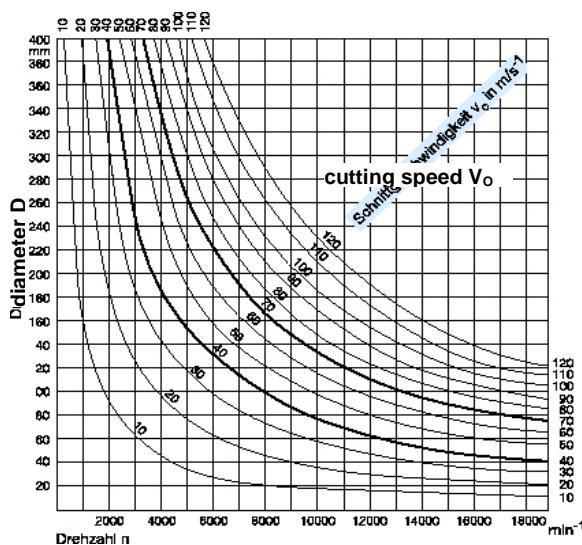


Figure 18: Cutting speed as a function of rotational speed and tool diameter (source: Leitz GmbH & Co. KG)

4. Processing

4.1 General information

Decorative laminates are semi-finished products and up to a thickness of approximately 2 mm require a substrate. The substrate should be rigid and have a smooth surface to insure the finished product has an acceptable visual appearance. The choice of a suitable adhesive, the amount of adhesive applied, as well as the contact pressure and bonding temperature also have a considerable influence on the appearance of the finished composite panel. Like many wood based materials, decorative laminates react to changes in temperature and relative humidity with changes in dimension (often different in machine and cross machine direction). The dimensional changes in the laminate can be different from the changes of the substrates and adhesives and should be taken into consideration during processing.

4.2 Substrates

The following table lists materials which can be used as substrates:

Type of material	Subgroup
Chip-based panels from wood material	Chipboard
	Panels made from long, flat, oriented strands (OSB)
Veneer-based panels from wood material	Plywood
	Laminated veneer lumber (LVL)
	Definitions, classification and specifications
Combined panels from wood material	Blockboard
MDF / HDF	
Paper honeycomb	
Foamed plastic panels	
Plastic honeycomb panels	
Plaster and cement based panels	
Full-size metal panels	
Metal honeycomb panels	

Special panel types (e.g. with higher resistance to humidity or fire), are used for special applications. In individual cases they may require special processing conditions. Contact the panel manufacturer for additional recommendations.

The following additional issues should be considered when selecting and using substrates:

- Regulations valid for the end product, e.g. CE marking
- Requirements regarding emissions, e.g. formaldehyde
- Guidelines specific to the intended end-use application
- Bonding temperatures and pressures
- Sufficient surface soundness of the substrate for the intended end-use application.
- Perform calibrating grinds with the substrate, when necessary
- Adhesives may penetrate (be absorbed) into the substrate, causing unacceptable bonding quality
- Components must be stored in the same climate (environmental) conditions
- Processing guidelines provided by the manufacturer should be followed
- EN 438 must be complied with in all parts (particularly part 7)
- It is always recommended to contact the manufacturers of the semi-finished products
- Thin substrates may not be self-supporting

4.3 Conditioning

Decorative laminates and substrates should be conditioned simultaneously before processing in order to obtain similar moisture content for both materials. Materials which are processed when too wet tend to shrink over time, which in turn can lead to cracking and warping. Materials which are too dry are more difficult to process and may expand over time, possibly leading to warping. The environmental conditions during subsequent use by the customer must be taken into account when planning and designing composite components.

Acceptable moisture content of the materials can be achieved at environmental conditions of 18 – 25°C and 50 – 65 % relative humidity.

The following practices are recommended:

- a) provide sufficient air circulation around each sheet for at least ten days (figure 19)
- b) stack decorative laminates and substrates for at least three days in the same way as they will subsequently be bonded (relative humidity should be similar to the environment of the intended end-use application) (figure 19).

