# HPL
## Compendium

Published by

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# Preface

The word “compendium” stands for “manual” or “guideline” and comes from the Latin word “compendium”, which roughly translates as “shortened path”. This original meaning describes one important characteristic of this booklet very well: The HPL Compendium offers readers a short, but effective way of learning about the vast range of qualities and possibilities of HPL (high pressure laminate). Qualities and possibilities of a material system for high-quality, durable and decorative surfaces which have continuously increased since its invention almost one hundred years ago. This has also lead to a significant expansion of the areas of application. HPL has proven to be a decorative surface which even in its standard type – meets a large number of modern indoor and outdoor design requirements. Where this standard type is not sufficient, the range of special HPL types offers attractive individual solutions.

The HPL Compendium essentially consists of three components. The first section presents and explains the material system. It provides information on the history, manufacturing and properties of HPL. The second section covers the joining of HPL to the substrates and the required machining and processing steps as well as the further processing of the resulting sheet material. The third part illustrates why HPL is such an excellent material, particularly in modern times. This section is primarily intended for architects and planners. Whether for private interior design, laboratories, shop equipment, wellness facilities, façade structures or even in shipbuilding – HPL is an exciting, modern and versatile material. Information on the environmental properties and other technical information in the appendix complete the publication.

The HPL Compendium is therefore a manual for installers and designers as well as for instructors and apprentices alike. Specialist workers receive support for the correct processing and proper handling of HPL. Architects and designers can discover important new and exciting information regarding the many application and design options of HPL. Finally, the HPL Compendium is intended for anyone who is interested in sophisticated surfaces and wants to know how to handle the HPL material system.

Carlos Cruz
ICDLI President

Ralf Olsen
General Secretary

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# 1. The HPL material system

## 1.1 The history of HPL

In 1907, Belgian chemist Leo Hendrik Baekeland was awarded the first patent for a product type with the commercial name “Bakelite”. He had discovered that a mixture of wood dust or fibres with phenol resins can be pressed into metal moulds and simultaneously hardened with heat. In the 1920s, a sheet material in flat shapes was developed which was manufactured by saturating paper with phenolic resin and then hardening it between steel plates.

The melamine required for HPL surfaces goes back to a discovery (1834) by Justus von Liebig. Melamine resin was first used in 1930 by Hermann Römmler for manufacturing Resopal. The development of decorative papers with a high absorption capacity for melamine resins was the fundamental step to HPL during the 1940s. The actual success story of HPL began in the 1950s. The crucial element was the pressing of core paper layers saturated with phenol resin onto decorative papers saturated with melamine resin.

Subsequently, the HPL material system was developed further and therefore opening up a wide range of new applications. Special emphasis should be placed on the development of HPL-Compact into a sheet with decorative surfaces on both sides and a thickness of 2 mm or more. The postforming process allows two-dimensional forming of HPL during bonding to a substrate. HPL with improved flammability opens up complex applications in the construction sector. It can be manufactured to be electrostatically dissipative, while deep surface textures give HPL special tactile properties. Special overlays provide increased abrasion resistance. Variants of HPL can be produced by using other surface materials, e.g. HPL can be combined with metal surfaces or real wood veneer to provide real metal or real wood surfaces. Highly resistant and antibacterial surfaces can be generated with HPL and open up applications in areas with special requirements. Translucent surfaces are possible, as well as fluorescent effects. Anti-fingerprint and highly scratch-resistant surfaces increase the performance. The possibilities of continuous manufacturing of HPL also increase the economically efficient production, while digital printing opens up new perspectives for customised manufacturing. HPL-Compact can also be used outdoors.

## 1.2 Manufacturing of HPL

HPL consists of layered cellulose fibre sheets (paper) which are impregnated with heat-curing resins. Impregnation is the process of completely saturating dry paper with a liquid resin. The top layer is impregnated with melamine resin and features decorative colours or printed designs. The core layers are impregnated with phenolic or melamine resins, both of which are condensation resins. Melamine resins are produced by a chemical reaction between melamine and aldehydes and are categorised as aminoplasts. Full hardening through polycondensation turns these resins into thermosetting plastics. Melamine resins harden to form transparent, light-fast, scratch-resistant and hard coatings. They are therefore ideal as surface layers for HPL. Phenolic resins are produced from phenols and aldehydes through polycondensation. After pressing, they produce a relatively elastic, thermoset core layer together with the kraft paper. The addition of heat (temperatures over 120 °C) under high pressure (at least 5 MPa) causes the resins to flow and then harden, bonding the paper layers into a homogeneous material. This creates a material with a sealed surface and a bulk density of ≥ 1.35 g/cm³. The kraft paper used for the core layers (80 – 300 g/m²) comes from a sustainably managed forest or from recycled materials. The paper is unbleached, has a high grammage and a strong absorption capacity for impregnation resins. Decorative paper (50 – 160 g/m²), consisting of high-quality cellulose fibres, is used for the HPL top layer. This paper is bleached so it can be dyed or printed (e.g. wood, stone or custom patterns). Overlay paper (15 – 80 g/m²) is bleached transparent paper with a high resin absorption capacity. It is used to protect the printed or dyed decorative papers and improves abrasion resistance.

### 1.2.1 Stationary manufacturing of HPL

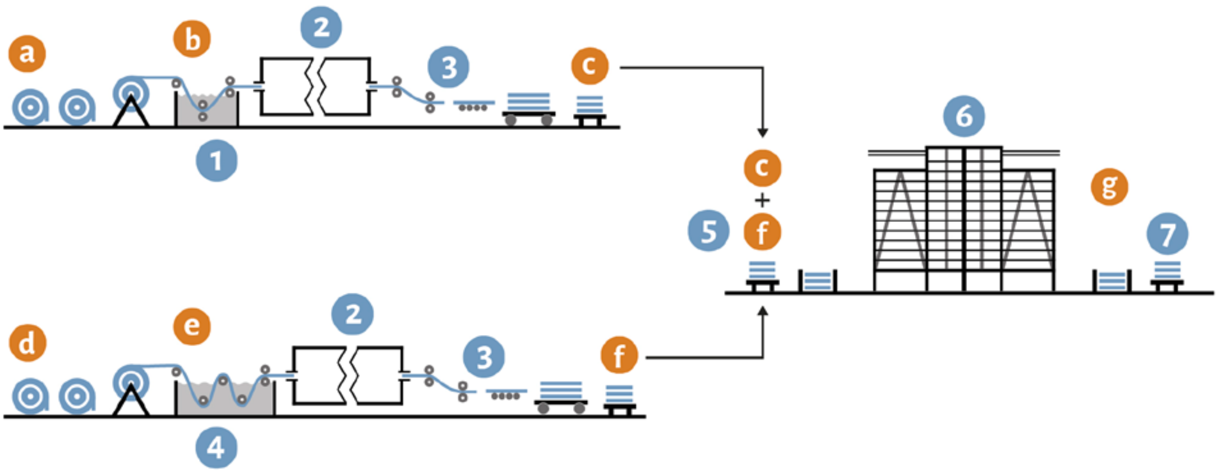



**Figure 1: Stationary manufacturing of HPL**

Top left:

- a Decorative paper/overlay | b Melamine resin
- 1 Melamine resin bath | 2 Drying channel
- 3 Cutting to size of impregnated materials
- c Melamine resin impregnated materials (sheets)

Bottom left:

- d Kraft paper | e Phenol resin bath
- 4 Phenol resin bath
- 2 Drying channel
- 3 Cutting to size of impregnated materials
- f Phenol resin impregnated materials (sheets)

Right:

- 5 Layering
- c Melamine resin impregnated materials (sheets)
- f Phenolic resin impregnated materials (sheets)
- 6 Press
- g Finished HPL sheets
- 7 Destacking

### 1.2.2 Continuous manufacturing of HPL

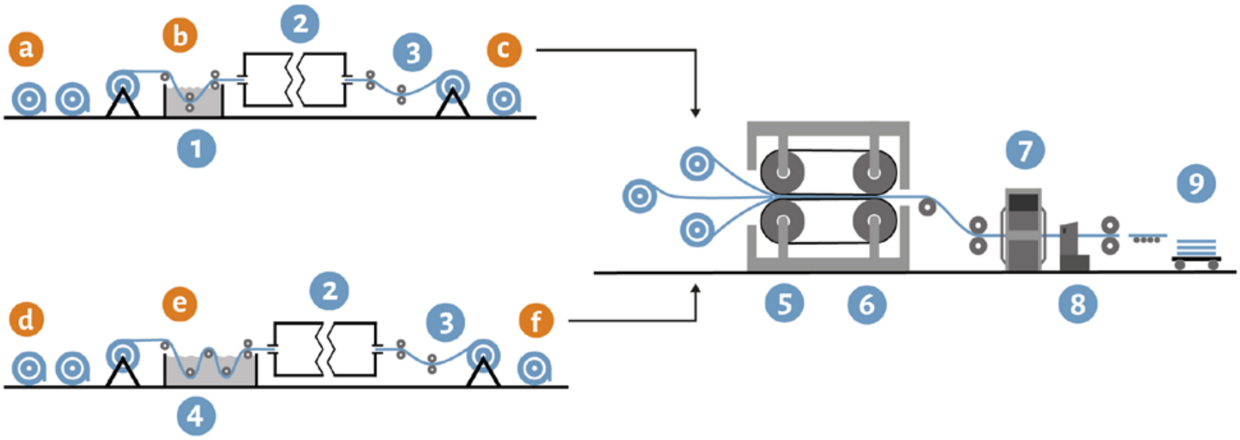



**Figure 2: Continuous manufacturing of HPL**

Top left:

- (a) Decorative paper/overlay | (b) Melamine resin
- (1) Melamine resin bath | (2) Drying channel
- (3) Winding of impregnated materials
- (c) Melamine resin impregnated materials (rolls)

Bottom left:

- (d) Kraft paper | (e) Phenolic resin
- (4) Phenolic resin bath | (2) Drying channel
- (3) Winding of impregnated materials
- (f) Phenolic resin impregnated materials (rolls)

Right:

- (5) Double belt press
- (6) Cooling
- (7) Edge seaming and reverse side sanding
- (8) Cutting to size
- (9) Destacking (sheets)
  Unwinding (rolls)

### 1.2.3 Resin production

Phenolic and melamine resins are produced in large reactors (approx. 10 to 25 m³), in batches and with careful monitoring. The production process takes about 4 to 12 hours. In these reactors, the raw materials are combined, i.e. formaldehyde is bound to the melamine or phenolic molecules and forms reactive molecules for the further condensation process. In the individual batches, condensation is stopped at a defined point to keep the resin water-soluble and suitable for limited storage. The condensation process is continued and completed after paper impregnation in the press, resulting in insoluble, non-melting, high-molecular cross-linked thermoset network.

### 1.2.4 Impregnation

Kraft and decorative papers are supplied in large rolls from approx. 0.5 t. In horizontal and continuously operating impregnation plants, the paper is unwound and immersed in the resin bath to saturate it with resin. Suitable rollers or scrapers remove the excess resin. Then the wet paper is suspended in the drying oven (approx. 15 – 25 m long) and dried in a stream of hot air (approx. 130 – 200 °C). Melamine resin impregnation machines operate with a feed rate of approx. 15 – 25 m/min, and with 50 – 250 m/min for phenolic resin impregnation. The air stream is purified through afterburning to prevent emissions into the environment. The heat energy in the hot air is recovered. The dried impregnated material, with still reactive resin, is cut to the required lengths or rolled up again and stored in conditioned rooms for subsequent further processing.

### 1.2.5 Composition and sheet structure

The impregnated papers are recalled from storage and assembled accordingly in clean, dust-free rooms. The HPL structure is determined by the desired colour, size, thickness and reverse side structure.

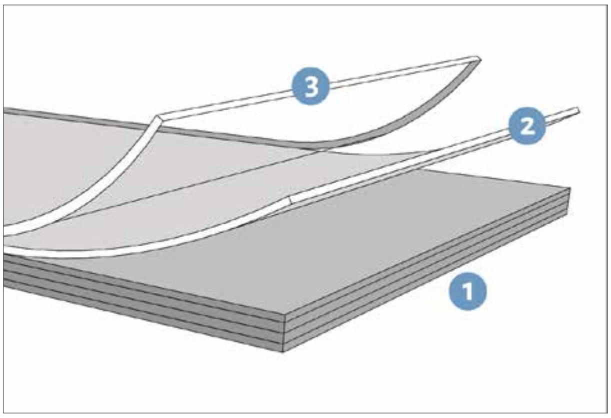



**Figure 3: Typical structure of HPL**

1 Kraft paper layers | 2 Decorative paper | 3 Overlay

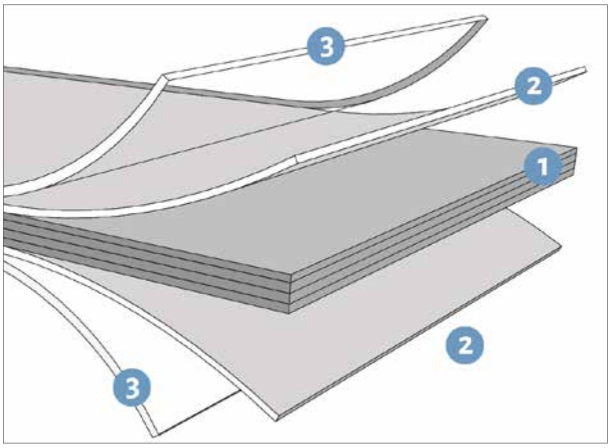



**Figure 4: Typical structure of HPL-Compact**

1 Kraft paper layers | 2 Decorative paper | 3 Overlay

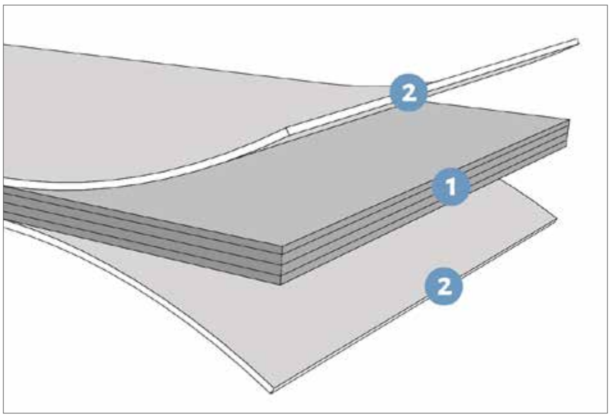



**Figure 5: Typical structure of HPL-Compact without overlay**

1 Kraft paper layers | 2 Decorative papers

HPL with decorative material on one side is always manufactured "back to back" using separating papers. These separating papers (usually coated special papers) or films are used to prevent the HPL from sticking together in the press. The visual sides of the semi-finished HPL are placed against a pressure plate which provides the desired surface texture. For multi-opening presses, the process is repeated several times until the press is filled. Presses with up to 45 openings are often used today. Each opening is filled with material for up to 24 single-sided HPL sheets (0.5 – 1.9 mm thick) or at least one HPL-Compact sheet (2 - approx. 42 mm thick).

### 1.2.6 The high-pressure pressing process

Today, HPL can be manufactured in multi-opening presses or in continuous presses. Both manufacturing processes permit the production of HPL that meets the visual and mechanical requirements of the EN 438 standard. Multi-opening presses are loaded at room temperature, closed, put under hydraulic pressure (> 5 MPa) and heated to temperatures above 120 °C. The heat achieves the flowing process of the melamine and phenolic resins. The liquified resins are pressed between and into the cellulose fibres under high pressure, which results in increased bulk density and a sealed surface. The surface texture (high gloss, matt, woodgrains, etc.) is determined by the pressure plates which are pressed against the melted and then hardening melamine resin layer. The subsequent completion of the chemical reaction (condensation) – the hardening – results in a fully cross-linked structure in the form of a sheet, giving it a high level of strength. The cellulose fibres strengthen the HPL. They are chemically bonded and fully integrated into the new structure. After hardening is completed, the pressed material is cooled down under pressure to release tensions. The complete pressing cycle takes around 100 minutes, depending on press loading and the maximum temperature.

If continuous presses are used, the impregnated paper webs (from rolls) are pressed between two steel belts. Depending on the thickness of the HPL (up to max. 1.2 mm) and the length of the production line, the feed rate varies between 8 and 30 m/min.

### 1.2.7 Cutting to size, sanding, quality control

After the pressing of HPL and HPL-Compact, any protruding material is removed. The edges are cut to the correct length and width in double-ended profilers by sawing or routing. Single-sided HPL is sanded on the reverse side to improve bonding on a substrate (e.g. chipboard). After checking the dimensions and the surface for contamination and defects, the HPL is packed for shipping.

## 1.3 The HPL standard EN 438

The dedicated European EN 438 standard has been in force for HPL since the 1980s. It is now incorporated into the international ISO 4586 standard. The nine parts of EN 438 define all relevant technical properties and test methods for HPL to ensure consistently high quality. HPL and HPL-Compact can only use these designations if they comply with EN 438.

### 1.3.1 The HPL classification system, HPL-Compact and HPL elements

For correct planning, installation and use of HPL, it is important to understand the classification system. The classification system shown in the following is based on the EN 438 HPL standard. EN 438-1 defines the basic requirements for HPL, EN 438-2 describes the test methods and EN 438-7 defines the conformity system for CE marking.

### 1.3.2 HPL with a thickness < 2 mm

EN 438-3 defines HPL intended for bonding to substrates.

*Main application areas:*

H Horizontal application
V Vertical application

*Requirements with reference to their resistance to abrasion, impact and scratch:*

G General requirements
D More stringent requirements for heavy duty applications

*Existing types:*

S Standard quality for HPL
P Postforming HPL similar to type S that can be formed at elevated temperature
F Flame-retardant HPL (meets increased requirements of different fire protection tests)

*Application example:*

HGS Horizontal application with general requirements
HGP Horizontal postforming application with general requirements
VGF Vertical, flame-retardant application with general requirements

### 1.3.3 HPL with a thickness ≥ 2 mm

EN 438-4 defines HPL-Compact for bonding to substrates or as a self-supporting element:

| | |
|---|---|
| C | Compact |
| G | General use |
| S / F | Standard or flame-retardant |

*Application example*

CGS HPL-Compact for general standard application

### 1.3.4 HPL with a thickness < 2 mm for floors

EN 438-5 defines HPL for floors and for bonding to substrates. The outstanding property is the high abrasion resistance, achieved by integration of inorganic particles (corundum). The abrasion resistance is divided in 6 categories: AC 1 (lowest abrasion category) to AC 6 (highest abrasion category).

### 1.3.5 HPL-Compact for exterior use

HPL-Compact as per EN 438-6 is designed for outdoor use under the influence of sunlight, rain or frost.

| | |
|---|---|
| E | Exterior use |
| G / D | Moderate or strong exposure |
| S / F | Standard or flame-retardant |

*Application example*

EGS Standard outdoor use for moderate exposure

### 1.3.6 HPL with surface design

Some variants of HPL are defined by EN 438-8. They are manufactured using other surface materials.

| | |
|---|---|
| A | Pearlescent effect |
| M | Metal |
| W | Wood veneer |

| | |
|---|---|
| C | Compact |
| T | HPL < 2 mm |
| S | Standard quality |

P Postforming HPL, suitable for postforming at increased temperature

F Flame-retardant HPL (meets increased requirements of different fire protection tests)

*Application example:*

MTS Standard HPL with metal surface

### 1.3.7 HPL variants with alternative core structure

Some HPL variants are defined by EN 438-9. They are manufactured using alternative core materials.

B Coloured core

R Metal-reinforced core

C Compact

T HPL < 2 mm

S Standard quality

F Flame-retardant HPL (meets increased requirements of different fire protection tests)

*Application example:*

BSC Standard HPL-Compact with coloured core

### 1.3.8 HPL composite elements

Some HPL composite elements are defined by EN 438-7. HPL composite elements, consist of wood based substrates (e.g. chipboard, MDF, fibreboard, plywood) with HPL applied on both sides. The properties of such composite elements with HPL surface are defined in the standard EN ISO 13894.

The following standards apply for the components:

| | |
|---|---|
| • HPL | EN 438 |
| • Chipboard | EN 309 / 312 |
| • Plywood | EN 313 / 636 |
| • Fibreboard (MDF, HDF) | EN 316 / 622 |
| • Wood adhesives for non-load bearing applications | EN 204 / 205 / 12765 |

## 1.4 Physical, chemical and electrostatic properties

Correct planning for the use of HPL requires knowledge of the most important material parameters. The following subchapters summarize the physical, chemical and electrostatic properties of HPL.

### 1.4.1 Physical properties

Table 1: Physical properties

| | |
|---|---|
| Physical state | Solid |
| Bulk density | ≥ 1.35 g/cm³ |
| Solubility | Insoluble in water, oil, methanol, diethyl ether, n-octanol, acetone |
| Boiling point | None |
| Outgassing | None |
| Melting point | None |
| Calorific value | Approx. 18 – 20 MJ/kg |
| Heavy metals | HPL contains no toxic compounds based on antimony, barium, cadmium, chromium$^{III}$, chromium$^{IV}$, lead, mercury or selenium |
| Stability and Reactivity | HPL is not considered to be reactive or corrosive |
| Hazardous reactions | None |
| Incompatibility | Strong acids or alkaline solutions will damage the surface (descalers) |
| Ignition temperature | Approx. 400 °C |
| Flash point | None |
| Thermal decomposition | Possible above 250 °C |
| Smoke and toxicity | HPL is classified as F2 in accordance with NF F 16101. Toxic gases (primarily carbon monoxide, carbon dioxide and ammonia) may be emitted depending on the burning conditions (e.g. temperature, oxygen content) |
| Flammability | HPL is classified as non-flammable and will only burn in the presence of open flames |
| Extinguishing media | HPL is categorised as Class A. Carbon dioxide, water spray, dry chemical foam can be used to extinguish flames. Water suppresses and prevents flames being rekindled |

| | |
|---|---|
| Explosion hazard | The processing of HPL through sawing, sanding and routing produces Class ST-1 dust.<br>Standard safety precautions and adequate ventilation must be provided |
| Explosion limit | The dust concentration should be below 60 $mg/m^3$ |
| Protection against explosion and fire | HPL must be treated as a wood-based material |
| Fire classifications as per EN 13501 | Standard and postforming quality D-s2, d0 or better flameretardant quality either B-s2, d0 or rather C-s2, d0 or better (classification depends on material thickness) |
| Working areas | The usual safety precautions for minimising dust accumulation must be applied |
| Formaldehyde release | < 0.4 mg/h $m^2$ as per EN 717-2, < 0.05 ppm as per EN 717-1 |
| Pentachlorophenol/Lindane | HPL contains no PCP (pentachlorophenol) or Lindane |
| Miscellaneous | HPL is an article and not a chemical substance and therefore REACh does not apply |

In addition, the values and information recorded in EN 438 apply to HPL.