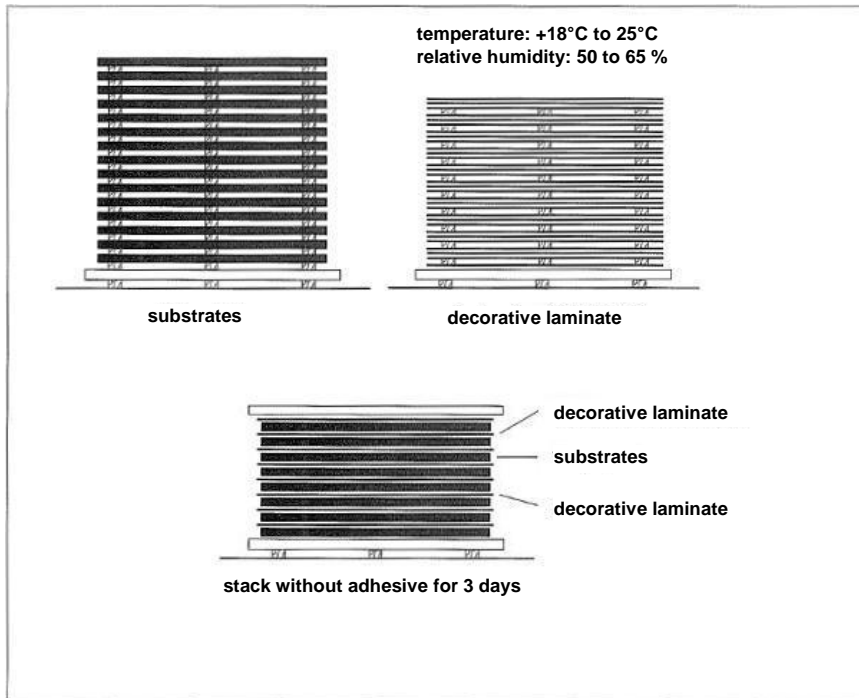


Figure 19: Conditioning

These recommendations are valid for processing in moderate climate zones. For extreme climate zones consult the manufacturer.

Climate chamber: 20 hours at 40°C
(optionally) 10 hours at 50°C

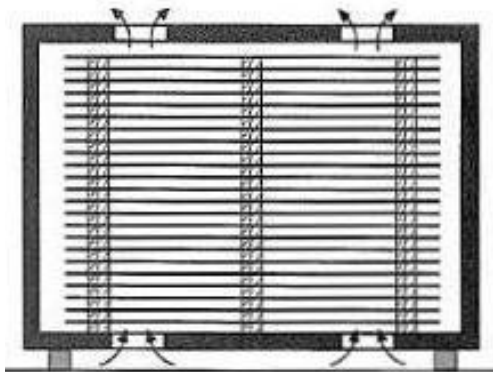


Figure 20: Conditioning in environmental chamber

If the finished composite component will be exposed to continuous low relative humidity during future use, it is recommended that the decorative laminate and substrate be conditioned at a correspondingly low humidity prior to processing in order to reduce shrinkage stress. Bonding must be carried out immediately after conditioning and provision made to maintain conditioning while the finished product is transported to the installation side. For questions about bonding and for new applications, please contact the technical field service of the adhesives manufacturer.

4.4 Stress compensation

4.4.1 Existing stresses

Stresses will always develop between two materials which are bonded together. Therefore a substrate should be laminated on both sides with materials which exhibit the same dimensional changes when subjected to heat and humidity. This is especially important when the finished composite board is intended to be self-supporting and will not be directly attached to a rigid structure.

4.4.2 Symmetrical structure

The best results are achieved by using the same decorative laminates on both face and back. Always use face and back laminates cut from the same direction of the laminate sheet and never at right angles to each other. Optimum results are achieved when the sheets are simultaneously bonded to the substrate with the same direction of sanding.

4.4.3 Balancing

Using "balancing sheets" of equal thickness will produce good results. Under certain circumstances it is also possible to use other materials for balancing, such as films, wood veneers, varnish coatings, impregnated papers etc. However, this special situation will require:

- a) selecting a material whose physical properties are as similar as possible to those of the decorative laminate and
- b) carrying out tests beforehand.

The results achieved with such "balancing sheets" cannot be predicted with certainty, therefore, general recommendations for their use can not be provided.

4.5 Bonding

4.5.1 General information

There are numerous adhesives on the market which provide the bond strength and resistance to temperature and humidity required to successfully fabricate a decorative laminate panel. The materials to be bonded as well as the transport and environment at the intended application must be taken into account when selecting an adhesive system.

4.5.2 Adhesives

All workplace safety and accident prevention regulations must be followed when working with adhesives!

Processing and storing adhesives requires special care. The guidelines and datasheets of the adhesive manufacturers must be carefully followed. For questions about bonding, and for new applications, please contact the technical field service of the adhesives manufacturer.