### 1.4.2 Chemical properties

HPL is resistant to most chemicals. Some chemicals, however, can affect the surface. Special consideration must be given to:

- the concentration of the chemical
- the pH value (acid/base ratio)
- the exposure time
- the temperature

The list shown in appendix 2 provides – without claiming to be complete – an overview of the resistance, limited resistance, lack of resistance of HPL to the most commonly used substances (in solid, dissolved or gaseous form). If chemicals other than those listed in the appendix are intended for contact with HPL, their compatibility must be tested.

### 1.4.3 Electrostatic properties

“Antistatic” is a general term, it entails no requirements. Antistatic does not mean “not electrostatic” or “counteracting electrostatic charge”. The reactions of the materials regarding the dissipation of electrostatic charges can be described with a scale where the empirical steps are indicated with the surface resistance in Ohm (Ω).

**Table 2: Surface resistance $R_o$ in Ω**

| Charge dissipation possible | | Charge dissipation possible to a limited extent | Charge dissipation not possible |
|---|---|---|---|
| Substances cannot be charged | | Transition area | Substances can be charge |
| Conductive | Dissipative | | Insulating |

$10^4$ $10^5$ $10^6$ $10^7$ $10^8$ $10^9$ $10^{10}$ $10^{11}$ $10^{12}$ $10^{13}$ $10^{14}$

The lower limit of $10^5$ was chosen for safety reasons. According to VDE 0100, at least $5 \times 10^4$ Ω are stipulated when working with voltages up to 100 V and at least $1 \times 10^5$ Ω for voltages up to 1000 V.

Materials which fall into the range between $10^5$ and $10^9$ Ω are referred to as dissipative materials, as long as they are grounded. In the high-Ohm range of $10^9$ Ω – $10^{11}$ Ω, electrostatic charges can accumulate.

HPL minimises the generation of electrostatic charge by contact change or friction with other materials and does not need to be grounded. The surface resistance of HPL is $10^9$ – $10^{12}$ Ω and the charge capacity according to EN 61340-4-1 is < 2 kV. HPL is therefore antistatic. Modifications can be made to make HPL dissipative with $10^5$ – $10^9$ Ω. The magnitude of this value depends essentially on the relative humidity.

## 1.5 Reaction to fire of HPL

HPL is difficult to set on fire and has the property of delaying the spreading of flames. Only low heat and little smoke are therefore generated, extending escape / rescue times. Gases produced during burning of HPL do not differ substantially from those from organic materials, e.g. wood, wool or cotton. Fire does not cause HPL to soften or melt. No burning droplets are generated. The properties in case of fire depend on the thickness, design and composition of the HPL.

HPL is a construction material and can be tested as such. These results can be integrated into the evaluation of a structural element.

### 1.5.1 European fire classifications for construction products and types as per EN 13501

The standard differentiates between reaction to fire, which is described in EN 13501-1, and fire resistance, which is described in EN 13501-2. To evaluate the fire behaviours in construction, a differentiation is made between building elements and construction materials. The definitions and classifications for construction materials and building elements with regard to their reaction to fire are described in the European standard EN 13501. Parts 1 and 2 are important for HPL. Part 1 describes the fire classification of construction materials for buildings. Part 2 describes the fire classification of structural elements for buildings.

The reaction to fire of a construction material (e.g. HPL, HPL-Compact, chipboard, plasterboard, substrates covered with HPL) has to be known if the intended installation point (e.g. wall or ceiling panels) is subject to the applicable fire protection regulations.
The reaction to fire is determined either from the applicable standards or through testing. The classification of a construction material can be improved by testing according to the standard compared to the established standard classification.

If a structural element is intended for applications which are subject to the regulation on fire resistance, a classification as per EN 13501-2 has to be conducted.

Fire resistance is the duration of the functional capability of a structural element (e.g. door covered with HPL, including mounted frame) in case of fire, taking into account different criteria (load capacity (R), separation (E), heat insulation (I)). For example: A component which retains its load capacity in case of fire for 120 minutes, its separation function for 60 minutes and its heat insulation for 30 minutes corresponds to fire resistance classification R 120 / RE 60 / REI 30.

### 1.5.2 European fire classifications

**Classification of HPL and HPL-Compact without further testing**

HPL, type S/P and HPL-Compact, type CGS have a CWFT classification of Euroclass D-s2, d0 (CWFT = classification without further testing). The CWFT classification was published in the Official Journal of the European Union (L201/25 dated 8-8-2003).

**Table 3: CWFT classification Euroclass D-s2, d0**

| HPL (1) | Product details | Minimum bulk density | Minimum total thickness | Class (2) (except floors) |
|---|---|---|---|---|
| HPL-Compact sheets without flame-retardant additive for indoor use (3) | Compact HPL as per EN 438-4, type CGS | 1350 kg/m³ | 6 mm | D-s2, d0 |
| Composite elements for indoor use; HPL without flame-retardant additive with wood substrate (3) | Composite element consisting of HPL without flame-retardant additive as per EN 438-3, bonded on both sides of a wood substrate without flame-retardant additive with 12 mm minimum thickness as per EN 13986, PVAc or heat-curing adhesive with an application weight of 60 – 120 g/m² (3) | Wood substrate with a bulk density of at least 600 kg/m³<br><br>HPL with a bulk density of at least 1350 kg/m³ | 12 mm wood substrate bonded on both sides with<br><br>HPL ≥ 0.5 mm | D-s2, d0 |

(1) Either fastened directly (e.g. without air gap) onto a material of Euroclass A2-s1, d0 or better and with a bulk density of ≥ 600 kg/m³ or mounted on a wooden or metal frame, with an unventilated (e.g. opening only to the top) gap of at least 30 mm, the reverse of the hollow space must be designed to have a reaction to fire classification of A2-s2, d0 or better

(2) Classes intended as per table 1 of the appendix to the decision of the Commission 2000/147/EG

(3) As per standard EN 438-7

### 1.5.3 Construction materials, classifications of reaction to fire as per EN 13501-1, except floors

Table 4: Classification of reaction to fire as per EN 13501-1

| Con-struction material class | Smoke generation | Dripping behaviour | Comment | Example |
|---|---|---|---|---|
| A1 | | | Organic portion≤ 1 % | Concrete, stone, metal, plaster |
| A2 | s1 | d0 | Bulk density ≥ 600 kg/m³<br>Paper weight ≤ 220 g/m³ | Plasterboard t ≥ 9.5 mm |
| B | s1<br>s2<br><br><br>s1<br><br>s1/s2 | d0<br>d0<br><br><br>d0<br><br>d0 | <br><br><br><br>Bulk density ≥ 1000 kg/m³ | HPL-Compact FR thickness ≥ 6 mm<br>Composite elements consisting of HPL FR bonded to flame-retardant wood substrate, e.g.<br>cement-bonded chipboard<br>t ≥ 10 mm or<br>flame-retardant chipboard t ≥ 12 mm |
| C | s2 | d0 | | HPL-Compact FR t < 6 mm<br>HPL-Compact sheet standard t < 8 mm<br>Composite elements consisting of HPL FR bonded to flame-retardant wood substrate |
| D | s2 | d0 | <br>Substrate ≥ 12 mm<br>Bulk density ≥ 600 kg/m³<br><br>Bulk density ≥ 400 kg/m³<br>Bulk density ≥ 400 kg/m³ | HPL-Compact standard t ≥ 6 mm<br>Composite elements consisting of HPL type S/P bonded to standard wood substrate, e.g.<br>plywood t ≥ 9 mm<br>or solid wood t ≥ 12 mm |
| F | | | | (LDF) Low density fibre board |
| F | | | No requirements defined | Some plastics |

# 2 Machining and processing HPL

HPL is a material that is easy to machine, whereby usually standard tools for wood working can be used. The following chapter describes the most important requirements which have to be taken into account for processing and machining HPL, HPL-Compact and HPL composite elements.

## 2.1 Storage

HPL has to be stored at normal room climate, i.e. at approx. 18 – 25 °C and 50 – 65 % rel. humidity so that it is protected against moisture, humidity and direct sunlight. The sheets should lie flat on a suitable horizontal surface, e.g. on a pallet with a backing plate. The stack has to be weighted down with a cover plate. If HPL are supplied in film packaging, it is recommended to reclose the film and replace the cover plate each time after removing any sheets. If horizontal storage is not possible, it is recommended to store the material at an angle of approx. 80° with support over the entire area and a counterweight on the ground to prevent sliding.

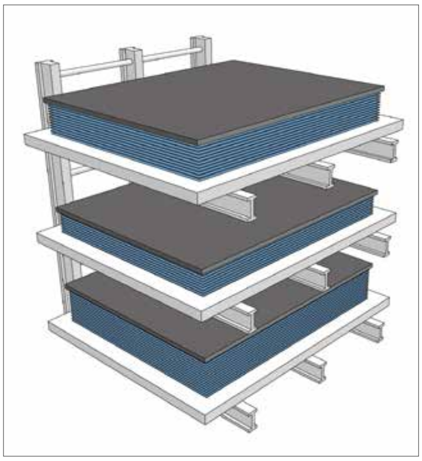


Figure 6: Horizontal storage of HPL with cover plate

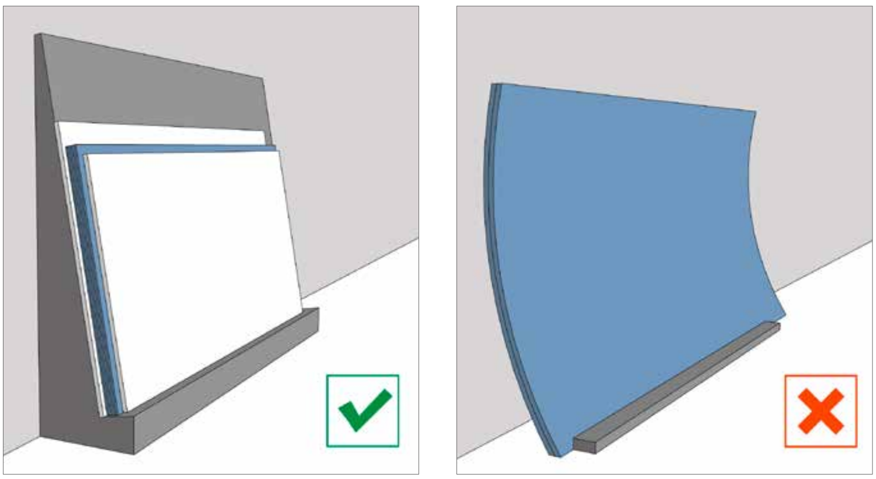


Figure 7: Diagonal storage of HPL with cover plate and full-surface support

## 2.2 Handling

When handling HPL, it should be ensured that it is always lifted. The decorative sides should never be pulled or slid against each other. For larger sizes it is recommended to carry the sheets curved along the longitudinal axis to prevent sagging which would otherwise occur. Individual sheets can also be rolled up for carrying (decorative side to the inside, making sure to avoid any fretting motions). Sufficiently large and sturdy pallets have to be used when transporting sheet stacks with transport vehicles. They have to be secured against sliding.

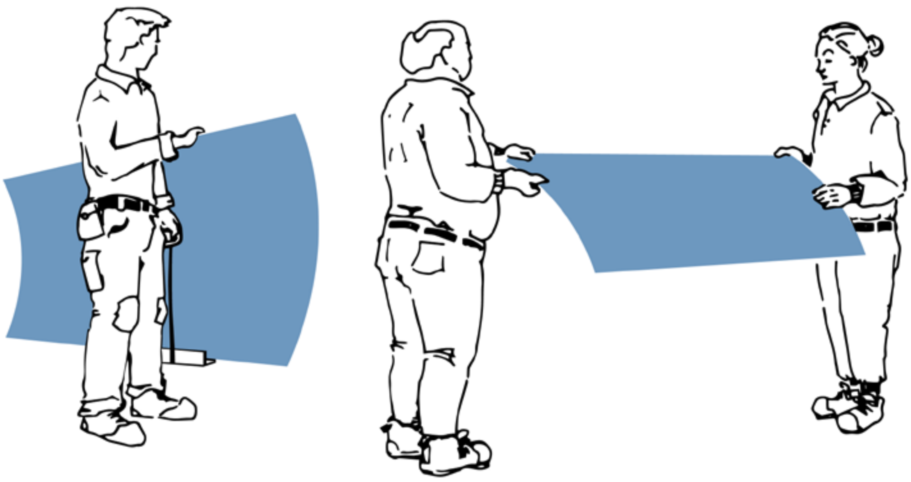


**Figure 8: Handling HPL**

## 2.3 Conditioning

HPL and substrates should be conditioned jointly before processing in order to obtain a similar moisture content for both materials. Materials which are processed when moist 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 later on, possibly leading to warping. The climatic conditions during subsequent use are always to be taken into account when planning and designing composite elements. Sufficient air circulation around each sheet for at least ten days (see figure below) is recommended. In addition, HPL and substrates have to be stacked in the order in which they will be bonded later on for at least three days. The relative humidity should be similar to that of the future application.

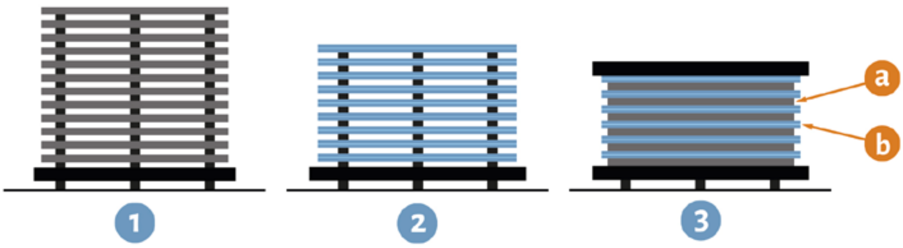



**Figure 9: Conditioning of HPL**

1 Stack with substrate boards | 2 Stack with HPL | 3 Preconfigured stack with a Substrate boards | b HPL

These recommendations apply to the processing and subsequent use in moderate climate zones. For extreme climate zones we recommend consulting the manufacturer.

If the composite element which is to be manufactured will be exposed to continuous low relative humidity during future use, it is recommended to expose the HPL and the substrate to a corresponding humidity during conditioning to anticipate subsequently occurring shrinkage stress. Bonding has to be carried out immediately after conditioning. We also recommend consulting the manufacturer about this.

Suitable conditioning is to be observed during transport as well.

## 2.4 Stress compensation

Stresses will always occur between two materials which are bonded together. Therefore a substrate has to be laminated on both sides with materials which are subject to the same dimensional changes caused by the influence of heat and humidity. This is especially important when the finished composite element is intended to be self-supporting and will not be directly supported by a rigid structure.

The best results are achieved with a symmetrical structure by using the same HPL sheets on both front and back. Always use front and back sheets cut from the same direction of the laminate sheet and never at right angles to each other. The sheets are simultaneously bonded to the substrate with the same direction of sanding. Using so-called "balancing sheets" of equal thickness also produces 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 always requires

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

The results achieved with such materials in practice cannot be generalised. Their use can therefore not generally be recommended.

## 2.5 Substrates

HPL up to a thickness of approx. 3 mm requires a substrate. The substrate has to meet different properties. In particular, it has to be rigid and has to have a smooth surface. This is an essential prerequisite for good visual appearance. The choice of a suitable adhesive, the amount of adhesive applied as well as the contact pressure and temperature for bonding also have considerable influence on the appearance and surface of the composite element. Like many other materials, HPL reacts to temperature and humidity fluctuations with

dimensional changes. These can be different to those of the substrates and the adhesives and have to be taken into account during processing.
The following table lists some materials as examples of what can be used as substrates:

**Table 5: Substrates, material types and subgroups**

| Material type | Subgroup |
|---|---|
| Chip-based wood boards | Chipboard |
| | Boards made from long, flat, oriented strands (OSB) |
| Veneer-based wood boards | Plywood |
| | Laminated veneer lumber (LVL) |
| Combined wood boards | Blockboard |
| Honeycomb sheets | Paper, metal and plastic honeycomb |
| Foamed plastic boards | Different polymers |
| Plastic honeycomb boards | Different polymers |
| Mineral substrates | Plasterboard/gypsum fibre/vermiculite/calcium silicate/fibre cement/cement-bonded chipboard |
| Full-size metal boards | Metal types |
| Metal honeycomb boards | Metal types |

Special panel types, e.g. with higher resistance to humidity or flames, are used for special applications. In individual cases they may require special processing conditions. It is therefore recommended to consult the panel manufacturers.

The following aspects additionally have to be taken into account:

- Regulations applicable to the end product, e.g. CE marking
- Requirements regarding emissions, e.g. formaldehyde
- Guidelines applicable at the place of use
- Press temperatures and pressures
- The surface soundness of substrates has to be sufficient
- If necessary, carry out calibration sanding on the substrate

- Adhesives may penetrate (absorb) into the substrate, causing unsatisfactory bonding quality
- The components have to be stored in the same climate before bonding
- Processing guidelines have to be observed, e.g. from the adhesive manufacturer

Composite elements made of HPL and mineral substrates have a wide field of application and are often mandatory where increased requirements for reaction to fire have to be met, e.g. for high-rise buildings, ship building or public transport.

### 2.5.1 Materials requirements

Materials requirements apply to HPL type S (standard quality) or type F (flame-retardant quality) as per EN 438. Which HPL is selected depends on the field of use and the respective fire regulations. Nearly all fire regulations require materials which are especially tested and have to be tested in the form in which they will be used later on. Testing is therefore not conducted only with the HPL, but also always with the complete composite element consisting of substrate, adhesive and HPL. The test also applies for this specific combination and design in each case. The company processing the composite elements consequently always has to verify that these meet the materials requirements for the different fields of use. This means a new test is required each time a change in the composition of the composite elements is no longer covered by a test report. It also means, however, that new or separate materials requirements always have to be taken into account. The required test reports can be obtained from the manufacturers of the composite elements. Be aware, that this list does not claim to be complete. New test procedures may have come into force. Therefore, it is important for the persons processing the composite elements to gain an overview of the latest regulations if composite elements are intended for applications where regulations for reaction to fire exist.

### 2.5.2 Mineral substrates

First of all, the basic principles of the general recommendations for working with HPL apply to the processing of special HPL composite elements. Due to specific features of the production of composite elements with mineral substrates and the stress they are subsequently exposed to, the following special processing information has to be noted. This applies in particular to pretreatment of the HPL. In all cases, it is necessary to apply HPL with the same quality and design to both substrate sides. It is also advisable to consult the manufacturer of the decorative laminate.

These substrates must have a cleanly sanded surface (thickness tolerance ±0.3 mm). They must not have any sanding marks or depressions. If it is not possible to manufacture the substrate with the required tolerances, joint-filling adhesives have to be used in order to create an even bond between substrate and HPL as well as a good surface quality.

Not all mineral boards are suitable for use as substrates for HPL. That is why the supplier should be notified of the intended use in order to obtain a usable product particularly where thickness tolerance and humidity content are concerned. The transverse tensile strength of the mineral substrates should be no less than 0.4 N/ mm². It should also be noted that mineral materials have lower peel strength and lower transverse tensile strength than most wooden substrates, causing possible peeling in the uppermost layer of the substrate as well as tensions in the core.

**Table 6: Overview of mineral substrates**

| Substrate | Typical applications |
|---|---|
| Vermiculite boards | Interior work/ship building |
| Calcium silicate boards | Public buildings/ship building |
| Fibre-cement boards | Public buildings/wet rooms |
| Cement-bonded chipboard | Public buildings/wet rooms |
| Plasterboard | Interior work |
| Fibre plasterboard | Interior work/public buildings |
| Compacted mineral wool | Interior work |

Adequate conditioning can prevent dimensional changes from the start. These would otherwise lead to warping of the HPL composite element or to tension cracks after bonding.

Mineral substrates are subject to smaller dimensional changes than wood materials or HPL. They absorb and release moisture faster which means

that simultaneous conditioning in the same stack together with HPL is not advisable.
HPL should be conditioned before processing in pairs or conditioned depending on the selected substrate or field of application. The relative humidity during conditioning should correspond to the subsequent climate conditions as closely as possible.

This pretreatment is of great importance for processing mineral substrates as well as for working with wood materials.

Subsequent changes in humidity cause strong tensions between the HPL and the substrate which can cause an increased occurrence of cracks and warping.

Material particles and dust caused by machining have to be removed carefully to avoid scratching the HPL surface.

National environmental and occupational safety conditions for processing mineral materials have to be followed. This also applies to composite elements made of HPL and mineral substrates.

Where the composite elements will later be subjected to dynamic loads through warping or moving, e.g. in ships or vehicles, sufficient room for movement should be provided during installation. This allows e.g. room dividers in ship's cabins to be fixed to floor and ceiling using suitable brackets. Suitable profiles allow sufficient clearance when mounting several plates side by side. The profiles should be interlocking because of the low transverse tensile strength of the mineral substrates. Where interlocking profiles are not possible for design reasons it is possible to work with groove and loose tongue, with the depth of the groove not exceeding half of the thickness of the mineral substrate. If fire regulations require the tongue to be wider, the depth of the groove has to be kept as small as possible in order to prevent the substrate from splitting later on.

If high dynamic loads are expected, the composite elements have to be reinforced at the back side at smaller intervals. Where moisture could act on the edges of the composite elements, these have to be protected with waterproof coatings before installation.

Composite elements made of HPL and mineral substrates are usually used in areas where fire regulations apply. Fixing methods and fixing materials therefore have to comply with these regulations as well. Special attention has to be paid to the connections between the individual elements. This applies to horizontal and vertical connections. Joints can have a crucial influence on fire behaviour. Regulations concerning the selection of joining materials have to be observed.

Where HPL composite elements are used as wall and/or ceiling panels, the area underneath has to be sufficiently dry. Composite elements can be used for partition walls, free-standing in steel frames.

Regardless of the selected fixing method, the spacing between the fixing points should be set in accordance with the substrate, the thickness of the composite element and the occurring load.
For screw fixings, the selected screw types have to be suitable for the respective substrate.

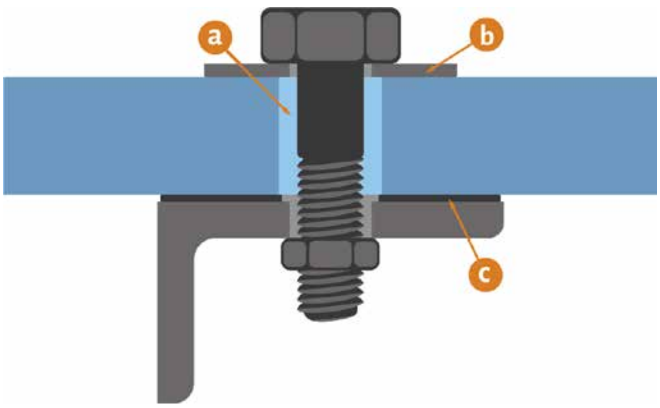



**Figure 10: Fixing with visible screw connection**

a Oversized drilled hole | b Washer | c Sliding film

There are many different fixing options for fixing composite elements made of HPL and mineral substrates together and to building components. They can be divided into four categories:

- invisible adhesive connections
- visible mechanical connections
- combination of invisible adhesive connections and visible mechanical connections
- invisible mechanical connections

### 2.5.3 Metal substrates

Processing of HPL with metal substrates is a special field of application for specific industries, e.g. for car manufacturing, ship building, transport and the high requirements of interior building work.

The following materials are examples for metal substrates.

- Aluminium sheets (plates)
- Aluminium composite sheets (honeycomb structure)
- Steel sheets (plates)

Sheets and plates have to be absolutely flat, without bends, bumps or any other faults.

Metal substrates have oxide or corrosion layers, are greased, oiled or additionally hardened, heat-treated, acid-treated or anodized. This influences wetting with adhesive and reliable bonding. Therefore, the surface has first to be pretreated for bonding. The time between pretreatment and bonding should generally be as short as possible to prevent renewed corrosion or soiling. The type of pretreatment depends on the type and thickness of the metal as well as the available equipment and the production quantity. Before bonding, metal substrates have to be fully degreased. This can be achieved by using steam, solvents or cleaning agents. After degreasing, it is important to prevent resoiling of the surface. Clean protective gloves have to be worn as even slight fingerprints can affect bonding quality.

Composite elements consisting of HPL and metal substrates combine the advantages of both materials:

- Decorative appearance: The full range of decorative designs and textures of HPL are available as a design element. In addition, the surfaces are easier to clean.
- The elements achieve a high mechanical strength compared to the weight.
- Reaction to fire: Metal sheets are categorised as non-flammable as per EN 13501. Standard HPL as per the same standard Euroclass D-s2, d0 can be supplied with flame-retardant finish. (Type F as per EN 438).
- Shaping freedom: Formed metal surfaces can be coated with HPL.
- Metal substrates can be used to achieve improved physical properties such as vapour barriers, magnetic properties, electrical properties (shielding against radiation).

Manufacturing these composite elements require knowledge of certain material properties which have a crucial influence on manufacturing:

- Both materials – HPL and metal sheet – are non-absorbent. This has to be considered during selecting and processing.
- HPL expands slightly in humid climate and shrinks as a result of dryness and extended exposure to higher temperatures. Climate conditioning before bonding, adapted to the subsequent area of application, reduces the possible dimensional changes to a minimum.
- Metal sheets, on the other hand, are unaffected by moisture, but expand significantly under higher temperatures and shrink when the temperature is reduced. This can result in a "bimetal effect" for the composite element, as e.g. the metal expands under higher temperatures. HPL on the other hand shrinks under extended heat exposure.
- The bond has to be elastic enough to compensate for the different tensions which occur. Metal sheets have to be prepared for bonding with mechanical or chemical pretreatment.
- The processing machines have to be capable of machining HPL and metal at the same time.

- As a rule, these should be bonded by using the cold pressing method. To meet fire protection regulations, it is often necessary to use flame-retardant HPL. We recommend consulting the manufacturer of the HPL.

Careful steam treatment achieves good removal of grease and oil. A completely clean surface exhibits an uninterrupted water film after the steam is switched off. The cleaned sheets have to be dried with warm air before stacking.

Solvents such as acetone, xylene and MEK can be used for manually cleaning the surface. To do this, saturate a clean, lint-free cloth or a clean wad of paper with the solvent and carefully wipe the surface, changing the cloth or paper frequently. This is followed by warm water rinsing and warm air drying. In general, solvent steam degreasing is the most efficient method, though. This, however, requires special systems. It involves placing the sheets into tanks, where the lower section contains a heated solvent and the steam from this condensates on the sheets, rinsing the surface with solvents. Note: Using degreasing solvents requires special caution. General health and safety regulations and recommendations from the manufacturers have to be observed.

Mechanical roughing is used to remove the oxide, corrosion or other foreign layers, simultaneously, but also for achieving good mechanical anchoring of the adhesive. On greased or oiled metal substrates, the surfaces to be bonded also have to be degreased beforehand. Roughing can be achieved:
- with sanding paper (grain P 80 – P120 for steel sheets or grain P 320 – P 500 for aluminium sheets)
- with wire brushes
- for sand blasting units only using sharp blasting sand such as aluminium oxide, emery or quartz (glass and metal beads are unsuitable)

We recommend always blasting on both sides due to the risk of warping. Blasting on both sides, however, is not suitable for smaller thicknesses or larger sizes, as it results in irreversible deformation. Repeated degreasing after each of these roughing processes is necessary.

Compared to mechanical pretreatment, chemical cleaning and etching is more effective, as it results in a better surface quality which is easier to control. Proceed as follows for degreasing and etching aluminium sheets and for degreasing steel sheets:

- Immerse the metal substrate in a commercially available alkaline degreasing and etching solution at approx. 50 °C. The immersion time depends on the type of metal and usually takes about five minutes.
- Remove the metal substrate from the solution and rinse it with water to remove any residue of the alkaline solution.
- Then apply a neutralisation bath in 5 % acetic acid.
- Dry with warm air before stacking.

Some adhesive systems require the substrate to be primed as a pretreatment for bonding. Priming and pretreatment should be conducted immediately after degreasing and directly before bonding. A primer contributes to an improved surface. The primer can be applied by machine or with hand-held rollers under normal operating conditions. Metal substrates have to be adapted to the processing temperature (room temperature) before priming to prevent condensation effects. The primer should be applied as per the manufacturer's instructions. Sufficient corrosion protection must be ensured.

When it comes to sawing and routing, HPL aluminium composite elements can be machined with tungsten carbide tipped (TCT) blades in the same way as HPL wood composite elements. The feed rate should be lower. HPL sheet steel composite elements can only be machined with metal saws, guillotine shears and nibblers. The special health and safety requirements have to be taken into account. Composite elements with a maximum HPL thickness of 1.0 mm and a maximum metal thickness of 0.8 mm can be punched cold. Preliminary tests to determine tool play have to be conducted.

It can be drilled with slow-running metal drills at a moderate feed rate, avoiding overheating. These composite elements must not be mounted rigidly, but must be provided with slack for dimensional changes by means of oversized drilled holes, washers under screw heads and a sliding film between the components.

Fasteners can be spot-welded onto the metal reverse side of the sheets (stud welding with tip ignition). For metal substrates with HPL on both sides, the HPL has to be removed in the areas where the stud is to be welded on. The minimum thickness of the metal support must be 1.5 mm. In addition to this, composite elements can also be attached with adhesive. To avoid corrosion, different metals should not come into contact.

For outdoor applications or in cases where narrow areas or surfaces of the metal substrate are exposed to moisture or corrosion, these parts must be protected.

## 2.6 Bonding

Bonding of HPL is of particular importance, as HPL can be bonded to different materials. The following chapter is dedicated to the optimum combination of HPL, substrate and adhesive. There are adhesives on the market which feature good adhesive strength and resistance to temperature as well as humidity. They are therefore very suitable for bonding HPL. The materials to be bonded as well as transport and application conditions must be taken into account when selecting a suitable adhesive system. Follow the health and safety regulations and accident prevention regulations when working with adhesives!

Processing and storing adhesives requires special care. The guidelines and data sheets of the adhesive manufacturers are therefore to be complied with in all details. If you have any questions about bonding and for new applications please contact the adhesives manufacturer.

The following types of adhesives are suitable: Dispersion adhesives (e.g. PVAc glues = white glues), condensation adhesives (e.g. urea, resorcinol and phenolic), contact adhesives (e.g. polychloroprene), reactive adhesives (e.g. epoxy, unsaturated polyester, polyurethane) and hot melt adhesives (e.g. polyurethane hot melt).

The expected moisture load of the bonding joints is classified as follows as per EN 204 (Classification of thermoplastic wood adhesives for non-structural applications):

D 1: Interior areas, maximum wood moisture content 15 %

D 2: Interior areas, with occasional short-term exposure to running or condensed water or to occasional high humidity, with the moisture content of the wood not exceeding 18 %.

D 3: 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

D 4: Interior areas with frequent long-term exposure to running or condensed water. Exterior areas exposed to the weather, but with suitable surface protection

The information on temperature resistance shown in the following tables applies only for short-term exposure of the glue joint. They must not be confused with long-term exposure of the composite elements (consisting of HPL, adhesive and substrate). The long-term durability of the composite element rather depends on type and class of the HPL, the substrate as well as on humidity and ambient temperature. Proper processing is always crucial. The manufacturer must always be contacted for special applications because the adhesives within the stated group have different properties and are under continuous further development.

## Table 7: Application of adhesives

| Adhesive type | Processing method | Comment | Typical application |
|---|---|---|---|
| **Dispersion adhesives:** | | | |
| PVAc adhesives<br>2-component PVAc adhesives | · manual (hand-held roller, trowel, etc.)<br>· automatic (roller) | Pressing using stationary press or clamp | Surface, edge |
| **Condensation resin adhesives:** | | | |
| Urea resin with high filler content Melamine/urea resin<br>Phenol/resorcinol resin | · manual (hand-held roller, trowel, etc.)<br>· automatic (roller) | Pressing using stationary press while applying heat | Surface |
| **Contact adhesives:** | | | |
| Contact adhesives without hardener<br>Contact adhesives with hardener<br>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 | Area and edge |
| **Reactive adhesives:** | | | |
| **1-component systems**<br>Polyurethane adhesives | · manual (hand-held roller, trowel, etc.)<br>· automatic (purpose-built roller, etc.) | 1-component systems require moisture from the surrounding materials. Use of heat shortens the processing time. | Surface, edge |
| **2-component systems**<br>Epoxy and polyurethane adhesives | | 2-component systems do not require moisture from the surrounding mate-rials. Use of heat may be required depending on the system. | Mainly surface |
| **Hot melt adhesives:** | | | |
| EVA<br>PO | · automatic | Application: Residential rooms | Edge |
| PUR | | Application: Mainly in areas with high levels of humidity and heat | Surface, edge |

The guide values in the following table refer only to the adhesive gap.

Table 8: Durability of the adhesives (based on experience)

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

(1) The stated values refer to a short-term load
(2) Substrate and edge protection have to be suitable for the respective expected exposure

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

### 2.6.1 Bonding processes

Both sides of the HPL and the substrate must be thoroughly cleaned immediately before bonding so that it's free from any release agents, particles and rough debris which could show on the surface after bonding. Grease and oil stains can be removed using suitable solvents – do not use nitrocellulose thinner (observe accident prevention regulations!).

As a rule, test bonding is recommended under the local conditions. The safety regulations must be observed for working with adhesives, solvents and hardeners.

### 2.6.2 Adhesive application and pressing processes

The adhesive always has to be spread evenly across the surface. It has to be ensured for composite panels that the amount of adhesive applied is the same on both sides in order to avoid warping. This is particularly important for water-based adhesive systems. In this case the amount of adhesive applied should therefore be kept as small as possible in this case. Adhesive can be applied by hand using a notched trowel or a hand roller, or automatically using glue application machines. Four-roller machines ensure especially uniform adhesive application and accurate dosing.

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

### 2.6.3 Pressing temperature

The safest pressing temperature for stress-free composite boards is 20 °C. Higher temperatures allow a reduction of pressing time. However, 60 °C should not be exceeded because the dimensional changes of the HPL in contrast to the substrate depend on temperature. This avoids increased stress which leads to warping and changes in the surface. The manufacturer's information has to be observed.

### 2.6.4 Dispersion adhesives

Dispersion adhesives generally use water as the mobile phase (dispersing agent) which contains the adhesive components as a dispersion. The water content generally lies between 40 and 70 weight percent. After application to the surface to be bonded, the dispersing agent penetrates into the work pieces or evaporates into the environment or the pH value changes, causing the dispersion to break. This causes the adhesive components to make contact and form a film which can connect the two work pieces. Today, aqueous dispersion adhesives are often used as a substitute for solvent adhesives. They are neither a fire or explosion hazard nor do they release solvents. However, water-based adhesives require more time or more energy for hardening.

Dispersion adhesives are e.g.:
- PVAc adhesives
- 2-component PVAc dispersion adhesives
- Low and even application of adhesives as well as compliance with the pressing temperatures and times have to be ensured.

### 2.6.5 Condensation resin adhesives

Condensation resin adhesives are in the group of adhesives which have to be processed with a minimum of 2 to 4 bar bonding pressure in order to allow multi-layer and composite layer bonding. This allows the joining of different types of materials. The adhesive batches require corresponding additives (e.g. flours) for elastification of the glue line. They also produce a visually more uniform surface. Different types of hardeners allow a larger variation of bonding and pressing parameters. Impurities on the surface caused by adhesives and hardeners have to be removed before bonding, otherwise they can no longer be removed later without damaging the surface. Release agents applied to affected areas prevent adhesive residue on the surface of the HPL and bonding plates. Phenol and resorcinol resin adhesives are also used for manufacturing composite boards with increased resistance to flames.

Condensation adhesives are e.g.:
- Melamine/urea resin
- Phenolic resin
- Resorcinol resin

**Hot presses:** Single and multi-opening presses, short cycle presses, double belt presses.

Please note that low and uniform application of the adhesive as well as observing the pressing temperatures, pressures and times is required.

### 2.6.6 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 after a certain time, which greatly increases their strength. First a uniform layer of adhesive is applied to both bonding surfaces. Pieces are left for the solvent to evaporate until the adhesive feels dry, that means it is no longer tacky when touched and only has a low level of immediate adhesion. As with solvent adhesives, at least one of the surfaces which are to be bonded has to be permeable to solvents, otherwise it can take a very long time until the adhesive reaches its final strength.

The adhesive can be applied by hand using a notched trowel and automatically with spray units (hot or cold). In addition, these adhesives can be applied to HPL and substrate using pouring units. When applying adhesives with a notched trowel, the directions of application on substrate and HPL have to be at right angles. Sufficient curing is important (finger test!). Open time can be reduced by accelerated drying of the adhesive films, ensuring to avoid overdrying. Contact adhesives require short but firm contact pressure to ensure safe bonding. This can be done e.g. with a hand-held pressing roller and or a roller press for narrow areas. Care has to be taken that no stresses occur in the material when bonding substrate and HPL.

### 2.6.7 Reactive adhesives

Reactive adhesives consist of usually two different substances which are joined to produce a bond in order to form a new plastic in a chemical reaction (polymerisation). This in turn bonds the workpieces together when it hardens. Examples for reactive adhesives are the 2-component adhesives made from epoxy resins or acrylate resins as well as the 1-component adhesives made from cyanacrylate and polyurethane, which require moisture for hardening.

Reactive adhesives are mainly used for special bonding applications. Due to the large number of different types, it is not possible to give general recommendations for processing. If you have any questions about bonding, please contact the technical field service of your adhesives manufacturer.

### 2.6.8 Hot melt adhesives

Hot melt adhesives are used in many areas due to their high processing productivity and their environmentally friendly properties (no solvents). These adhesives can be found in almost all areas of modern production (surface laminating, edge laminating, production of abrasive materials, furniture manufacturing, car manufacturing, etc.). Hot melt adhesives differ in their chemical composition, which also determines the use of the product. There are ethylene vinyl acetate (EVA), polyamide, polyester, polyolefin and polyurethane hot melt adhesives. Reactive polyurethane hot melt adhesives are very frequently used for laminating different substrates with HPL.

Hot melt adhesives are available in different containers, depending on their chemical composition. EVA, polyamide and polyolefin adhesives are often supplied as 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 vapour diffusion tight packaging, preventing humidity from entering during the stated storage time. Protective gas can be applied to the adhesive sticks in their packaging or they can be protected with vacuum packaging. They are applied using hot glue devices with heated hoses and application heads.

**Table 9: Adhesive table**

see flap on rear cover

## 2.7 Machining and processing of substrates finished with HPL

After correct covering and bonding, the HPL can be machined further together with the substrate.

The surface of HPL consists of high-quality melamine resins, which makes it relatively hard. Tool wear is greater than with most wood-based products. Tools with TCT blades have proven to be very suitable. Polycrystalline diamond blades are also suitable for standard machining processes. Machining of unbonded sheets should be carried out on a flat, solid surface.

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 HPL. For machine tools it is possible to use flat bearing surfaces with grooves instead, in order to keep the contact area with the HPL as small as possible. No base is required for tables with air cushion support.

Avoid any vibration and fluttering of the sheet. Sharp blades and smoothly running tools are essential for flawless working. Breaking, splintering or bowing of the decorative side are the result of incorrect machining or unsuitable tools. The resulting grooves can lead to the formation of cracks on composite elements.

All corners of cutouts and inner openings on composite panels and HPL-Compact should be rounded. The inner radius should be as large as possible: For cutouts up to 250 mm side length, the corners have to have a minimum radius of 6 mm (see fig. 23, p. 72).

### 2.7.1 Cutting HPL to size with and without substrates using hand-held tools

Use a guide or stop bar to obtain straight cuts with a hand-held circular saw. Cutting has to be carried out face-down to avoid chipping on the visible edge. Please note the blade projection for portable circular saws with plunge function.

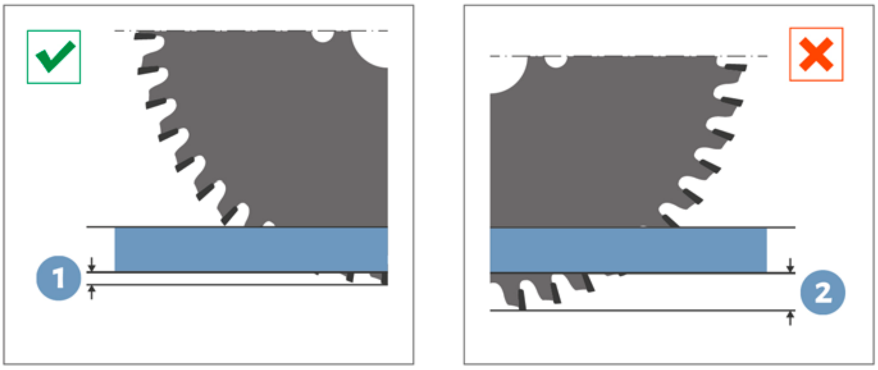



**Figure 11: Saw blade projection on portable circular saws**

1. Clean cut with approx. 3 – 5 mm projection
2. Cut with tears with > 5 mm projection

Jig saws are only suitable with the correct saw blades and reworking of the edge. Cutting has to be carried out face-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.

### 2.7.2 Splitting with fixed circular saws and sliding table saws

For a good result when splitting with fixed circular saws and sliding table saws, the decorative side has to be face up. The quality of the cut edges depends on the height adjustment of the saw blade, among other things. The ideal height depends on the thickness of the HPL and the circular saw blade which is used.

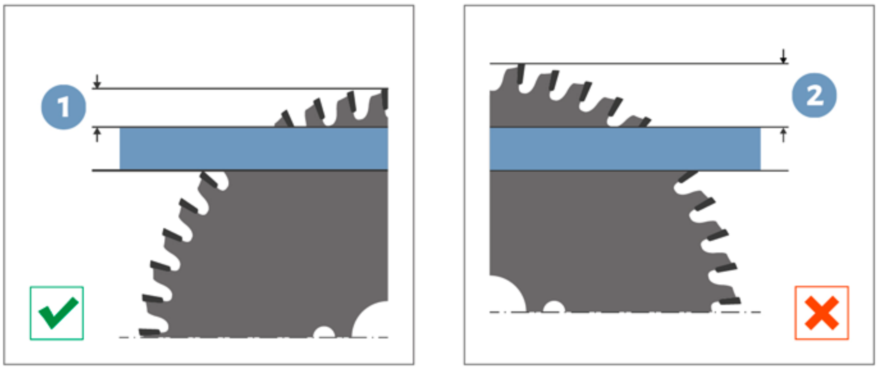



**Figure 12: Saw blade projection for fixed circular saws and sliding table saws**

1. Clean cut with approx. 10 – 15 mm projection
2. Cut with tears with > 15 mm projection

The HPL has to rest on the cutting table securely and flat. It has to be held down firmly in the area of the saw blade to prevent fluttering. A pressure beam or a pressure bar should be used.