The following types of adhesives are suitable for bonding decorative laminates:

- dispersion adhesives (e.g. PVAc glues = white glues)
- condensation adhesives (e.g. urea, resorcinol and phenol)
- contact adhesives (e.g. polychloroprene)
- reactive adhesives (e.g. epoxy, unsaturated polyester, polyurethane)
- hot melt adhesives (e.g. polyurethane)

4.5.3.1 Guide for using adhesives

Type of adhesive	Processing method	Comment	Typical application
<u>Dispersion adhesives:</u> PVAc adhesives Two component PVAc adhesives	- manual (hand roller, spatula etc.) - automatic (roller)	Pressing using stationary press or clamp	Surface, edge
<u>Condensation resin adhesives:</u> Urea with high filler content Melamine/urea resin Phenol, resorcinol resin	- manual (hand roller, spatula etc.) - automatic (roller)	Pressing using stationary press while applying heat	Surface
<u>Contact adhesives:</u> Contact adhesives without hardener Contact adhesives with hardener Contact adhesives with integrated resin hardeners	- manual (hand roller, spray gun with cup, brush etc.), application on both sides with subsequent curing	Pressing with short, high pressure using a roller	Surface and edge
<u>Reactive adhesives:</u> <u>One component systems</u> Polyurethane adhesives	- manual (hand roller, spatula etc.) - automatic (purpose-built roller designed etc.)	One component systems require humidity from the surrounding materials. Use of heat shortens the processing time.	Surface, edge
<u>Two component systems</u> Epoxy and polyurethane adhesives		Two component systems do not require humidity from the surrounding materials. Use of heat may be required depending on the system.	Mainly surface
<u>Hot melt adhesives:</u> EVA PO	- automatic	Application: living quarters	Edge
PUR		Application: Mainly in areas with high levels of humidity and heat	Surface, edge

4.5.3.2 Guide for adhesive durability

The guidelines in the following table refer exclusively to the glue line and are based on past experience.

Type of adhesive	Temperature resistance (approximate values) ¹⁾	Durability following DIN EN 204* 2)
<u>Dispersion adhesives:</u> PVAc adhesives Two component PVAc adhesives	- 20 °C to + 100 °C - 20 °C to + 100 °C	D 2 / D 3 D 3 / D 4
<u>Condensation resin adhesives:</u> Urea with high filler content Melamine/urea resin Phenol, resorcinol resin	- 20 °C to + 150 °C - 20 °C to + 150 °C - 20 °C to + 150 °C	D 3 D 3 D 3 / D 4
<u>Contact adhesives:</u> Contact adhesives without hardener Contact adhesives with hardener Contact adhesives with integrated resin hardeners	- 20 °C to + 70 °C - 20 °C to + 100 °C request from manufacturer	--- --- requests from manufacturer
<u>Reactive adhesives:</u> Epoxy, unsaturated polyester and polyurethane adhesives	- 20 °C to + 100 °C	D 3 / D 4
<u>Hot melt adhesives:</u> EVA PO PUR	- 20 °C to + 90 °C - 20 °C to + 110 °C - 30 °C to + 140 °C	--- D 2 D 2 D 3 / D 4

* EN 204 only applies to thermoplastic adhesives (dispersion adhesives)

1) The stated positive values refer to a short-term load

2) Substrate and edge protection must be suitable for the intended application

EN 204 (classification of thermoplastic wood adhesives for non-structural applications) provides the following definitions for	Comments
<p><u>D 1</u> Interior areas, maximum wood moisture content 15%.</p> <p><u>D 2</u> Interior areas, with occasional short-term exposure to running or condensed water and/or to occasional high humidity, with the maximum wood moisture content 18%.</p> <p><u>D 3</u> Interior areas, with frequent short-term exposure to running or condensed water and/or heavy exposure to high humidity. Exterior areas not exposed to weather.</p> <p><u>D 4</u> Interior areas with frequent long-term exposure to running or condensed water. Exterior areas exposed to the weather, but with suitable surface protection.</p>	<p>Values in the column "Temperature resistance" are valid only for short-term strain on the glue line. They must not be confused with long-term strain on the composite board (consisting of decorative laminate, adhesive and substrate).</p> <p>The long-term durability of the composite board depends on type and class of the decorative laminate, the substrate, and humidity and ambient temperature at the end-use location. Proper processing is crucial.</p> <p>The manufacturer should be contacted for special applications, as the adhesives within each group may have different properties and are being continuously modified.</p>

4.5.4 Bonding processes

4.5.4.1 General information

Both sides of the decorative laminate and the substrate have to be carefully cleaned before bonding. Immediately before bonding they must be free from any release agents, particles, sweat stains and coarse particles which could show on the surface after bonding. Grease, oil and sweat stains can be removed using suitable solvents - do not use nitro solvents (observe accident prevention regulations!).