The quality of the cut edge mainly depends on:

- Quality and condition of machine and circular saw blade
- Tooth shape
- Number of teeth
- Cutting speed
- Feed rate

HPL sheets can also be cut in stacks.

Four types of circular saw blades are commonly used for cutting HPL, HPL-Compact and HPL composite elements:

Flat top is the simplest tooth shape which can achieve good results. Flat top is easy to use and allows economical sharpening.

Alternate top bevel 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 very good edge quality at the start side. Easy to use and economical sharpening.

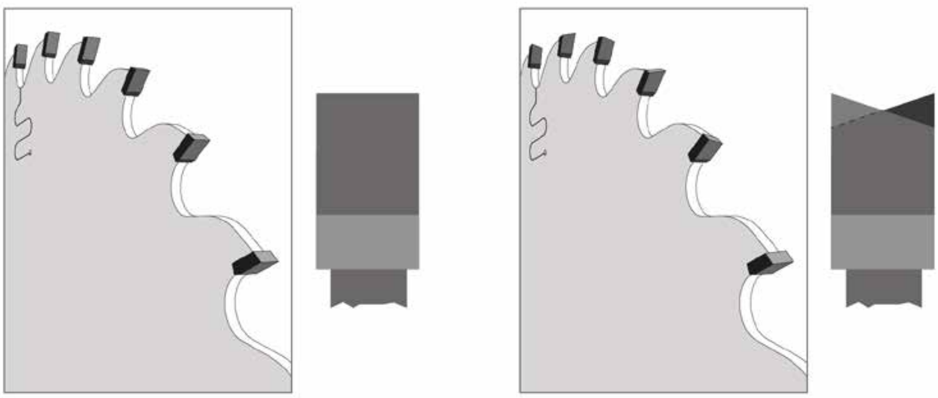


**Figure 13: Flat tooth (left) and alternate top bevel (right)**

Trapezoidal/flat tooth, which can also be sharpened, 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.

Top tooth/hollow tooth 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. Especially suitable for machines without scoring unit. We recommend having sharpening carried out only by certified specialist companies.

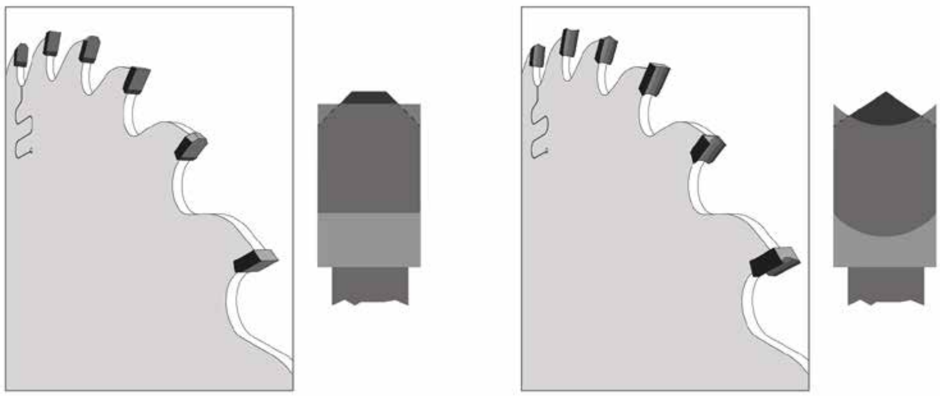


**Figure 14: Trapezoidal/flat tooth (left) and top/hollow tooth (right)**

### 2.7.3 Cutting speeds and feed rates

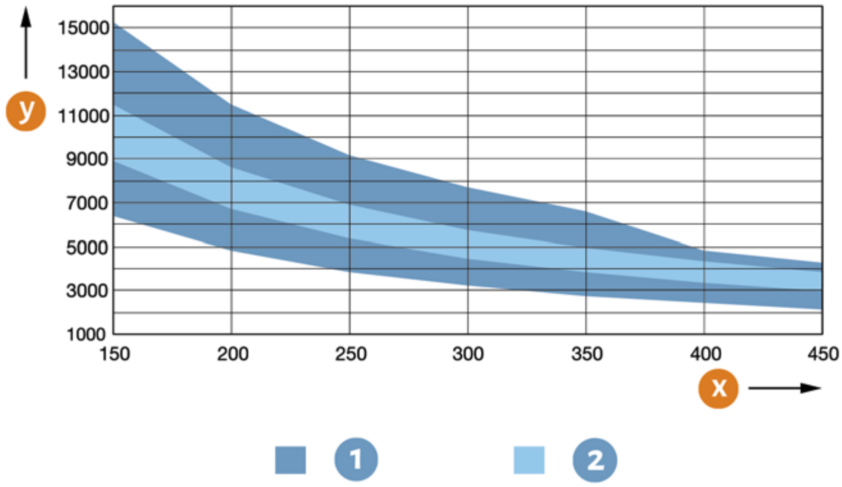



**Figure 15: Speed diagram, maximum operating speed, recommended operating speed**

(y) Speed n [rpm] as a function of (x) circular saw blade diameter D [mm]

(1) Maximum operating speed | (2) Recommended operating speed

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

$v_f = n \times Z \times f_z / 1000$

Z: No. of teeth | n: Speed | $f_z$: Tooth feed rate.

Recommended for HPL: $f_z = 0.03 – 0.06$ mm

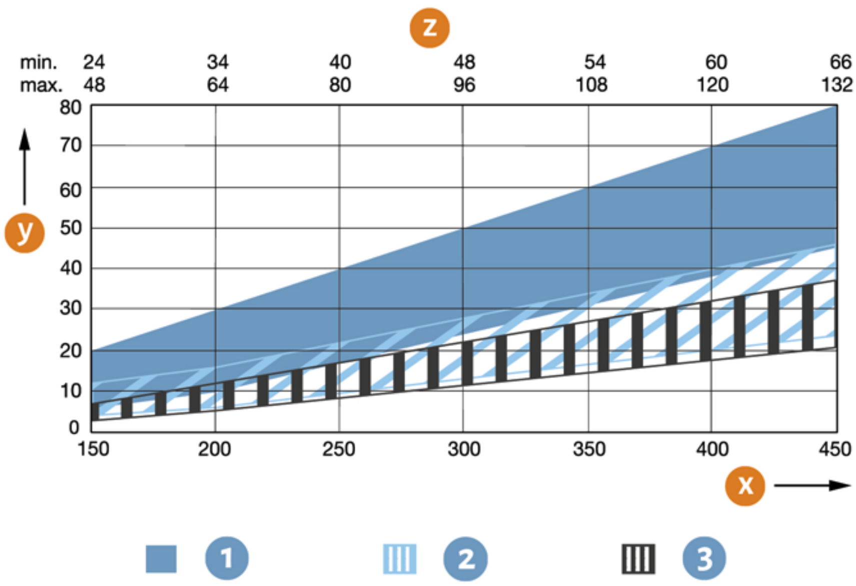



**Figure 16: Cutting height diagram**

(y) Cutting height h [mm] as a function of (x) circular saw blade diameter D [mm] with associated, (z) of teeth Z [-] | (1) Solid wood | (2) Wooden materials | (3) HPL

### 2.7.4 Drilling in HPL composite elements and HPL-Compact

#### Drilling tools

Drills for plastic materials are the most suitable for drilling in HPL. These are spiral drills with a point angle of approx. 60 – 80°, rather than 120° for normal metal drills. They also have a steep pitch with a large chip space. HSS drills are recommended for hand-held tools, TCT drills for machines with mechanical feed. Feed rate approx. 1500 – 3500 rpm. Multi diameter or step drills are suitable for stepped holes with different diameters, while cylindrical drills are suitable for holes with larger diameters.

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

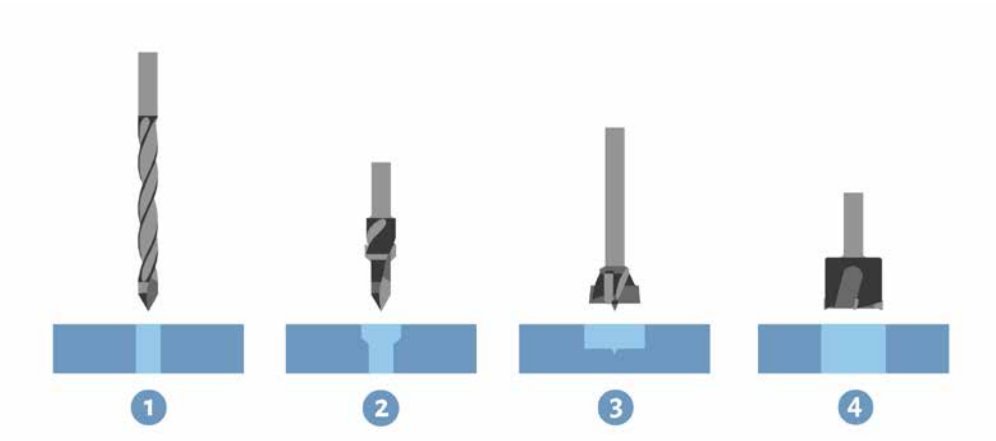



**Figure 17: Drill types**

1 Spiral drill | 2 Stepped drill | 3 Cylinder head drill | 4 Circle

## Drilling technique

The penetrating speed of the drill has to be adjusted to avoid damaging the HPL. The cutting speed for HSS drills is approx. 0.8 m/s, for TCT 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 HPL base can prevent buckling of the material at the exit point of the drill. Even better results for series production 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.

### 2.7.5 Treating cut edges and profiling

**File, sand paper**

Files are suitable for edge finishing. Always file from the decorative side towards the substrate. Fine files or sand paper (100 – 150 grit) can be used for breaking edges.

**Hand Planes**

Hand planes can also be used for edge finishing. It is recommended to use metal planes with HSS blades, where the contact surface does not wear out when sliding along the sheet edge. The cutting angle of the blade should be approximately 15 °.

**Edge finishing with hand-held routers**

Hand-held routers are mainly used for trimming protruding sheet edges. The handheld router has to be covered with a non-abrasive material to protect the surface during sliding. Dirt particles and routing shavings always have to be removed carefully.

- Routing tool diameter: approx. 10 – 25 mm
- Speed: 20000 rpm
- Cutting speed: 10 – 25 m/s

Routing cutters with single or double flute TCT cutters are recommended, for larger diameters those are also available with reversible plates. Height-adjustable routing cutters with axially parallel blades are preferable because they allow more efficient use of the tool. The edges are broken afterwards. The sheet should only protrude as much as necessary (2 – 3 mm) to avoid unnecessary strain on the tool.

**Edge finishing with stationary machines**

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

- With axially parallel blades for sheets covered on one or both sides
- With diagonal blades on one side for sheets covered on one side
- With diagonal blades on both sides for sheets covered on both sides

A speed of 12000 rpm is preferable when routing HPL up to approx. 5 mm thickness and a tool diameter of e.g. 100 mm (Note: the maximum speed of the tool used!). This is equivalent to a cutting speed of 60 m/s. Lower tool speeds are recommended for HPL composite elements (approx. 3000 – 6000 rpm, equivalent to 15 – 30 m/s). The tool life depends on the height setting of the tool location and shape, required cutting quality and substrate. For large quantities it is advantageous to use tools with polycrystalline diamond cutters.

Bench routers can be used with single or double flute TCT cutters, also with interchangeable blades, at an ideal cutting speed of 10 – 15 m/s. This tool is also used for cutouts. HPL-Compact and HPL composite elements can only be routed properly if clamping devices are used. 2 mm allowance per edge is sufficient in most cases. For curved edges, it is often advisable to pre-cut the approximate shape to avoid excessive routing.

A surface planer (with a feed rate of 5 – 15 rpm, a cutting speed of 12 – 15 m/s and a speed of 3000 rpm) is only of limited suitability due to the short service lives of the usual blades. TCT blades should be used for larger quantities.

Edge-banding machines play an important role. With feed speeds of 10 – 32 m/min they are recommended particularly for order-specific 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 a edge banding section. Edge finishing consists of a cutting unit, a pre-routing unit, a profiling or alternatively an external routing unit as well as scraper, sanding or polishing units for producing the edge finish. Jointing cutters with polycrystalline diamond cutters (PCD) are recommended for joining the workpiece edges.

Double-end profilers in the classic sense consist of two parallel routing units which can be independently moved using an adjusting system. After the routing units, a laminating system can be directly linked to the system. The maximum feed speeds mainly depend on the type of edging tape and range from approx. 20 m/min for solid wood banding and sophisticated soft forming edges and approx. 40 – 60 m/ min for plastic edges (1 – 3 mm thickness) to 120 m/min for thin edges (melamine paper edges with 0.3 – 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, equipped with PCD.

### 2.7.6 Edge finishing for HPL composite elements

The edge finishing material is selected depending on the requirements for appearance, function and usage properties of the finished workpiece edge.

- Edges/narrow areas on high-use worktops (e.g. kitchens, canteens, laboratories)
- Edges on areas with normal use in residential and commercial areas (e.g. table tops)
- Edges on areas with less use in kitchens, bathrooms and sanitary rooms (e.g. storage areas)
- Edges in wet/damp rooms (e.g. changing rooms, window ledges)
- Edges in areas with hygiene requirements (e.g. in medical facilities)
- Edges with purely decorative function (e.g. decorative edges)
- Edges as coverings without visual/mechanical requirements (e.g. blind edges)

**Possible edge materials**

Edging materials are available in different structures and formats (e.g. sheets, strips, rolls).

Thermosetting plastic edging can be postformed. If the rear side of the edging is treated with hot melt adhesive, bonding agent or a self-adhesive coating, edging can be processed with simple tools and devices.

HPL edging is made of the same material as the element surface and can offer an identical or contrasting colour and texture. For better adhesion, melamine edging is sanded at the rear or supplied with a special, unsanded rear side without resin.

Polyester edging is manufactured in single-layer or multi-layer versions up to 1 mm thickness. The rear side can be smooth, rough or pre-coated with hot melt adhesive.

Single-layer edging can be placed around lightly rounded narrow element surfaces, even without heat application (soft forming process).
Double-layer edging consists of an impregnated base paper and a painted decorative paper (finish film) which are joined with different binding agents.

Thermoplastic edging made of plastic such as PVC, ABS, PP or PMMA are available in a variety of designs. These are up to 10 mm thick and can have a corresponding treatment on the rear side for adhesion (e.g. primer application).

Solid wood edging can be used for design effects and there are virtually no limits to profiling and processing options.

Primer edging consists of resin-saturated paper sheets, are cured and have no finished surface. A coat of paint or varnish is usually applied after the edging has been applied.

It is also possible, however, to use aluminium edging tape, paint coats, moulded polyurethane edging or premade cover profiles (e.g. made of metal).

### Edge finishing for different substrates

Different substrates can be used for manufacturing HPL composite elements. The following instructions have to be observed when coating the respective edges.

It is of the utmost importance that the edges of the substrate are clean and even. Otherwise, uneven surfaces or even incomplete adhesion can result.

All wooden materials with sufficiently solid cut edges are suitable.

For lightweight construction panels, i.e. workpiece edges on porous substrates (e.g. foam boards), the effective adhesion area has to be at least a third of the total edge area, with even distribution of the voids. If the adhesion area is smaller (e.g. honeycomb panels), this can be achieved with a pore-filling primer, foam-filling of the voids, a supporting edge or a frame structure.

No generally applicable statements can be made for mineral and metal substrates due to the large variety of materials. Edges on metal substrates are usually not finished. We recommend always consulting the substrate manufacturer.

**Table 10: Suitability of adhesive types for bonding the edging materials**

| | Dispersion adhesives (1) | Condensation resin adhesives | Solvent adhesives | Reactive adhesives | Hot melt adhesives (2) |
|---|---|---|---|---|---|
| **HPL edging:** | | | | | |
| from sheets as per EN 438 | ● | ● | ● | ● | ● (3) |
| **Melamine edging, multi-layer:** | | | | | |
| melamine both sides, rear side sanded | ● | ● | ● | ● | ● |
| melamine on one side, rear side not sanded | ● | ● | – | ● | – |
| **Polyester edging, multi-layer:** | | | | | |
| with smooth rear side | ● | – | – | – | ● |
| with rough rear side | ● | ● | ● | ● | |
| multi-level with pretreated reverse side | ● | ● | ● | ● | ● |
| **Single-layer edging (made from urea/acrylic resin):** | | | | | |
| with smooth rear side | – | ● | ● | ● | ● |
| with rough rear side | ● | ● | ● | ● | ● |
| **Doubled and primer edging:** | | | | | |
| made from melamine, polyester, acrylic resin | see edging types above | | | | |
| **Thermoplastic edging:** | | | | | |
| made of PVC, ABS, PP, PMMA | ● | – | ● | ● | ● |
| **Solid wood edging:** | ● | ● | ● | ● | ● |

(1) For the cold bonding activation process with pre-coating
(2) For polyamide hot melt adhesives, a primer coat with special bonding agent is recommended
(3) If necessary, pre-coating with bonding agent

**Edge sealing**

In addition to the decorative function, the edges on HPL elements primarily have the function of protecting the substrate against moisture. For this reason, the edge protection has to be attached to the workpiece on all sides. The following list contains a selection of options for edge protection ("E") and for special designs ("EE").

**Edge protection "E"**

- HPL edges
- Polyester edges
- ABS edges
- PVC edges
- PP edges
- Melamine edges

**Edge protection "EE"**

- Special paint systems for sealing
- Hardwood inset edging tape (5 mm), sealed
- Plastic inset edging tape (e.g. made from HPL-Compact)
- Cast resin
- Sealing compounds

The edge materials listed under "E" can be used as edge protection "EE" if the edges of the substrates (e.g. chipboard) were sealed first and the sealing permits bonding of the edges. We recommend consulting the manufacturers of the listed materials as to whether these are suitable for the respective intended use.

### 2.7.7 Edge bonding

Hot melt adhesives are processed on machines using the hot-cold process. This creates a bond through the physical process of cooling. When refilling adhesive, it has to be ensured that the required temperature in the melting tank is maintained. Adhesive residue and contaminations have to be removed from the walls and ceiling of the melting tank at regular intervals. The residue would cause the adhesive temperature to be lowered. The processing temperature of the adhesive in the adhesive tank and on the application roller has to be reduced to the temperature recommended by the adhesive manufacturer when the edge banding machine is at a standstill (e.g. during work breaks), otherwise the adhesive will degrade. The applied adhesive quantity depends on the texture of the substrate edge. Porous workpiece edges with many voids require a higher adhesive quantity to ensure reliable bonding of the edging material. If the substrate or the edging material is too cold, the hot melt adhesive layer will cool down suddenly, resulting in incomplete adhesion. A draft in the room after adhesive application can also cool down the boundary layer (skin formation). Preheating the edging material with an infrared radiator, heating bar or hot air fan directly before passing it through the machine can be beneficial in this case.

The following factors have a crucial influence on the quality of the adhesion:

- clean, dust-free and grease-free adhesion surfaces
- moisture content of the edging material
- selection of the hot melt adhesive types suitable for the edging material
- processing temperature of the hot melt adhesives
- material temperature and the room temperature
- feed rate of the edge banding machine
- other parameters (e.g. sufficiently high and even roller pressure parallel to the edge of the workpiece)

Laser/plasma processes have been developed as an alternative to the conventional bonding methods. Functional layers adapted to the process are applied to the rear side of the edging by the edging manufacturer. Afterwards, the processing company activates the functional layers using special machines. This creates an almost seamless transition between board and edge.

For the thermal activation process (cold bonding activation process), modified PVAc adhesive is applied to the workpiece edges in the edge banding machine using adhesive rollers or spray units. The adhesive is then dried and activated with hot air or infrared radiation. The pre-coated edging material with activated adhesive layer is then introduced. The two activated adhesive films are then bonded together in the pressure zone (rollers or belt). Immediate further processing is possible. Cleanliness must be ensured during processing. We recommend applying a suitable release agent to the workpiece surface to prevent adhesive residue from adhering to the surface.

For stationary methods, the edging material is pressed on either with edge presses, bonding wheels or stands or using c-clamps with a rigid support layer. The adhesive is applied to the workpiece edge cold with a brush or roller. The applied quantity has to be selected so that the evenly applied adhesive sufficiently fills the porous workpiece edges and wets the full surface of the edging material. The applied edging material is pressed on with the recommended tools. Excessive contact pressure can result in uneven surfaces. Excessive temperature can result in surface damage on the edging material. If PVAc or condensation resin adhesives are used, the curing times can be reduced with heating bars. The temperature of the heating bar depends on the adhesive type used. The actual temperature of the heating bar can easily be checked with melting salts or heat sensitive pens. Processing solvent adhesives requires special care. The adhesive is applied to the substrate material and edging material using a brush or spray gun. A primer coat is recommended for strongly absorbent workpiece edges. Thorough curing (finger test) before joining the workpieces is important; the contact pressure should not be below 0.5 $N/mm^2$.

### 2.7.8 Postforming

Postforming is a special processing method for HPL. The process aims to produce technically and visually flawless composite elements, whereby wooden materials are preferred. The required HPL with postforming capability has the same structure as standard HPL. Postforming HPL allows forming of concave and convex curves with relatively tight radii. This forming capability opens up special design options and expandable areas of application:

- Soft, joint-free contours can be achieved with postforming HPL sheets.
- Rounded edges meet increased safety requirements and are less sensitive to impacts.
- Elements with joint-free curves are easy to clean. Ingress of moisture is prevented. These elements are more hygienic as dust and dirt accumulation on the edge is prevented.

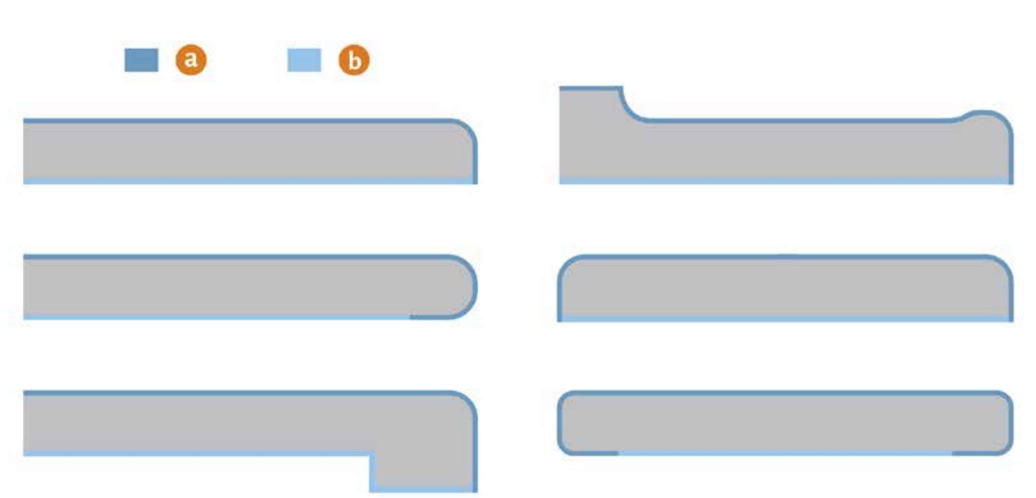



**Figure 18: Postforming elements**

a HPL | b HPL balancing

For all postforming processes, the HPL sheets have to be heated to the temperature required for forming in the forming area. The heat source and its activation period have to be chosen depending on the selected process. The selection essentially depends on:

- form and radius of the desired curve
- available machines
- desired degree of completion
- batch size
- economical considerations

In practice, two processes are used:

- Pre-forming the HPL with subsequent bonding to the substrate (separate work step)
- Full-surface bonding of the HPL with subsequent forming of the protruding HPL while simultaneously bonding the curves (stationary or continuous)

Convex curves can be achieved with all processes mentioned. The pass-through method is ideal for series production.
Concave curves can usually only be achieved with stationary methods.

### 2.7.9 Material properties and formability of postforming HPL

Postforming HPL generally have a thickness of 0.5–1.2 mm and allow a bending radius of at least 10 times of the sheet thickness. These values apply to convex and concave curves parallel to the HPL sanding direction. These radii have to be at least 20 times of the sheet thickness, at 90° to the sanding direction.

It is especially important to store postforming HPL under normal climate conditions (18 – 25 °C and 50 – 65 % relative humidity), as incorrect storage has a negative influence on the bending properties. Excessive drying results in a marked deterioration of the bending properties. In addition, the bending properties of the HPL can deteriorate through material ageing over time.

### 2.7.10 Forming and processing technology for postforming HPL

The forming area of the postforming HPL has to be heated to the forming temperature recommended by the HPL manufacturer. The selected process and with it the relationship between applied heat quantity, energy type and application time mostly determines the behaviour of the HPL material during forming. The heat can be applied with infrared radiators (medium, long or short wave) or heating bars. Exact temperature control of the HPL in the forming area is therefore indispensable (e.g. temperature sensor, optical measuring systems). If the defined temperature is exceeded, delamination (bubbles) can occur in the HPL. If the temperature is too low, cracks can form.

Reaching and maintaining the temperatures required for forming are essentially influenced by the following factors:

- Radiator type (wavelength)
- Radiator output
- Radiator distance from work piece
- Heat absorption of the HPL depends on colour, surface design and thickness
- Adhesive type and quantity in the curved section
- Temperature of the substrates and the HPL
- Feed rate or forming speed

The forming speed essentially depends on the applied energy quantity, the thickness and sanding direction of the HPL, the radius of the curve to be formed and on whether it is concave or convex. Fastest possible heating of the HPL and a rapid forming process are crucial. It is important that the required contact pressure is applied evenly during forming.

Due to the complex parameters, we recommend that users discuss the process beforehand together with the HPL, adhesive and machine manufacturers. Forming trials and quality tests are required at regular intervals.

### 2.7.11 Preforming HPL with postforming capability with subsequent bonding

**Forming over heated bars (contact heat)**

For forming over heated bars, the HPL is clamped to a sturdy fixture. A heated rail with the desired forming radius is attached flush with the front edge. The heated rail has to ensure a constant temperature. The postforming HPL is clamped in the bending fixture accordingly. The area to be formed has to protrude over the heated rail. When the HPL has reached the required forming temperature, a pressure roller is slowly rolled over the protruding HPL area.

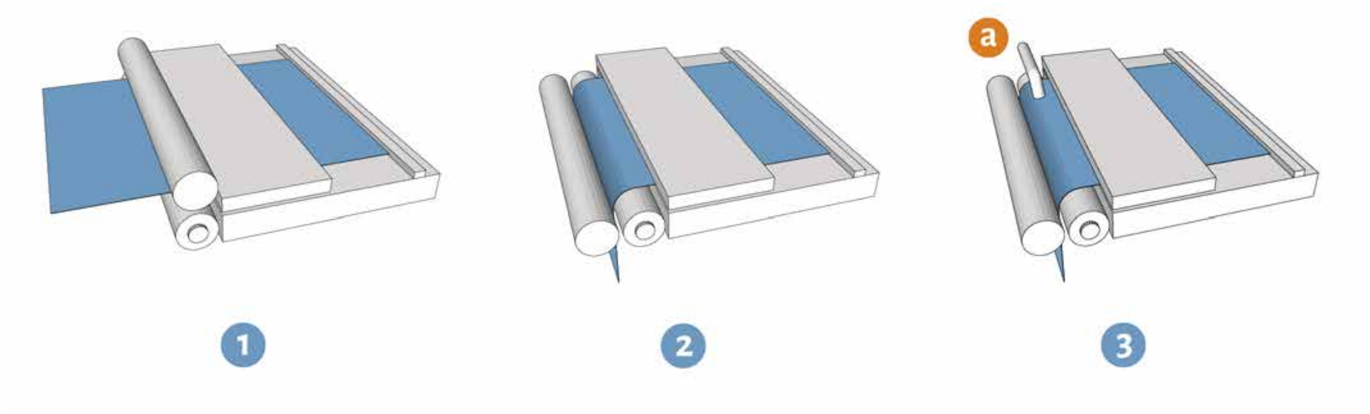



**Figure 19: Stationary forming over heated bars (contact heat)**

1 Heating using contact heat | 2 mechanical forming | 3 curing with a cold air supply

**Forming with heated bars (infrared)**

HPL can be formed in a single-stage or two-stage process by using an infrared radiator. In the two-stage process, the material is heated in the first step with an infrared radiator in the area to be formed later on. Immediately after reaching the required forming temperature, the part is placed in a fixture which consists of a holder and a bending flap. The fixture should be made of wood to avoid accelerated heat dissipation. The mould has to be formed in such a way that overforming is prevented. Forming has to take place immediately after insertion of the HPL into the fixture, in which cooling takes place afterwards.

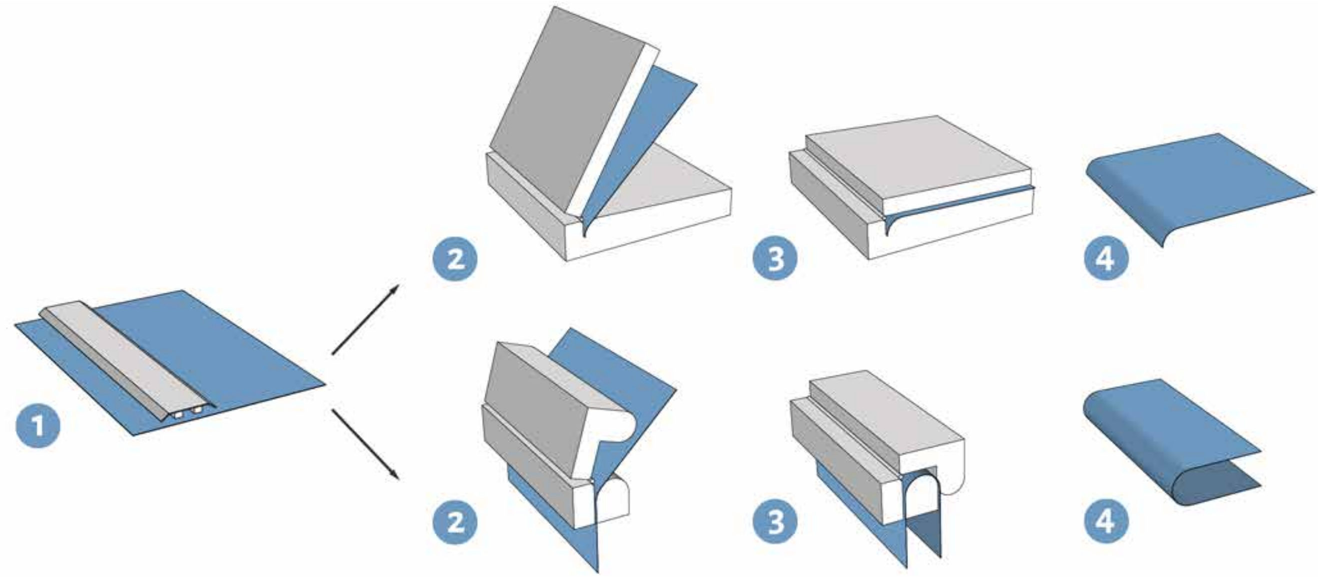



**Figure 20: Stationary forming using infrared radiators**

1 Heating | 2 Forming | 3 Cooling | 4 Postformed HPL

**Forming with heated bars (infrared) in a machine**

For the single-stage process, the HPL is clamped to a sturdy fixture. The HPL area protruding over a mould is heated with infrared radiators. Immediately after reaching the required forming temperature, the infrared radiator has to be swivelled out of the forming zone and the HPL has to be formed with a manually or automatically operated flap. Then the postformed HPL has to cool down in the fixture.

**Bonding of preformed HPL**

Only the recommended adhesives may be used for bonding preformed HPL. The required contact pressure can be generated either with corresponding negative moulds or by applying a vacuum (vacuum bag).

### 2.7.12 Stationary forming and bonding curved shapes in a single step

Stationary forming and bonding curves in a single step corresponds to the method described above. The only difference is that instead of the mould, the substrate – a chipboard with the desired curve – is used. First, the HPL is bonded to the flat surface of the substrate. For this, the HPL has to protrude over the substrate with the required width. The remaining area of the substrate and – depending on the adhesive type – the protruding HPL area have to be coated with suitable adhesives.

**Forming with heated bars (contact heat)**

Forming HPL and bonding to the substrate are achieved with a flat, heated, movable bar under pressure. This forming bar heats the HPL to the required forming temperature using contact heat. Under constant pressure, this bar automatically follows the respective profile and connects the HPL to the workpiece. The speed for the motion sequence during the bending process can be adjusted and can be adapted to different surface materials. This allows the required forming temperature to be optimised to the forming process.

### 2.7.13 Continuous forming and bonding curved shapes in a single step

The following processes are only suitable for producing convex curves. All currently known pass-through processes use the same principle and only differ in the use of different adhesives and the consequently required special machine equipment. The postforming HPL is first bonded to the large surface area of the substrates. These parts then run through the forming machine which can be adjusted to the required width.

When they run through the machine, generally suitable adhesives are first applied to the rear side of the protruding HPL and the routed profiles of the substrate sheets. Then, the areas to be formed are heated to the required forming temperature with infrared radiators and guided around the profile of the substrate sheet using a forming rod. In the final phase, profile rollers press the HPL into the final shape and generate the contact pressure between substrate and HPL required for bonding.

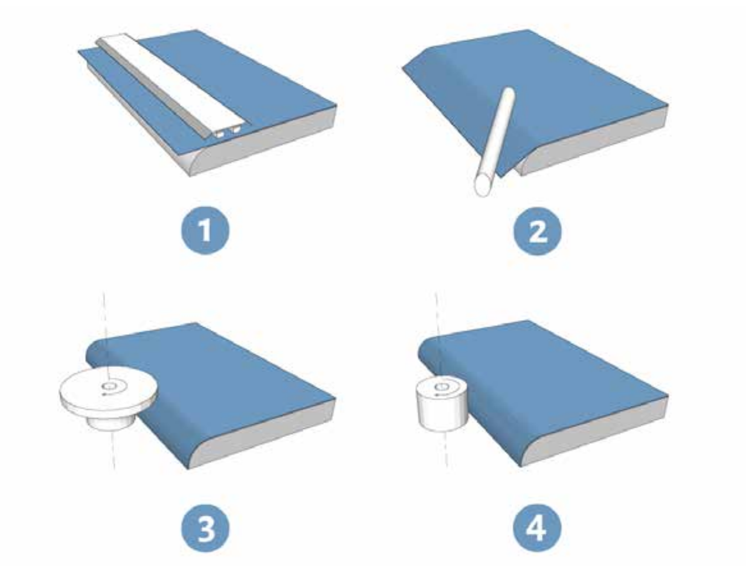



**Figure 21: Continuous forming with infrared radiator**

1 Heating | 2 and 3 staged forming process | 4 Cooling

### 2.7.14 Producing curved shapes on full-surface bonded HPL

To achieve concave curves, the radius to be bent has to be freely accessible. This can be achieved by e.g. routing or grooving the substrate beforehand. The areas to be shaped are heated with infrared radiators or heated bars. The formed area is stabilised by applying cast resin or a correspondingly profiled inset edging tape.

For convex curved shapes, the substrate is routed according to the rounding before bonding. The required spacing between the parts can also be achieved by inserting a spacer bar. After this preparation, the HPL can be bonded to the surface. After bonding, the rear side is routed accordingly or the spacer bar is removed. The adhesive has to be applied to the joint from the underside before forming the HPL. Then the HPL is heated to forming temperature and the convex shape is produced. The two workpiece halves are held together by a clamping device until the adhesive has cured. Hollow spaces in the curved area should be filled with suitable cast resins.

### 2.7.15 Machining the workpieces

Cut edges without tearing or damage on parts with curved shapes on both sides can be achieved with up-milling or down-milling machines which can be swivelled in the entry area. Formed composite elements with concave curves can only be joined with miter cuts.

## 2.8 Worktops

Worktops with modern decorative surfaces have become firmly established in kitchens and shops. Due to their excellent properties and hygiene benefits, they meet the highest requirements, especially when it comes to design in combination with the requirements for contact with food. HPL meets the strict legal guidelines for food hygiene. The following basic rules apply for machining and installing worktops with HPL surfaces.

### 2.8.1 Structure of a worktop

The “worktop” composite element essentially consists of a wood based substrate (primarily with a thickness of 28 or 38 mm). It is equipped with HPL on the top side and with a suitable balancing (to protect against steam and water influence) on the underside. On postforming worktops, the transition between the HPL and the balancing is protected against ingress of moisture or water with a sealing coat. In addition, there is an option of applying suitable edge banding to the edges of the worktop.

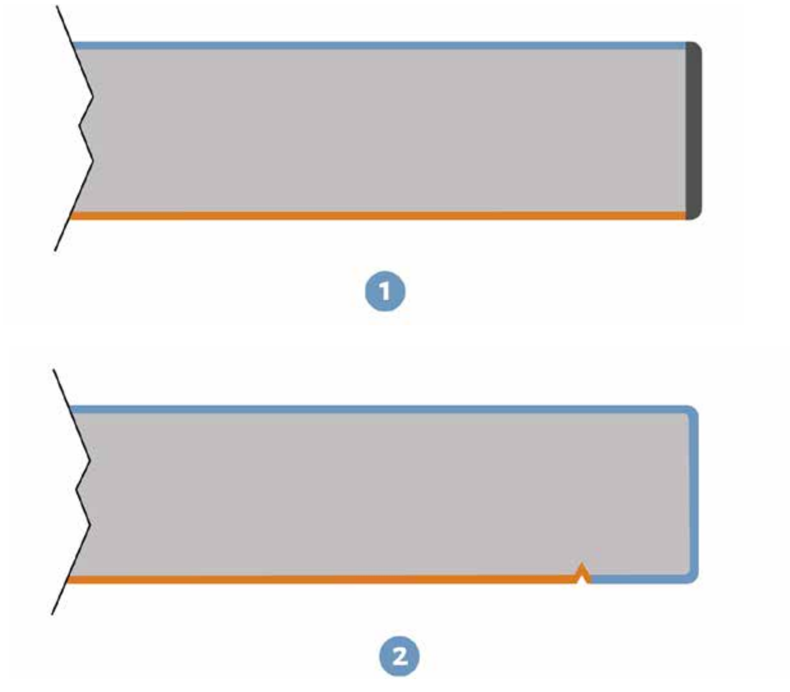



Figure 22: Worktops

1 Worktop with bonded edge | 2 Worktop with postforming profile

### 2.8.2 Machining and design options

The “worktop” HPL composite element allows the use of all general wood machining tools. All complex solutions can be implemented, resulting from the installation shapes of hobs, sinks, etc. but also from the ideas of modern kitchen design. This combination of simple mechanical sturdiness on site and the adaptation to local conditions cannot be rated highly enough. Many other materials – especially those based on inorganic raw materials – do not have these additional benefits. Visually appealing results can be achieved with the combination of worktop elements with other materials (e.g. edge banding, end strips, metal feet).

**Routing, drilling, sawing**

For all routing, drilling and sawing work on the worktop, a sufficiently rigid supporting surface has to be ensured, so that no breaks or tears occur in narrow board sections.

Cutouts and inner openings are required in the worktop for installing hobs or sinks and for pipe openings. The corners always have to be rounded. The inner radius should be as large as possible: For cutouts up to 250 mm side length the corners need to have a minimum radius of 6 mm.

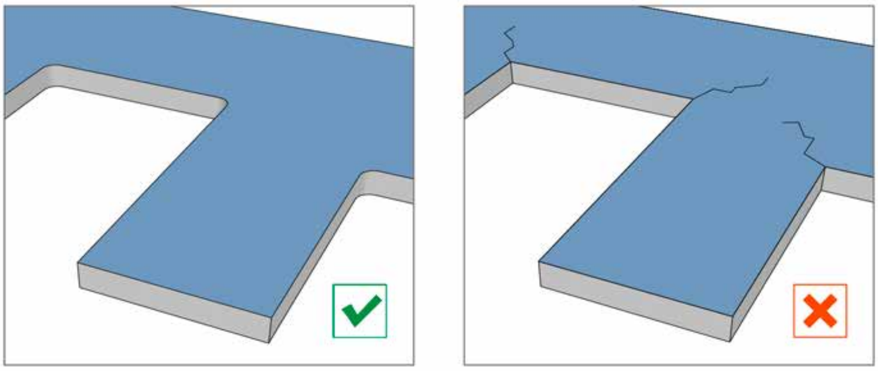


**Figure 23: Cutouts in worktops**

A hand-held router is generally recommended for cutouts. When using a jig saw, the corners have to be drilled first. Cuts with a jig saw have to be made with the board turned upside-down to minimise scratches in and tearing of the cover layer. The material is not suitable for sharp edges as these can result in cracks. This particularly applies to the hob area where the frequent heat influence causes increased shrinkage tension. All cut edges have to be free from tears as torn edges can also result in cracks.

If the edges cannot be reworked with a router, sanding paper, files or small hand-held plans can be used to break the edges. Metal plans with TCT blades have proven particularly suitable for this.

### Holes and cutouts

Holes and cutouts have to have a size which allows sufficient expansion capacity for any installed components (e.g. pipes, cables, fasteners). Cutouts in the element, e.g. for access points, switches or fan grids, need to have rounded inner edges with an internal radius of at least 6 mm. The edges of the cutout should also be smooth and free from grooves, dents and cracks. All cutouts, holes and access openings which expose the chipboard substrate have to be carefully sealed with sealants.

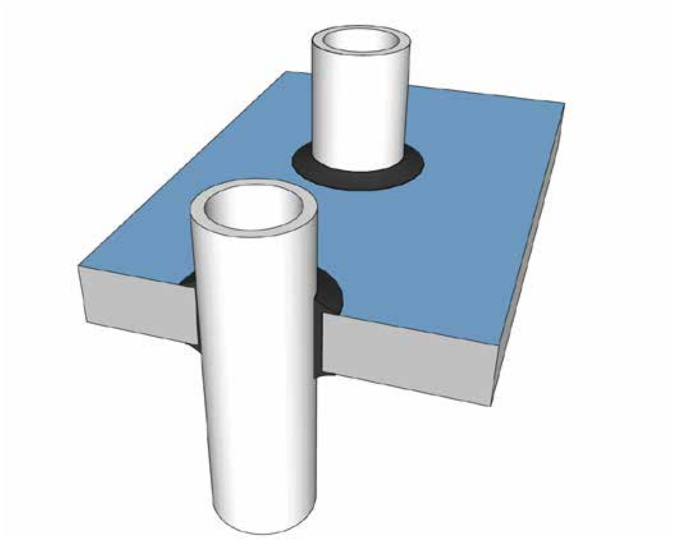


Figure 24: Sealing an access opening

Due to the expected movement in the worktop itself or from installed pipes, these have to be centred so that a minimum spacing of 2 – 3 mm is ensured in all locations. This is to prevent condensation from reaching the substrate. The cut edges on the access openings have to be sealed.

### 2.8.3 Corner joints and sheet joints

Corner joints and sheet joints have to be sealed. They must not be weakened by cutouts or notches. The sheets are installed using mechanical fastening and adhesives. Moisture has to be prevented from entering into the material system, which could lead to swelling. For hygiene reasons, we recommend sealing all open edges of the substrate.

On postforming worktops, corner joints can be created with mitre cuts or profile routing. Suitable metal covers are used for butt joints. Edges have to be cleanly routed and the two boards have to be joined tightly. An exact, level transition from one board surface to the other is achieved by using springs, dowel pins, plastic elements, etc.. All machined edges must be coated with a suitable protection (e.g. sealing).