During bonding the ambient environmental conditions should be 18 - 25 °C and 50 - 65 % relative humidity (see section 4.3 "Conditioning").

Observe the information from the adhesive manufacturer. It is recommended that bonding trials be conducted under local environmental conditions. The safety regulations of the trade associations and Health and Safety department must be observed when working with adhesives, solvents and hardeners.

4.5.4.2 Pressing temperature

The recommended pressing temperatures for producing stress-free composite boards is 20°C. Higher temperatures allow a reduction of pressing time, however temperatures should not exceed 60°C since the dimensional change due to temperature of the decorative laminates may be different than the substrate. A lower pressing temperature can minimize the residual stress which can lead to warping and visual defects in the surface. Follow the manufacturer's guidelines.

4.5.4.3 Applying adhesive and pressing

The adhesive should be spread evenly across the surface. For composite panels the amount of adhesive applied must be the same on both sides in order to prevent warping. This is particularly important for water-based adhesive systems where the amount of adhesive applied should be as small as possible.

Adhesive can be applied by hand using a notched trowel or a hand roller, or automatically using glue application equipment. Four-roller machines ensure uniform adhesive thickness and accurate metering (figure 21).

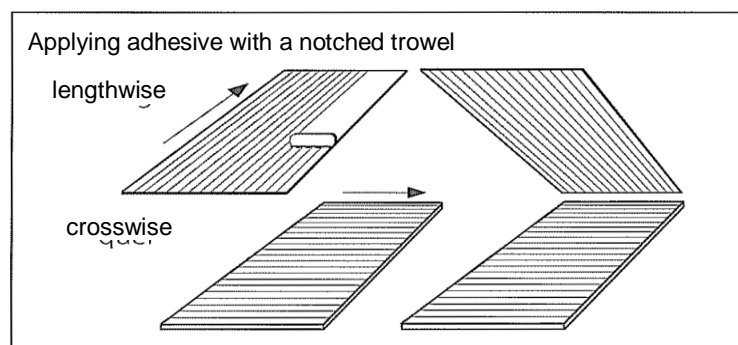


Figure 21: Applying adhesive

4.5.4.3.1 Dispersion adhesives

Dispersion adhesives generally use water (aqueous) as the mobile phase (dispersing agent) into which the adhesive components are dispersed. The water content is generally between 40 and 70 percent by weight. After application to the surface to be bonded, the dispersing agent either penetrates into the workpieces, evaporates into the environment, or the pH value changes, causing the dispersion to break. This allows the adhesive components to make contact and form a film which connects the two workpieces. Today, aqueous dispersion adhesives are often used as a substitute for solvent adhesives. Aqueous dispersions are neither a fire nor an explosion hazard and do not release solvents. However, water-based adhesives typically require either more time or more energy to cure.

Dispersion adhesives include:

- PVAc adhesives
- 2 component PVAc dispersion adhesives

Press types suitable for dispersion adhesives are:

- *Cold presses*: Screw presses, single or multi opening.
- *Warm presses*: Single or multi opening, short cycle opening, roller opening, and double belt opening.

Warm pressing is sensitive to adequate and uniform application of the adhesive as well as correct pressing temperature and duration.

4.5.4.3.2 Condensation resin adhesives

Condensation resin adhesives must be processed with a minimum of 2 to 4 bar bonding pressure in order to allow multi-layer and composite layer bonding. This permits the joining of materials of different types. The adhesive batches require corresponding additives to produce an elastic (flexible) bond line. They also produce a visually uniform surface. Different types of hardeners allow a larger range of bonding and pressing conditions. Impurities on the surface caused by adhesives and hardeners must be removed before bonding, otherwise they cannot be removed without damaging the surface. Release agents can be applied to corresponding areas to prevent adhesive residues from sticking to the surface of the decorative laminates and bonding plates. Phenol and resorcinol resin adhesives are also used for manufacturing composite boards in applications requiring increased resistance to fire.