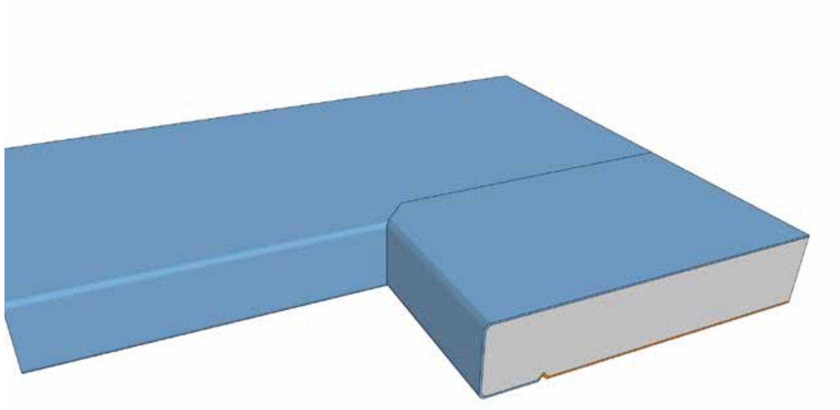


Figure 25: Routed corner joint

The following connection types have proven successfully:

- Board connectors: 2 per 60 cm worktop depth
- Tongue and groove: at least 3 per 60 cm worktop depth

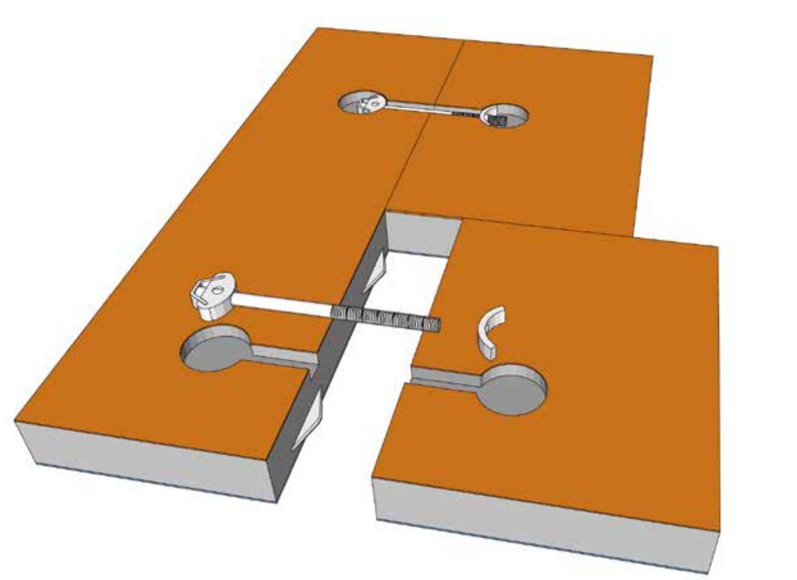


Figure 26: Board joint connection details

**Board connectors**

The sealing compound or the adhesive is applied directly to the board joint. When tightening the board connector nuts, it has to be ensured that the two worktop surfaces are aligned at the same level and that the sealing compound is emitted on all sides. Attention: Excess sealing compound has to be removed immediately without using sharp tools!

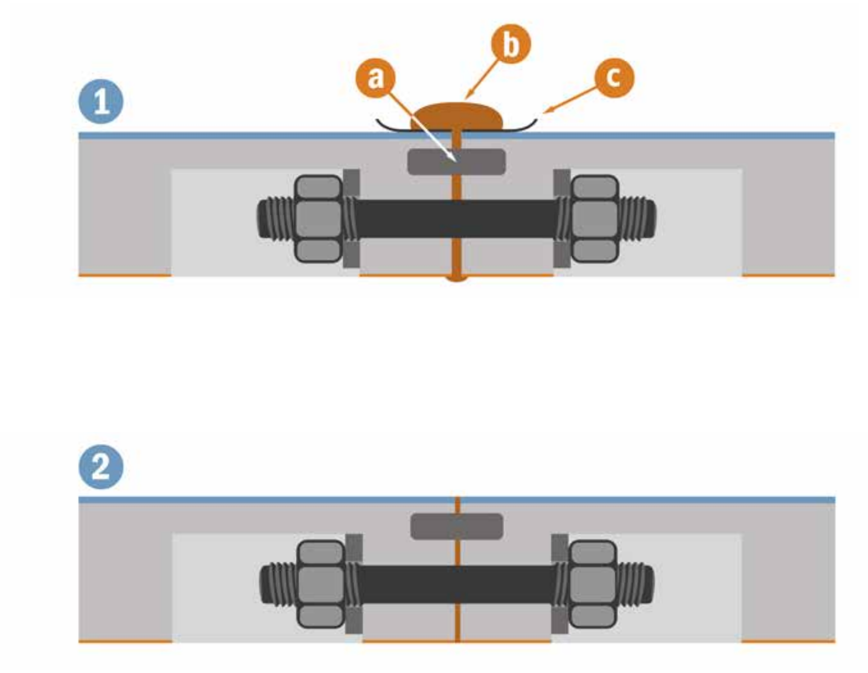



**Figure 27: Board connectors**

1 Board joint before tightening the board connectors

a Spring | b Sealing compound | c Adhesive tape

2 Complete board joint

### Tongue and groove

To achieve flush surfaces, the HPL surface is selected as a reference surface for producing the grooves for loose tongues or short tongues. The tongues should have a tight fit. The cut edge of the worktop has to be sealed with a sealing compound, which also acts as an adhesive. The excess sealing material must be removed immediately with suitable means. We recommend pressing the joint horizontally together (e.g. by blocking against the wall) until the sealing compound has cured.

### Metal cover profiles

Appropriately shaped metal profiles are suitable for covering a board joint. To a certain extent, they save the need of precise machining, but on the other hand they interrupt the flat, easy-to-clean HPL surface. Before attaching the metal profile, seal all edges – including the postforming edge of the worktop – with sealing compound or adhesive.

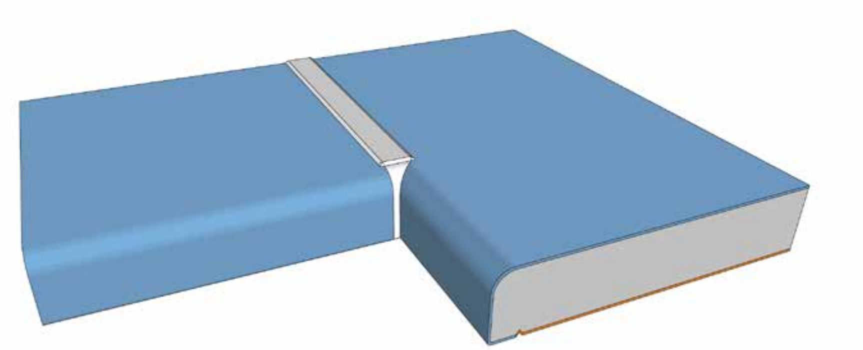


Figure 28: Board joint with cover profile

### Wall connections

Before sealing towards the wall, it has to be ensured that the worktop – especially for larger, self-supporting sections – is sufficiently supported, as otherwise the sealing joints could be destroyed under load.

Smooth (tiled) walls have to be degreased with solvent, just as the worktops, and coated with a suitable primer. Porous surfaces have to be coated with a film-forming primer. For pretreatment with primers, the instructions from the sealing compound manufacturer have to be followed closely. It is important that the sealing compound sufficiently overlaps onto the surface of the worktop. This avoids excess moisture from entering into the rear edge joint. Sealing towards the wall also has to be applied for worktops which are extended upwards along the wall.

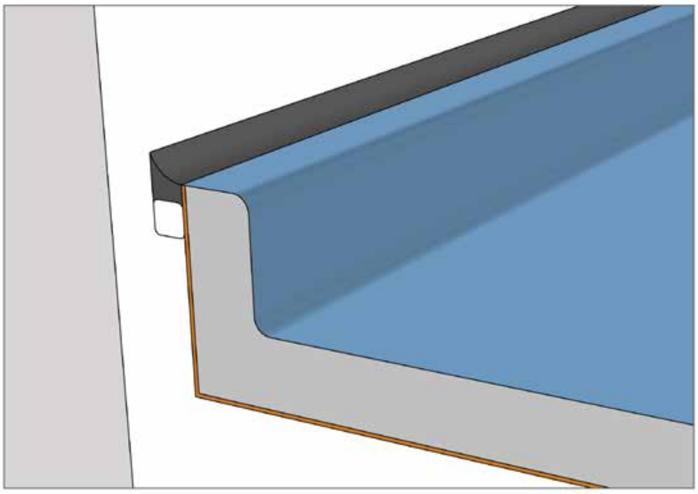


Figure 29: Wall connection with an extended worktop

When installing the worktop, it also has to be ensured that it absolutely does not slope towards the wall. This type of installation would also create excess stored moisture.

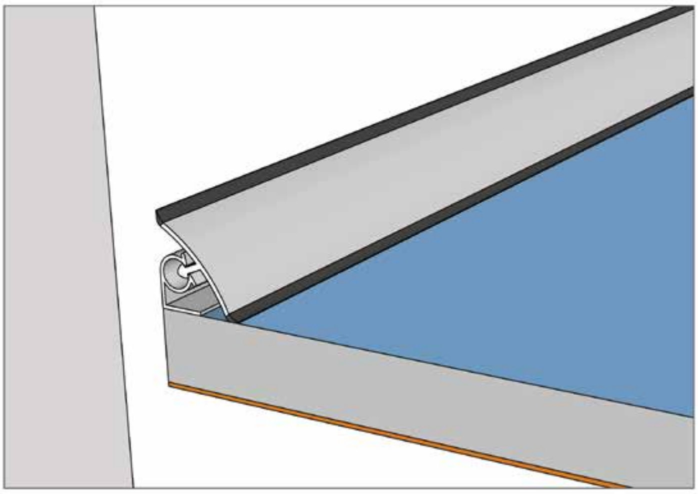


Figure 30: Wall connection wall end profile

### 2.8.4 Influence of humidity

The substrates for worktops are usually chipboard. As these tend to swell under the influence of moisture, direct influence of water or steam on the substrate has to be avoided under all circumstances. Special attention has to be paid to the treatment and sealing of the following areas:

- Board joints and corner joints
- Cutouts and inner openings
- Open edges
- Worktop undersides for ovens and dishwashers

Damage to the balancing layer or the sealing in the area of the front edge before or after installation also restricts the user benefit of the worktop. The affected parts must be treated with waterproof sealing materials afterwards. In any case, high-quality sealing materials have to be used.

With the HPL, the manufacturer reliably protects kitchen worktops against ingress of water or steam. Machining, however, always produces unprotected edges, joints and fastenings. Generally, the installation instructions from the manufacturers of sinks, hobs and installed appliances must be observed. Sealing profiles and cross-linking sealing compounds, especially those based on silicone, polyurethane and acrylic, have proven successful for sealing chipboard. In addition, the following materials can also be used for sealing:

- Special paint systems (single or dual component paints)
- Foam filling with closed pores
- Cast resin
- D3 / D4 adhesives (glues)

### Dry seals

Manufacturers of installed appliances usually supply sealing rings, sealing profiles or self-adhesive sealing strips. These have to be applied during installation.

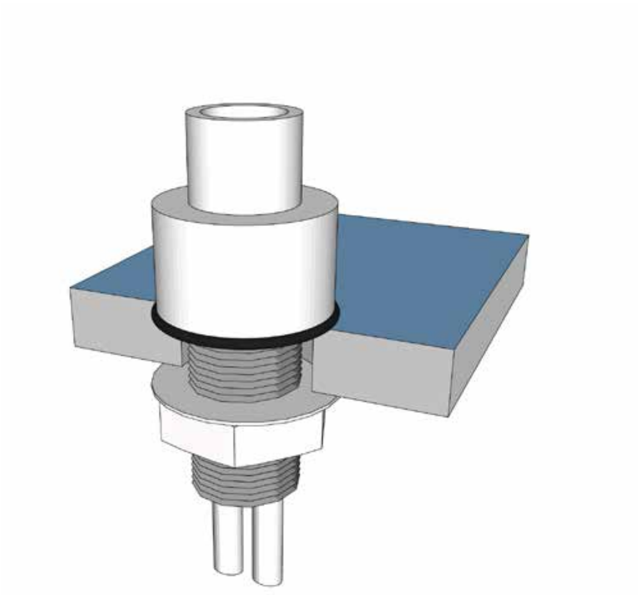


**Figure 31: Sealing with sealing ring**

### Sealing compounds

It is essential that the areas to be sealed are cleaned carefully. Then, a primer has to be applied to ensure reliable adhesion. When using a cleaning primer, prior cleaning can be omitted. After a curing period, the sealing compound has to be applied without hollow spaces according to the manufacturer's instructions. The surface has to be smoothed immediately. To prevent contamination of the element surfaces with sealing compound and to achieve an evenly wide joint pattern, we recommend masking the joint edges with tape before applying the sealing compound. Sealing systems which are hard and inelastic must not be used.

### 2.8.5 Fastenings on the worktop

Holes in the HPL cover layer have to be pre-drilled at least 1 mm larger than the screw diameter. This is necessary to avoid possible tensions in the material. Before installing the screws, the inside of the drilled hole has to be protected against water by inserting sealing compound.

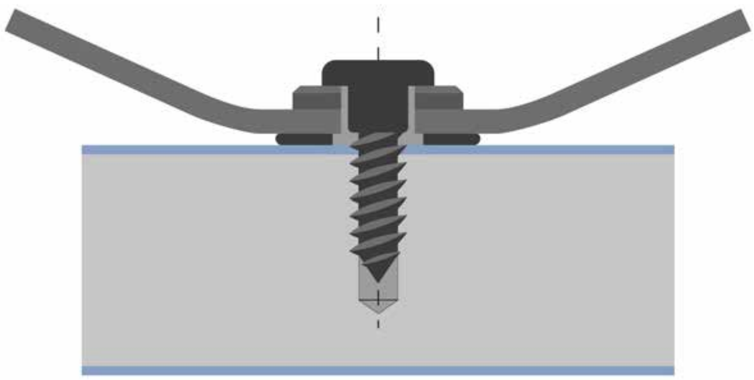


Figure 32: Sealing a drilled hole using sealing compound

### Sinks, hobs

All work areas in a modern kitchen which are set into the worktop, such as sinks or hobs, can easily be installed on site. This excludes flush-mounted sinks, which can usually only be purchased ready-mounted or have to be specially manufactured. Generally, the installation instructions from the manufacturers of sinks, hobs and installed appliances must be observed.

### Top-mounted sinks

Top-mounted sinks are usually supplied with dry seals and have to be installed carefully according to the installation instructions.

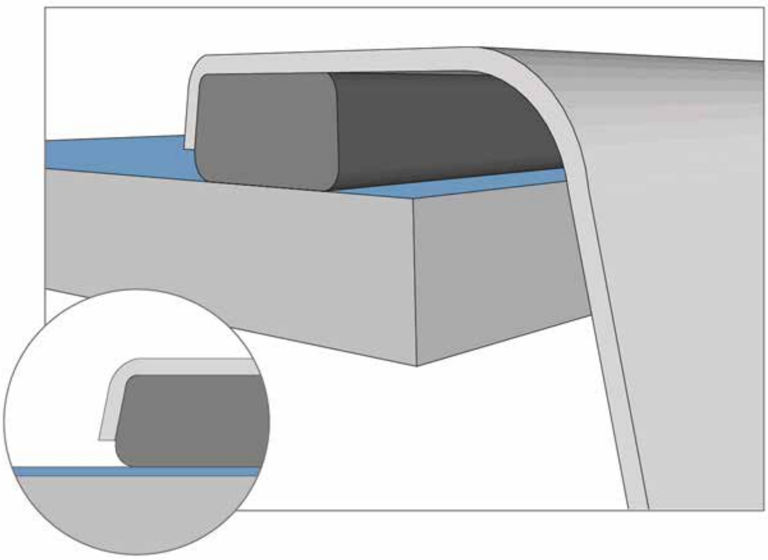


Figure 33: Seal with sealing strip underneath

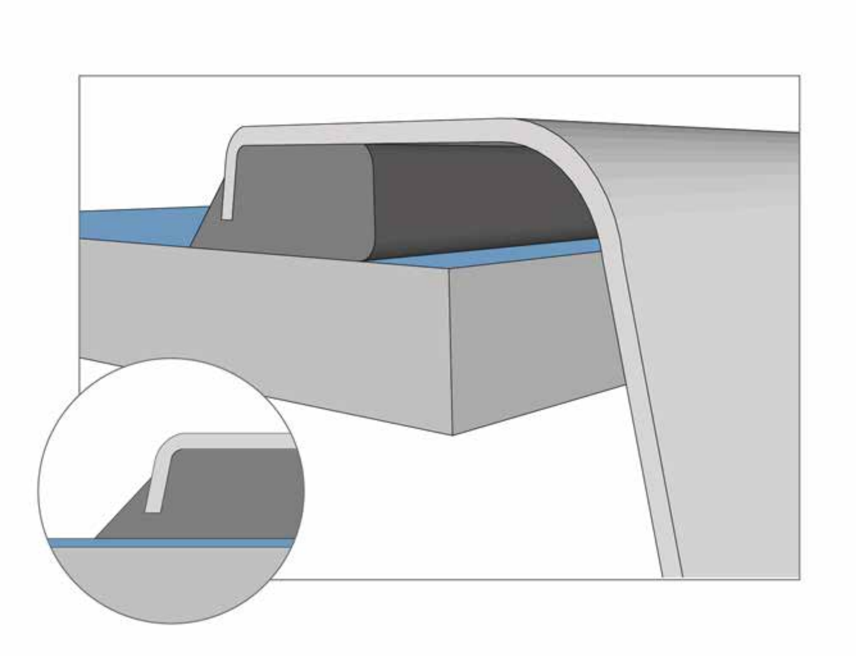


Figure 34: Seal with sealing profile underneath

Only the sealing systems defined by the manufacturer are permitted for the installation of plastic sinks. All edges of cutouts must be sealed before installation. If drilled holes are required (e.g. water pipes) in connection with sink installation, the instructions on holes and cutouts must be observed.

### Flush-mounted sinks

#### a) Installation from above

It always has to be ensured that the sink that has to be installed is suitable for flush mounting in the sense of the method described here. A sufficiently large expansion joint has to be provided and the minimum radii for cutouts have to be observed.

The process is characterised by a groove made in the worktop from above. The sink is placed into this groove. The height of the groove has to be adapted so that the sink sits flush in the worktop. Special attention has to be paid to sealing the system and the prior sealing of the cut edges.

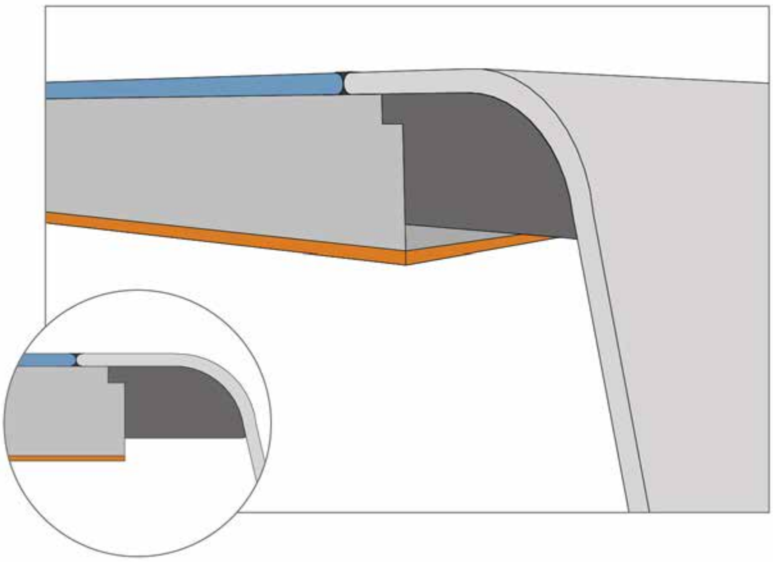


Figure 35: Flush-mounted sink with filler compound

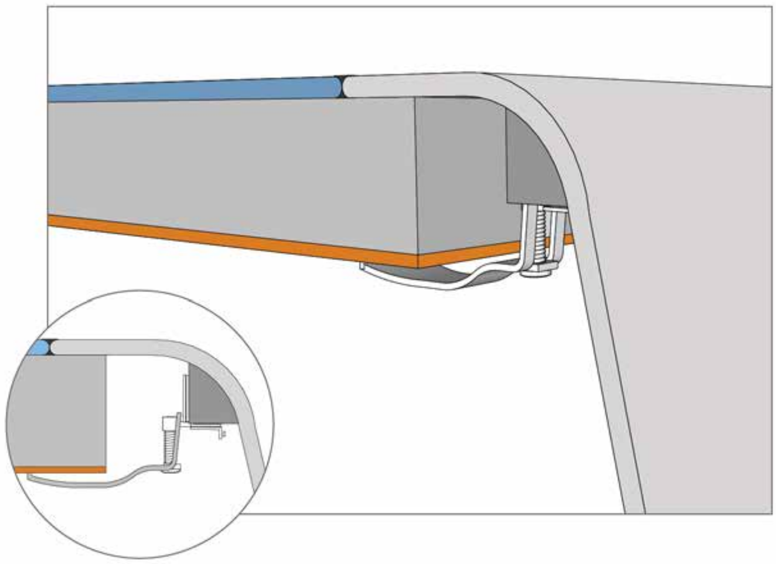


Figure 36: Flush-mounted sink with support brackets

b) Installation from below

Flush-mounting from below the worktop is more complicated and requires substantial technical skills and equipment.

Hobs

Even before the installation of a hob, the cut edge of the worktop has to be carefully protected against moisture. The supplied installation templates have to be used to provide centred positioning, so that an even and sufficient safety distance of the hob to the cut edge is ensured. Covering the edge with aluminium foil and thermal tape has proven to serve as reliable additional protection against the heat radiation. Before installation, the required opening has to be cut with great care so that the HPL remains free from splinters and grooves at the edges. Only the sealing systems defined by the manufacturer are permitted for installation.

### Ovens and dishwashers

Steam from ovens and dishwashers can have a negative impact on the adhesive joint at the underside of the worktop. Therefore, worktops have to be protected with a paint coat, silicone or a self-adhesive aluminium tape in this area. The adhesive tape has to be sufficiently temperature-resistant. If the appliance manufacturer has supplied barrier profiles, they must be installed to deflect any steam and to dissipate the thermal radiation.

## 2.9 Machining HPL-Compact

Due to the thicker boards, some special factors have to be taken into account for machining HPL-Compact, especially when it comes to selecting suitable tools. These have to meet the highest requirements. We therefore recommend coordinating the selection of the required TCT tools, particularly for saws and routers, with the respective manufacturers. This especially applies if e.g. larger batches have to be manufactured or if higher requirements exist for the cutting quality. Appropriate prior testing is also recommended in these cases. As a rule, local overheating from improper tool guiding has to be avoided for all machining processes. Furthermore, a good extraction system has to be provided in the workplace to reduce dust pollution.

As already explained, HPL-Compact sheets are HPL sheets with a thickness of over 2 mm. They are large format sheets with a decorative, durable surface and homogeneous, closed cut edges. One or two sheet sides have decorative surfaces, which can be smooth or textured.

HPL-Compact offers the following advantages:

- Good dimensional stability
- Self-supporting function
- High impact and shock resistance / impact resistance
- Especially high resistance to water and steam
- Resistance to frost and heat
- Non-corroding and durable
- High colour fastness
- Easy to clean
- Non Hazardous
- Meeting the highest hygienic requirements; surface and edges can be disinfected
- Resistant to organic solvents
- Low electrostatic charge (no accumulation of dirt)
- Easy installation, variation and replacement, space-saving
- Easy machining
- Good fire behaviour (low smoke development; non-dripping; non-melting)
  Type CGS (Euroclass D-s2, d0 (CWFT) ≥ 6mm)
  Type CGF (Euroclass B-s1, d0 with verification ≥ 6mm)

In thicknesses under 3 mm, HPL-Compact can be bonded to rigid supports. For self-supporting applications, rigid supports are required at shorter spacings for thickness up to 5 mm. For greater thicknesses, however, HPL-Compact sheets are usually self-supporting. Sheets with a thickness over 8 mm are suitable for large area (horizontal) use with more widely spaced supports. It is up to the user to adapt the thickness of the product to the maximum requirements according to the specific purpose.

Free-standing edges and corners of HPL-Compact always have to be chamfered to avoid injuries.

### 2.9.1 Sawing

HPL-Compact sheets have to be handled with a slower feed speed than HPL composite sheets. On HPL-Compact sheets with decorative surfaces on both sides, tearing of the lower decorative layer can be effectively prevented by changing the exit angle. This can be achieved by varying the height adjustment of the saw blade. With increasing projection, the upper cutting edge is improved and the lower cutting edge is poorer, and vice versa. Good results can also be achieved by placing plywood, chipboard or HPL underneath. Best possible cutting quality of the lower edge is achieved by pre-scoring the underside of the sheet with a small circular saw blade. This prevents tearing on the underside of the sheet because the scoring has already produced a clean cut in the decorative layer on the underside. The scoring saw usually runs in forward direction, regardless of whether the following saw blade runs in forward or reverse direction.

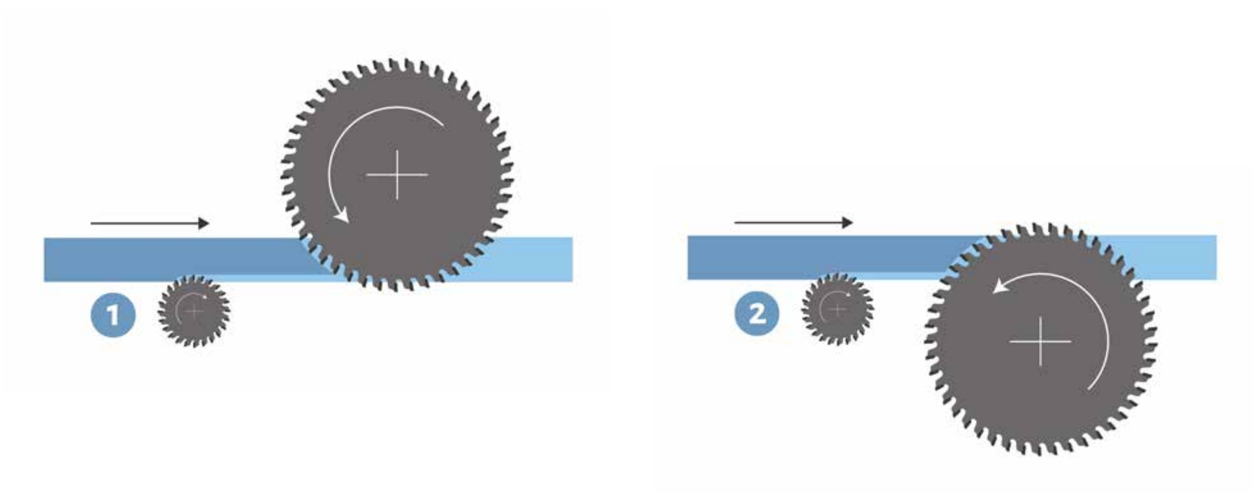



**Figure 37: Saw blades in forward or reverse direction**

1 Reverse running with scoring | 2 Forward running with scoring

The feed speed has a crucial influence on the cutting quality for HPL-Compact. A feed per tooth between 0.03 and 0.05 mm has proven successfully.

The feed is calculated with the following formulas, whereby the speed of the machine is usually set for maintaining the ideal cutting speed.

Feed per tooth: $S_z = \frac{S}{n \times Z}$ [mm/tooth]

transposed to feed $S = S_z \times n \times Z$ [mm/min]

transposed to number of teeth $Z = \frac{S}{n \times S_z}$

Where:

$S_z$ = feed per tooth in mm

S = feed in mm/min

n = rpm

Z = number of teeth

*Example:*

Number of teeth Z = 52, rpm n = 3500,

feed per tooth $S_z$ = 0.04 mm

Substituted into the formula $S = S_z \times n \times Z$, this yields a feed of

0.04 × 52 × 3500 = 7280 mm/min = 7.28 m/min

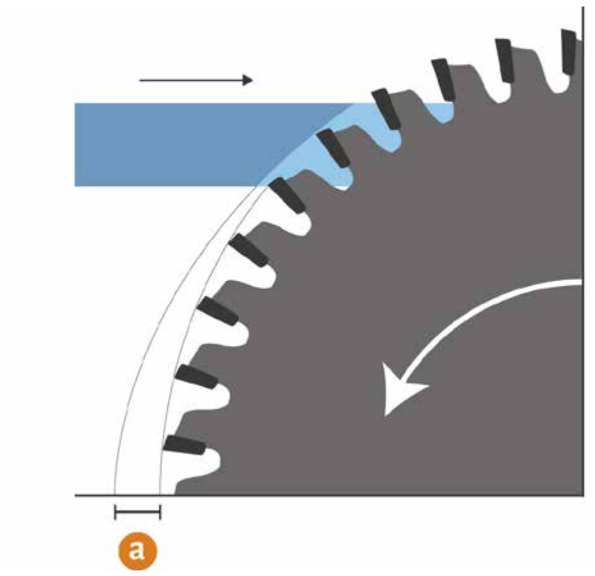



**Figure 38: Feed per tooth ($S_z$)**

a Feed per tooth [mm]

### 2.9.2 Routing and edge remachining

The cut edges of HPL-Compact can be machined. A machining allowance of 2 – 5 mm is recommended for good edge quality.
For large batches, the use of special router heads which were developed for HPL-Compact has proven successful. For profile milling, we recommend the use of diamond tipped tools. Due to the high cutting pressure, secure guiding of workpiece and tool is imperative.

A special edge protection such as coating or painting is generally not required for HPL-Compact. A variety of design options are available for edges which are to remain visible:

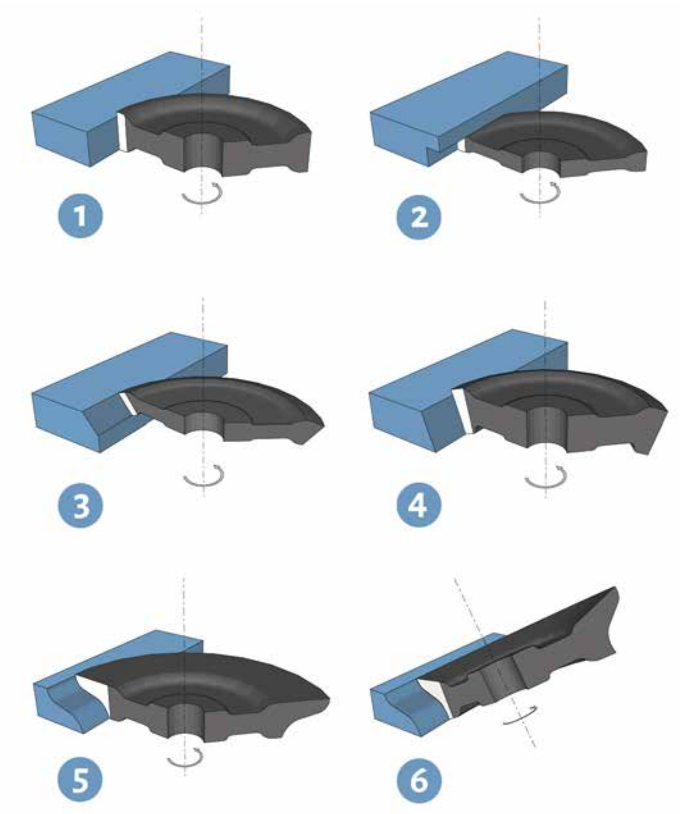



**Figure 39: Types of edge machining**

1 Straight edge | 2 Rabetted edge | 3 Chamfered edge | 4 Bevelled edge
5 and 6 Profiled edges

Marks from the blade impact of the profile routers on the routed surface are inevitable. They can be reduced through climb cuts (only with mechanical guiding!). They can be removed during the subsequent profile finish through sanding and then polishing.
To further improve the appearance of the routed edge, we recommend treating the edge with silicone-free furniture oils after machining.

### 2.9.3 Drilling

Drills for plastic materials are the most suitable for drilling in HPL-Compact. These are special drills with a point angle of approx. 60 – 80°, rather than 120° for normal metal drills. They also have a steep pitch with a large chip space. Drills with a tip angle of 50 – 60° should be preferred for drilling through.

To prevent splintering at the exit point on the HPL-Compact, the feed speed of the drill has to be continuously decreased. We also recommend working with a firm base which can be drilled (e.g. chipboard, plywood).

For drilling blind holes, the hole depth should be chosen so that at least 1.5 mm sheet thickness (a) remains.

For holes drilled parallel to the sheet plane, the remaining thickness (b) has to be at least 3 mm. Arbour-mounted counterbores can be used for simultaneous drilling and countersinking. In addition to carbide tools with fixed tips, carbide inserts are often used for drilling and routing recesses.

Furthermore, it is easy to cut threads into HPL-Compact; self-tapping screws can also be used.

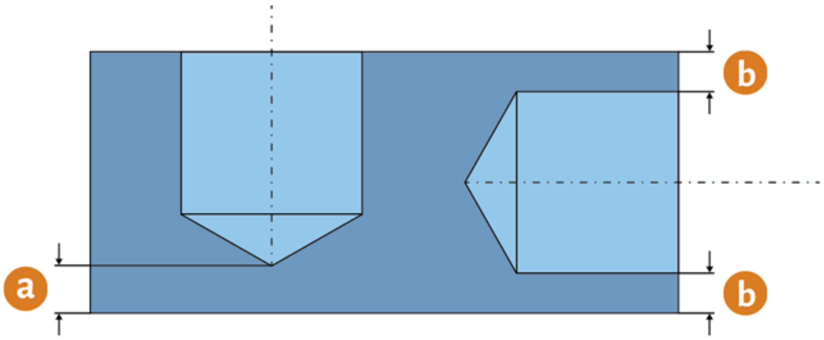



**Figure 40: Drilled holes in the sheet**

Remaining thickness for (a) vertical drilled holes at least 1.5 mm and

(b) at least 3 mm for horizontal drilled holes

### 2.9.4 Processing

With regard to the subsequent use, it must be taken into account that HPL-Compact slightly changes in dimension when the climate changes. The change in length of the sheets is only half of the change in width. Known fastening and connection methods (e.g. continuous or concealed profiles, tongue and groove, screws) can be used for HPL-Compact. In areas with moisture influence, corrosion-resistant fastening materials have to be used. If bonding to carrier materials becomes necessary for structural reasons, the principles of the "General recommendations for working with HPL" have to be observed.

### 2.9.5 Joining HPL-Compact elements together

If two HPL-Compact sheets are connected with tongue and groove, groove width (a) and groove side thickness (b) have to be at least 3 mm. Where the design allows, the groove side thickness (b) should be larger than the groove width (a). The groove depth should be kept as low as possible (max. 10 mm). As for the rest, the following guide values apply:

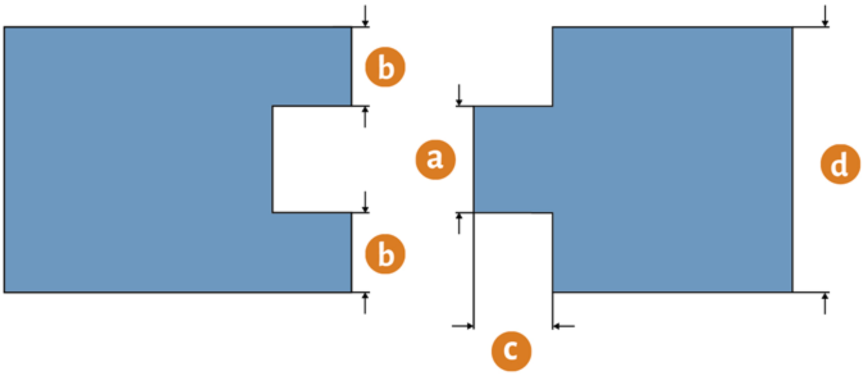



**Figure 41: Connection with tongue and groove**

a Tongue width | b Tongue side width | c Groove width | d Sheet thickness

| | |
|---|---|
| Tongue width a | 3 mm |
| Groove side width b | ≥ 3 mm |
| Tongue width c | < 10 mm |
| Sheet thickness d | ≥ 10 mm |

Due to the possible dimensional changes, the HPL-Compact sheets have to be mounted with sufficient play between tongue and groove. HPL-Compact sheets with less than 10 mm thickness should not be connected with tongue and groove. A connection with a “false tongue” is also beneficial because it allows the full plate format to be used and simplifies processing. Adhesive bonding has to be carried out in such a way that the dimensional changes of the HPL-Compact are not impeded. It also has to be ensured that the sheets are only bonded in the same running direction because the dimensional changes differ in length and width, which may cause tensions.

Corner joints should only be executed with squares or angle rails depending on the expected load.

## 2.10 HPL with coloured core

A dark or black layer of phenol-resin saturated core papers is usually visible on HPL. On HPL with coloured core, the colour of the core can match the surface or provide a contrast. The structure and colours can be used to achieve special decorative effects which open up a variety of design options. HPL with differently coloured cores in the layers, for example, can be used to achieve striped effect. Due to the structure, the properties of the cut edges are similar to that of regular HPL. HPL with colour core is described in part 9 of EN 438. The surface and the core consist of melamine-resin impregnated and white or colour-pigmented cellulose sheets. HPL with coloured core has to be machined and used in the same way as HPL or HPL-Compact, but usually is more brittle.

This applies e.g. to the resistance to temperature, scratching, abrasion and impact, light fastness and many other physical properties. Certain limitations apply with regard to machining by sawing, milling/routing and sanding. It also has to be taken into account that the shrinking and swelling behaviour is greater than in normal HPL and HPL-Compact. For edges, HPL with a thickness up to 3 mm can be used.

A fully symmetrical structure of the composite element has proven practical (with regard to the thickness and colour of the HPL). Beyond this, the running direction (sanding direction) of the HPL on the front and rear sides has to be the same. Due to the good material properties, no other surface treatment is required.

### Edge material

For thicker edges on HPL with coloured core, it is quite possible to continue the milled radius of an HPL/HPL composite element in the fully coloured edge material to produce a visually appealing result:

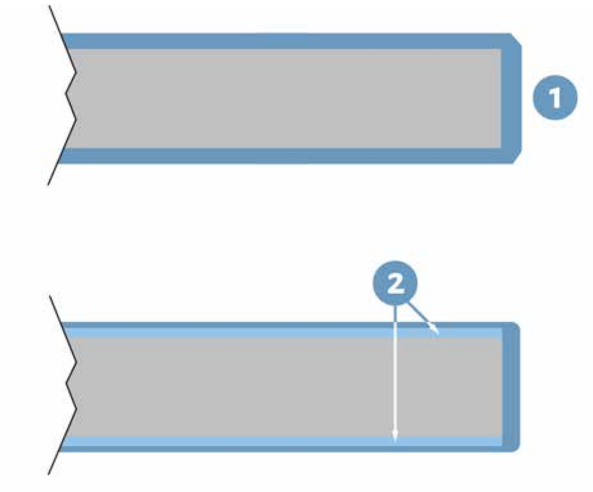



**Figure 42: Edge formation**

1 Uniformly coloured HPL

2 HPL with differently coloured core

### Surface material

HPL with coloured core are particularly attractive due to the matching colours of the structure. Optimum transition from the surface to the matching edges can be achieved with the coloured core. The same applies if e.g. sinks or washbasins are adhered directly underneath this HPL to achieve an appealing colour connection.

### Engraving material

HPL with coloured core is also suitable as an engraving material for all types of name, designation and information signs.

## 2.11 Outdoor use

HPL, and especially HPL-Compact, can be used in outdoor areas due to their high level of durability. A range of special factors have to be taken into account for planning.

### 2.11.1 Reaction to fire

HPL can be manufactured with normal flammability or in flame-retardant quality. As per EN 13501, the quality with normal flammability is categorised as Euroclass D-s2, d0 and the flame-retardant quality as Euroclass B-s2, d0. HPL only burns under the influence of open flames. In case of fire, HPL only develops little smoke and does not drip. It does not splinter under the influence of fire extinguishing water. The national and local fire protection requirements must be observed.

### 2.11.2 Colour selection and light fastness

Each colour pigment tends to gradually fade under the influence of light (especially UV light). Only colour-fast and environmentally friendly pigments are used for HPL. HPL-Compact as per EN 438-6 type EGS/EGF is intended for moderate use outdoors and is usually only offered in light colours. The EDS/EDF qualities are intended for heavy-duty outdoor use and are equipped with additional weather and UV protection. They are offered in a large variety of colours.

### 2.11.3 Surface finishing

HPL-Compact as per EN 438-6 type EDS/EDF shows virtually no changes in surface properties and appearance. Even after many years of outdoor use, only slight colour changes can be detected. For HPL-Compact as per EN 438-6 type EGS/EGF, the melamine surface gradually loses its transparency after years of outdoor use, similar to other materials. Micro cracks appear, which appear as greying especially on darker colours. This can affect the cleaning result over the years. Mechanical strength and usability are maintained..

### 2.11.4 Installation

With regard to the subsequent use, it must be taken into account that HPL-Compact slightly changes in dimension (< 2.5 mm/m) when the climate changes. The change in length of the sheets is only half of the change in width. Rear ventilation or the same climate conditions on both sides are advised.

Known fastening and connection methods (e.g. continuous or concealed profiles, tongue and groove, screws, rivets) can be used for HPL-Compact. We always recommend using corrosion-resistant fasteners (caution: contact corrosion!).

For adhesive bonds, it has to be ensured that the dimensional changes of the sheets are not impeded. The adhesives have to be selected according to the expected stress. It is advisable to consult with the manufacturers.

For installation on a substructure, it has to be taken into account that metal substructures change their dimensions during temperature changing. The dimensions of HPL-Compact also change under the influence of fluctuating relative humidity. These dimensional changes of metal and HPL can act in opposite directions. Sufficient flexibility therefore has to be ensured during installation so that both materials can move accordingly.

The sheets are usually mounted after alignment along a fixed point. This can be achieved with a drilled hole diameter adapted to the fastener (e.g. screws, rivets) or a fixed-point sleeve. The other hole diameters are implemented as sliding points, so that they are 2 – 3 mm larger than the diameter of the fastener.