Condensation resin adhesives include:

- melamine/urea resin
- phenol resin
- resorcinol resin

Press types suitable for condensation resin adhesives are:

- *Cold presses*: Screw presses, single or multi opening.
- *Warm presses*: Single or multi opening, short cycle opening, roller opening, and double belt opening.

Warm pressing is sensitive to adequate and uniform application of the adhesive as well as correct pressing temperature and duration.

4.5.4.3.3 Contact adhesives

Contact adhesives can be solvent adhesives as well as dispersion adhesives which are processed using contact bonding. Polymers are used as bonding agents for this type of adhesive; after evaporation of the solvent they change from an amorphous to a crystalline state while curing, which greatly increases their strength. First a uniform layer of adhesive is applied to both bonding surfaces. Then the solvent is left to cure until the adhesive feels dry (no longer tacky when touched) and has only a low level of immediate adhesion. As with solvent adhesives, at least one of the surfaces which are to be bonded should be permeable to solvents to avoid excessively long cure times.

The adhesive can be applied by hand, using a notched trowel, or automatically with spray units (hot or cold). These adhesives can be applied to decorative laminates and substrates using pouring units. When applying adhesives with a notched trowel the directions of application on substrate and decorative laminate should be at right angles. Sufficient curing is important (use the finger test!). Contact adhesives require short but firm contact pressure to ensure a good bond. Careful attention should be paid that no stresses occur in the material when bonding substrate and decorative laminate. Open time can be lowered by accelerated drying of the adhesive films, making sure to avoid over drying. Over dried adhesive can be reactivated by applying heat (e.g. infrared radiation).

Press types suitable for contact adhesives are:

- hand pressing roller
- roller press (for narrow surfaces)

4.5.4.3.4 Reactive adhesives

Reactive adhesives generally consist of two different components which merge at the bondline forming a new plastic through a chemical reaction (polymerisation). This reaction bonds the two surfaces together as it hardens. Examples of reactive adhesives are the two component epoxy and acrylate resins, as well as the one component cyanoacrylate and polyurethane resins; in the latter two systems the second component is the moisture in the surrounding environment.

Reactive adhesives are primarily used for special bonding applications. Because of the large number of reactive adhesive types it is not possible to give general recommendations for processing. For questions about bonding and for new applications please contact the technical field service of the adhesives manufacturer.

4.5.4.3.5 Hot melt adhesives

Hot melt adhesives are used in many applications due to their high processing productivity and their environmentally friendly properties (no solvents). Hot melt adhesives can be found in almost all areas of modern production (surface laminating, edge laminating, production of abrasive material, furniture manufacturing, automotive manufacturing, etc.). Hot melt adhesives differ in their chemical composition allowing selection of the best adhesive for the intended application. Hot melt adhesives include ethylene vinyl acetate (EVA), polyamide, polyester, polyolefin and polyurethane. Reactive polyurethane hot melt adhesives are frequently used for laminating different substrates with a decorative laminate.

Depending on their chemical composition hot melt adhesives are available in different containers. EVA, polyamide and polyolefin adhesives are often supplied as a granulate in bags. Not every hot melt adhesive is suitable for pulverising and the production of adhesive films.

Polyurethane hot melt adhesives are always supplied in a water vapor proof packaging, preventing humidity from entering during storage. Protective gas can be applied to the "adhesive sticks" in their packaging or they can be protected by using vacuum packaging.

Hot melt adhesive are applied using hot glue devices with contain heating hoses and application heads.

4.6 Appendix General calculation of the bonding pressure for hydraulic presses

To obtain the correct bonding pressure for different board sizes it is necessary to calculate the pressure exerted by the pistons and the corresponding board gauge pressure.

Example:

$$\frac{\text{required bonding pressure}}{\text{number of pistons}} \times \frac{\text{board area (cm}^2\text{)}}{\text{piston area (cm}^2\text{)}} = \text{pressure gauge pressure in bar}$$

$$\text{Piston area} = r^2 \times \pi$$

Example: For a given hydraulic press containing 6 pistons with a 12 cm diameter each (i.e. radius $r = 6$ cm), and a board to be laminated with dimensions of 210 cm x 80 cm. The required bonding pressure is 3 bar.

$$\frac{3}{6} \times \frac{210 \times 80}{6^2 \times 3,14} = 74 \text{ bar gage pressure } (\approx 74 \text{ kp/cm}^2)$$

Note: For workpieces with frame constructions, only the supporting area of the frame and insert (e.g. honeycombs) is to be taken into account.

Unit Conversion:

Bar	N/mm ²	kPa	Kp/cm ²
1,0	0,1	100	1,02

Note: Kilopond (Kp) is the German name of the Kilogram Force: 1Kp = 1 Kgf

5. Cleaning and maintenance

With their durable, hygienic and watertight surface decorative laminates require no special maintenance. The surface can be cleaned with warm water followed by wiping dry with a paper towel or a soft cloth. Persistent marks can usually be removed with non-abrasive household cleaners such as washing powder, liquid or solid soap. Removing stubborn stains may require leaving the cleaning agent in contact with the stain for a longer period of time. After the extended application of the cleaning agent, rinse with water and dry; repeat several times if necessary. Remove all residue of the cleaning agent to prevent smear marks. Dry the surface with a clean, absorbent cloth or a paper towel. The procedure for removing stains can be improved by using a sponge or nylon brush.

5.1 Staining caused by household chemicals

Decorative laminates are a homogeneous, non-porous material and resistant to most household chemicals. Even though liquids cannot penetrate the material, stains should be wiped off immediately. Prolonged contact with caustic substances such as aggressive household cleaners, toilet, and oven cleaners should be avoided.

5.2 Staining caused by lime

Clean the surface with warm 10% vinegar or citric acid solution and rinse with hot water. When using a household scale remover the surface must be immediately rinsed with water.

5.3 Staining caused by paraffin or wax residue

Paraffin or wax residue should first be removed mechanically using a plastic or wooden spatula to avoid scratching the surface. Cover any remaining residue with an absorbent paper and briefly apply heat with a hot iron.

5.4 Staining caused by water-soluble paints, varnishes and adhesives

Fresh stains can usually be removed with warm water. Dried residue can be removed with solvents such as ethanol, acetone, mineral spirits, lacquer thinner, or nail polish remover. The corresponding recommendations of the manufacturer should also be observed.

5.5 Staining caused by solvent-based paints, varnishes and adhesives

Both fresh stains and dried stain residue can usually be removed with solvents. Suitable solvents are ethanol, acetone, mineral spirits, lacquer thinner, or nail polish remover. Follow the recommendations of the solvent manufacturer.

5.6 Staining caused by two component adhesives and varnishes

Two component adhesives and varnishes are generally based on epoxy resin or polyurethane (PUR). Staining caused by two component adhesives and varnishes must be removed from the decorative laminate immediately. After hardening it is usually not possible to remove these materials without leaving residue. The surface should be cleaned with a suitable solvent immediately, making sure to follow the information from the manufacturer of the adhesive or varnish system.

5.7 Staining caused by sealing material on silicone or polyurethane

Sealing material residue should first be removed mechanically using a plastic or wooden spatula to avoid scratching the surface. Any remaining residue can be cleaned with suitable removers (e.g. silicone remover), even after prolonged exposure. Prolonged exposure of the silicone remover can result in changes on the laminate surface. Follow the recommendations provided by the manufacturer of the removal system.

5.8 Staining caused by solvents

After coming into contact with solvents the surface should be rinsed with hot water, then dried with a clean, soft, absorbent cloth or paper towel. Cleaning agents containing stronger acids or bleaching additives (e.g. toilet cleaner, amidosulfon-acid based scale removers) should not come into contact with decorative laminate surfaces. If contact occurs, they must be wiped off immediately.

6. Environment and disposal

Resins used to make decorative laminates are thermosets and once cured are relatively inert, hard, non-corrosive and non-oxidizing. There is no migration to food, therefore, they are safe and approved for food contact.

Decorative laminates are difficult to ignite and also delay flame spread, providing increased evacuation time. The same fire fighting techniques as for other building materials containing wood can be used for fires involving decorative laminates.

The high thermal value of decorative laminates makes them suitable for energy recovery. Modern, approved industrial incineration plants provide the recommended conditions for clean burning.

Decorative laminates can normally be disposed of as household waste, observing municipal regulations.

This document makes no claim of completion regarding listing the full details of any standards referred to in the text.

All information is based on the current state of technical knowledge, but it does not constitute any form of liability. It is the personal responsibility of the user of the products described in this information leaflet to comply with the appropriate laws and regulations.

For more than 50 years the ICDLI has been the international representative of the interests of European laminate manufacturers.

Further information about the ICDLI and the data sheets published up to now can be found at www.icdli.com

This application was compiled by the International Committee of the Decorative Laminates Industry.

It considers the conditions of application technology in the European countries. If you have further questions, please contact us:

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