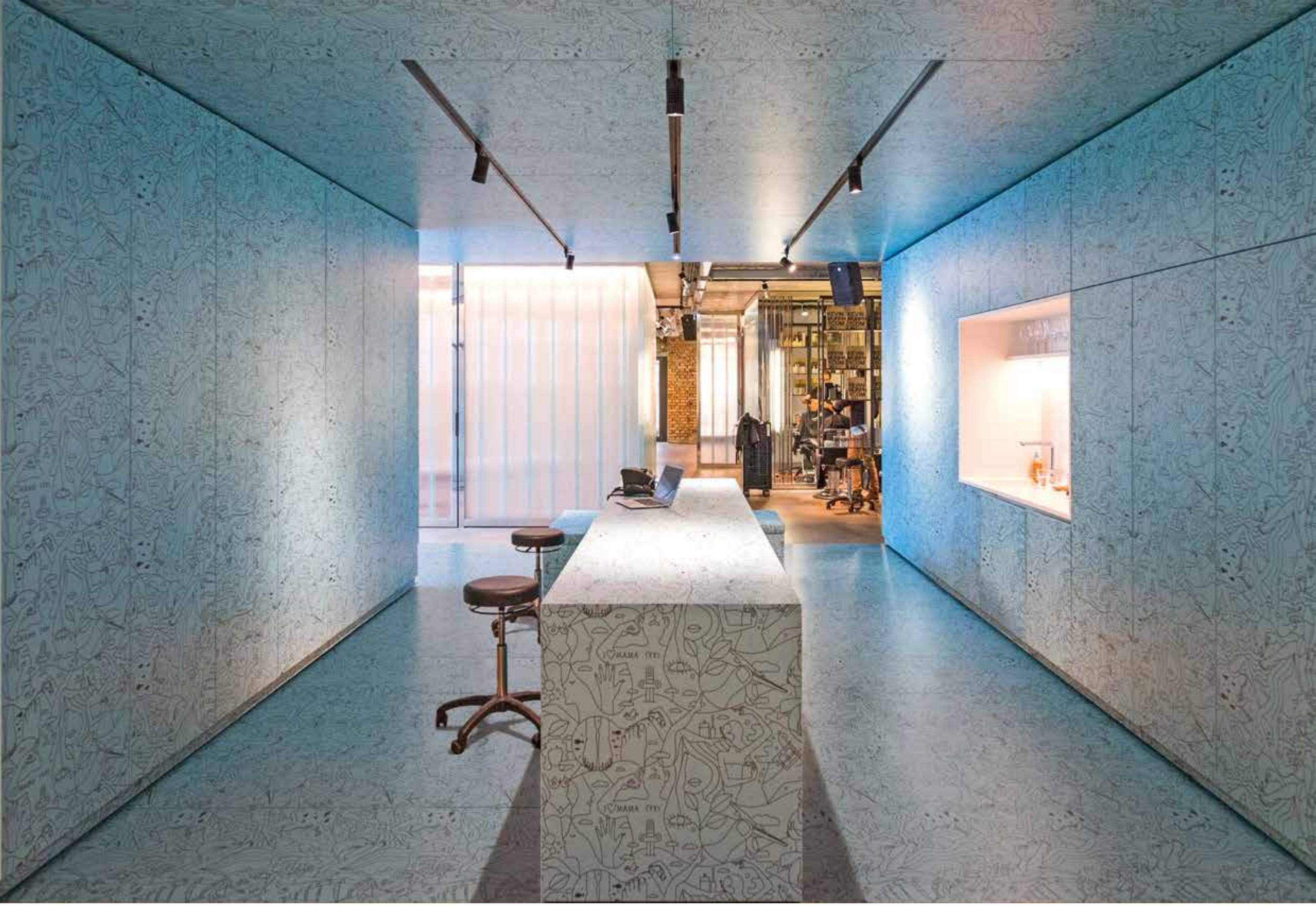


Image 1: Floor, wall and ceiling elements with HPL

# 3. Versatility of HPL

The design and usage requirements for surface materials have increased in all market segments, not in the least because of the transitions between the different areas of application that have become more fluid. HPL meets exactly these new requirements for construction and furnishing materials, probably like no other material. Therefore, the use of HPL is recommended wherever modern, attractive design for commercial or private exterior and interior spaces is required. The material ensures a high level of safety and durability as well as a long service life. In addition, the increasing range of special qualities from manufacturers means that there are now virtually no areas of application where HPL cannot offer the advantages mentioned. Today the market segments where HPL products are used in a variety of different applications are accordingly comprehensive.


Image 2: Individual, modern interior design with HPL

## 3.1 Interior design with HPL

HPL is much more than just a material for manufacturing furniture. HPL can be used for optimum implementation of a variety of different interior design concepts, whether private, public or commercial. As the previous chapters showed, the exceptional design range of HPL is based on the vast range of colours and wood/stone/fantasy patterns in combination with different textures and gloss levels. In addition to this, excellent reproductions of materials, e.g. textiles, exotic veneer wood and stones, can be produced at customer request. This is made possible with printing technologies such as digital, screen and offset. In addition to this, alternative surface treatments such as real metal, real wood veneer or pearlescent effects are possible. HPL has a significantly longer service life compared to other decorative materials, e.g. paint, thermoplastic films and veneer. In addition to these virtually unlimited variations of patterns and colours, HPL permits a variety of different formats as well as large-area wall and floor coverings without gaps.


Image 3 – 5: Wall panels and functional furniture with HPL

HPL can generally be used without limitations for applications on vertical surfaces, e.g. doors, furniture or wall panels. When selecting a surface texture for horizontal use, the type of expected stress should be considered. Standard HPL can resist temperatures up to 160 °C. Extreme heat, e.g. from Bunsen burners or infrared radiators, can lead to colour changes or destruction through carbonization. In these situations, the HPL surfaces should be protected with heat-resistant materials (e.g. steel, ceramics).


weapon which you can use to chang
nelson

Image 6 – 7: Modern kitchen design with HPL

Image 8: HPL in kitchens, suitable for food contact

## 3.2 HPL in kitchens

Private, but especially commercial kitchens are not always furnished with readymade elements, but are often created by interior designers based on the customer's wishes. Therefore, HPL with its extraordinary possibilities and qualities play a particularly important role. It is the optimum material, especially for worktops.

Image 9: Individual, modern interior design with HPL

## 3.3 HPL in offices

When it comes to planning and designing offices today, interior designers have to take a vast range of requirements into account. Customers expect an attractive design of the different areas (e.g reception, work stations, conference rooms, archive, relax and multimedia areas) as well as a high level of durability for the furnishings and the option of short-term rearrangement through moving dividing wall systems.

For decades, HPL has been an important material for furnishings and therefore also for the design and implementation of a variety of different office concepts. In view of the expanded requirements, HPL has become even more important for office design. Thanks to easy machining and attractive design options, the material allows custom shaping for individual and series production. In open-plan offices and conference rooms, HPL offers attractive solutions for wall panels, dividing walls, doors, floors and ceilings. The wide range of special qualities offered by the manufacturers also allows the optimum combination of design and robustness. If required, HPL multifunctional surfaces (e.g. write-on, projection, magnetic) can be installed.

Image 10: Functional and visual design of modern workspaces with HPL

## 3.4 Multifunctional HPL surfaces

Multifunctional surfaces with HPL are ideal for use as projection screens and write-on surfaces. They can also be equipped with magnetic layers. Moreover, they feature a unique combination of properties with respect to surface wear, chemical resistance, colours, designs and surface textures.

### 3.4.1 Write-on surfaces

Basically, HPL surfaces can be labeled. However, since there are a wide range of pens and different HPL surface textures available and new variants are always coming onto the market, the coverage rate of the colour pigments varies depending on the combination. This also applies to the effort involved in cleaning a surface that has been labeled, which can vary significantly depending on the combination.

The smoother, and thus the shinier a surface is, the easier it is to wipe off the markings. In the simplest scenario, this can be achieved using a dry, absorbent cloth – or a damp cloth, if necessary – with relatively little effort. With frequent use, textured surfaces, long-dried inks and certain types of pens, a dry, absorbent cloth will often no longer be sufficient for obtaining a clean surface. For pens with water-soluble inks, we recommend an absorbent


Image 11: Multifunctional surface, magnetic and write-on shelf system with HPL

cloth and window cleaning product (i.e. non-moisturising soapy water with 5 – 10 % alcohol content). Non-water soluble inks should not be used. They have to be removed with an absorbent cloth and alcohol or acetone (warning: some plastic edges are not resistant to acetone) and washed off with non-moisturising soapy water. Nail polish remover and other solvents may leave residues on the surfaces.

If blackboard chalk is used to write on HPL, it is advisable to use a finely textured, matt surface. Some abrasion of the chalk on the board is required to achieve a beautiful, high-contrast typeface. On a smooth or less textured surface, this is not the case. Clean by using water and an absorbent cloth. When using liquid chalks, select a surface that is as smooth as possible because finely textured surfaces require more effort to clean, particularly when it comes to dried-on markings. To prevent streaking, we generally recommend drying the surfaces subsequently with a clean cloth.

Image 12: Multifunctional, magnetic and chalkboard wall panels with HPL

### 3.4.2 Whiteboards

Whiteboards are frequently made of HPL. As the name suggests, white HPL sheets are generally used for this. However, they can also be manufactured using any other available HPL design. HPL surfaces can be labeled with special felt-tipped pens (whiteboard markers) and wiped clean with a cloth. In practice, many different – more or less suitable – felt-tipped pens are used, whereby ink remains in some cases on the surface for a long time and can dry out excessively. The surface should be as smooth as possible in order to ensure easy cleaning over the long term, and we recommend occasionally cleaning with a window cleaning product and an absorbent cloth, e.g. a microfibre cloth.

### 3.4.3 Magnetic surfaces

HPL surfaces equipped with magnetic layers generally have a ferritic layer. To ensure the processing of HPL elements in timber-processing workshops (no flying sparks, depending on the version), steel sheets are only a few micrometres thick. These layers are locally magnetised via the applied permanent magnets, providing the adhesion. This magnetisation diminishes over time once the permanent magnet is removed.

Permanent magnets are made from various materials and are available in a wide variety of shapes and designs. Their adhesive force is primarily determined by the material of the magnets, the adhesion surface, the thickness of the magnet, the material of the counter-magnet, the material being attracted and the distance to the material being attracted.

Low-cost permanent magnets are usually made of hard ferrite and are relatively thin (approx. 2 – 3 mm). Those are sufficient for securing a DIN-A4 page of standard paper with 1 – 2 magnets. For size A1 layouts are those, unlike more expensive neodymium magnets, less suitable. Therefore, it is necessary to decide for each particular application which and how many magnets have to be used for a specific task. Generally speaking, HPL with magnetic adhesion poses no risk to human health, e.g. persons with pacemakers.

### 3.4.4 Projection surfaces

Projection screens normally feature a white, matt surface, so that the impinging light from projectors is scattered evenly and diffusely and no distracting reflections are created. These features fulfil the requirements for projection screens in offices and classrooms. HPL surfaces can be manufactured with these features. The gloss level should be as low as possible (measurement at 60° angle). HPL surfaces with gloss levels ≤ 10 are suitable for reducing reflections. Higher values (10 – 20) can be used with some limitations, i.e. reflections may occur at certain viewing angles. Extremely matt HPL surfaces have gloss levels of approx. 2 – 5. They are finely textured.

### 3.4.5 Write-on, magnetic projection surfaces

Equipping HPL with magnetic properties has no impact on the HPL surface. This means that it can be combined with write-on or projection surfaces without any problems.

The combination of marking and projection on the same surface is more difficult, since the two requirements conflict with each other, depending on the writing material used. To this end it is useful if, prior to using a multifunctional surface, it is known what kind of writing material will be used. When using blackboard chalk, a slightly rough, i.e. matt, surface is required in order to achieve good contrast. These conditions are ideal since matt surfaces with gloss levels of less than 10 (60° measurement) are the most appropriate for projection screens, too.


**Image 13: Multifunctional, write-on, magnetic projection surface with HPL**

Most other pens – such as whiteboard markers, liquid chalks, wax and oil crayons, felt markers, fluorescent markers, etc. – can also be used on matt (rough) surfaces. But cleaning the surface properly can be extremely laborious. To simplify the cleaning process, smooth or glossy surfaces are more suitable for these pens. These surfaces feature gloss levels of approx. 80 (60° measurement) and more. For projection screens, however, such surfaces have too much reflection.

A good compromise would be surfaces with a gloss level of approx. 10 – 20. These surfaces exhibit minor reflection during projections and can be cleaned with relatively little effort. Since various textures are feasible at these gloss levels, we recommend opting for a certain type of pen, testing the effort that it takes to clean the available surfaces (gloss level < 20) and selecting the combination that involves the least effort.


## 3.5 HPL wall panels

Due to its properties, HPL is an excellent material for wall panels in new buildings as well as for renovation projects. It is either applied to suitable substrates or used as self-supporting HPL-Compact. The material meets the highest requirements regarding hygiene, fire resistance and resistance to moisture. HPL composite panels and HPL-Compact allow fast and easy installation on site. For renovations using dry construction methods. Any existing wallpaper, textile floor coverings, tiles or other wall coverings do not necessarily have to be removed. Where HPL is used for wall panels, however, storage, installation method and structural design play a crucial role. The applicable building regulations also have to be taken into account. For any other installation methods, please consult the manufacturer.

Different substrates can be used for composite elements with HPL as wall panels. The selection of the substrates depends on the subsequent use of

Image 14: Wall and door design with HPL

the room and on the structural and fire protection requirements. The wall elements can be installed in a variety of edge designs with vertical and horizontal orientation. The structure of gaps, joints, ceiling and wall edges as well as the size and format of the elements determine the overall effect in the room.

The room, the wall panel elements and the substructure should be sufficiently conditioned at the time of installation to reduce subsequent dimensional changes. New walls (brick, concrete or with plaster) contain substantial moisture levels and have to be completely dry before the installation of HPL. When using thermal insulation and vapour barriers, the general principles of building physics must be taken into account.

## 3.6 HPL in wellness areas

HPL is the ideal material for wellness areas, as it combines a warm, inviting and relaxing appearance with a moisture-resistant and hygienic surface.

For wall panels in particular, the large-format HPL-Compact or HPL composite elements allow joints to be reduced by up to 90 % compared to tiles. This provides significant benefits with regard to hygiene and easy cleaning. Other advantages of the HPL elements or HPL-Compact include quick and easy installation which can be done as drywall construction. The materials can easily be processed with normal wood processing machines, using suitable tools.

### 3.6.1 HPL elements and HPL installation elements in wet rooms

Modern bathrooms are considered to be living spaces. Bathroom furniture consequently has to meet high aesthetic demands despite the exceptionally high strain on the materials. Furnishings made from HPL-Compact and HPL elements meet these requirements in many ways. Increased care should be taken, however, when manufacturing bathroom furniture from HPL composite


Image 15 – 16: Wellness areas with HPL

elements with regard to the sealing of holes and edges, the substrate and the adhesive.

Thicker HPL-Compact is self-supporting and usually has a decorative surface on both sides. The high resistance to water makes HPL-Compact particularly suitable for areas with high exposure. Cut edges and access openings usually require no additional protection. HPL-Compact can therefore be used for any type of installation such as wall panels (observe CE marking requirements), shower enclosures, changing rooms and washbasins.

The market offers prefabricated composite elements with HPL which are adapted to the special requirements of humid and wet areas. They consist of durable substrates which are coated with HPL on both sides using suitable adhesives. According to the subsequent exposure, these elements can be selected with different substrates and adhesive systems.

Image 17: Modern bathroom design with HPL

## 3.7 HPL in laboratories

Laboratories are workspaces with a variety of different, usually high requirements for the materials used. Due to their performance and material characteristics, HPL has the prerequisites for meeting those requirements. As decorative design elements, they can additionally cater to individual demands for the furnishing and design of laboratories.

As different as laboratories are in their equipment, they all have work tables, desks, furniture and interior fittings in common. For all these, HPL has proven to be a highly suitable material for surfaces as well as in the form of HPL-Compact.

In laboratories, HPL surfaces on furniture often come into direct contact with chemicals. Their resistance to organic solvents is excellent. Some decorative colours are sensitive to acid due to their pigment composition which can lead to discolourations. We therefore recommend coordinating the selected colours and surface textures with the HPL manufacturer.

Image 18 – 19: Functional laboratory surfaces with HPL

Water as a cooling medium and as steam is omnipresent in laboratories. HPL is very resistant to water, moisture and even steam. The large sizes allow joints to be reduced to a minimum, preventing the ingress of water into the substrate (usually wood materials).

Laboratories are often subject to extreme temperature influences which put a great strain on the surfaces. HPL is resistant to brief temperature stress up to 160 °C. The thermosetting resins used for HPL cannot melt or soften. Hot objects should always be placed on a base or in a special fixture. HPL show excellent resistance to cold. It does become brittle even at very low temperatures. This also makes it highly suitable for use in cold stores, e.g. for food testing.

Worktops and doors in laboratories can be subject to high mechanical impact. HPL is highly scratch resistant, abrasion resistant and shock proof and the combination of these properties makes it one of the materials of choice for laboratory furnishings.


Image 20: Individual design for internal wall systems and doors with HPL

Many laboratories require clean to sterile conditions. HPL meets these requirements with its closed surfaces without pores. The option of large, joint-free units therefore provides advantages over materials with more joints. In addition, HPL is antistatic ($10^9 - 10^{12}\ \Omega$). Electrostatically discharging HPL as a special quality reaches $10^5 - 10^9\ \Omega$.

Image 21: Splash guard, joint-free horizontal and vertical surfaces with HPL

Due to its favourable combination of properties from chemical, mechanical and thermal resistance, HPL, and in particular HPL-Compact, are suitable for manufacturing worktops and fume cabinet for many types of laboratories.

Doors are also an essential part of room design. Laboratory doors are often complex special structures with regard to fire, radiation and sound protection. HPL is ideal as a surface covering for these doors due to its high practical value. In addition to meeting technical requirements, it also offers numerous design benefits such as light cut-outs or adaptation to the interior design concept.
HPL also offers attractive solutions for covering supply shafts, pipe and cable ducts or for machine coverings or housings, particularly as postforming elements, HPL-Compact or compact formed parts. Other proven applications with HPL are buffer panels and splash guard installations.

Image 22: Window sill with HPL

## 3.8 Window sills

Internal window sills in buildings come in a variety of different versions. They generally consist of natural or artificial stone, metal, wood, HPL-Compact or composite elements laminated with HPL. Window sills with HPL have excellent physical properties and are subject to only minor thermal length expansion and structure-borne sound transmission. In addition, they offer a high level of thermal insulation, good mechanical strength and durability. These window sills also allow a large variety of shapes, from simple “board” style variants to designs with folded edges in different widths or cable duct with different edge designs. Due to the easy machining of the materials, a great variety of shapes can be achieved compared to conventional window sill materials.

Image 23: Façade design with HPL

## 3.9 HPL in outdoor use

In addition to the great durability, especially of HPL-Compact, the extraordinary design options with screen and digital printing should be a main factor in convincing more and more architects to use HPL for façade design. In recent years, an increasing number of attractive HPL façades have appeared all over the world, underlining what has become possible with HPL. In addition to this, HPL offers protection against UV radiation, extreme temperatures, moisture and mechanical stress, while allowing individual façade design with large format patterns and photographs.

As mentioned already, self-supporting HPL-Compact has proven to be particularly durable in outdoor use. The structure of HPL gives it a high modulus of elasticity and high impact and bending strength, and excellent

Image 24: Façade design with HPL

longterm durability with regard to these properties. It is resistant to rain, moisture and water. Permanent water emersion should be avoided, though.

HPL is not sensitive to temperature shock, it is resistant to frost and does not alter its properties even at low temperatures. The dimensional change due to temperature and humidity in the range from -20 °C to +80 °C and 10 – 90 % relative humidity is about 0.4 %. As a non-metal material, it does not corrode. The influence of exhaust emissions or acid rain on HPL is very low.

Façades and balcony panels are subject to building regulations and in many countries also require building inspection approval. As a rule, the respective building authorities are obligated to grant approvals only after test procedures have been completed.

## 3.10 Cleaning HPL surfaces

The HPL surface can simply be cleaned with warm water and then dried with a paper towel and a soft cloth. More persistent marks can usually be removed with non-abrasive household cleaners such as washing powder, liquid or solid soap. Depending on the degree of staining it may be necessary to allow an extended contact time for the cleaning agent to take effect. Afterwards rinse with water and dry, repeat several times if necessary. Remove all residue of the cleaning agent to prevent smear marks. Use a clean, absorbent cloth to dry the surface. The above procedure can be improved by using a cleaning sponge or a nylon brush.

HPL is 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, mainly with caustic substances such as descaler, aggressive household cleaners, toilet and oven cleaners should be avoided and must be removed immediately.

Limescale deposits can be removed with a warm 10 % acetic acid or citric acid solution. When using a household descaler, the surface must be rinsed with water immediately.

Paraffin or wax residue first has be removed mechanically using a plastic or wooden spatula to avoid scratching the surface.

Fresh contaminations from water-soluble paint, varnish and adhesives can be removed with water as usual. dried residue can be removed with solvents such as ethanol, acetone or paint thinner.

Fresh stains from paint, varnish and adhesives containing solvents can usually be removed with solvents, even dried residue after prolonged exposure, if necessary. Suitable solvents are ethanol, acetone or paint thinner.

Staining caused by two component adhesives and paint has to be removed from the HPL immediately. After hardening, it is not possible to remove these stains without leaving any residue. The surface has to be cleaned immediately with a suitable organic solvent, observing the information from the manufacturer of the corresponding adhesive or varnish system. Two component adhesives and varnishes are based on e.g. epoxy resin or polyurethane (PU).

Staining caused by sealing material based on silicone or polyurethane, requires the residue of the sealing material to be carefully removed mechanically beforehand. A plastic or wooden scraper is ideal for preventing scratches on the surface. Any remaining residue can be cleaned with suitable removers (e.g. silicone remover), if necessary even after prolonged exposure. Prolonged exposure times to the silicon remover can lead to changes on the surface. After coming into contact with solvents, the surface has to be rinsed with warm water and then dried with a clean, soft, absorbent cloth.

# 4 HPL and the environment

A life cycle analysis in 1998 already underlined that HPL has excellent environmental properties. An environmental product declaration (EPD) for HPL was issued for the first time in 2012. There are three distinct types of environmental product declarations in accordance with the international ISO 14020 standard. Type III is the most comprehensive level that can be achieved. As this type is verified by an independent third party, it has the greatest degree of objectivity and neutrality. The environmental product declaration for HPL was issued to this highest standard type III. An EPD is valid for five years.

A new EPD was issued in 2017, also to the highest standard type III. The current version differentiates between two types of HPL – standard HPL (0.8 mm) and HPL-Compact (8 mm). While the former is used with a substrate, HPL-Compact can generally be used as a self-supporting element with visible or invisible fastening, e.g. on walls.
Environmental product declarations provide quantitative, verified and objective information about the effects of a product or service on the environment by means of clearly defined parameters. The complete life cycle of the product (raw material extraction, production, transport, use, disposal) is taken into consideration in this process. Environmental product declarations are used more and frequently in the building sector in particular by architects and building contractors in order to verify and guarantee the most sustainable construction possibility. Environmental product declarations are also drawn up for products beyond the field of construction.

The environmental product declaration must contain certain parameters so that the life cycle assessment of a product can be presented in a transparent way. The life cycle inventory analysis describes which resources a product consumes during its life cycle (e.g. energy, water, renewable and non-renewable resources). The life cycle inventory analysis also states the air, water and ground emissions. The impact assessment is based on the results of the life cycle inventory analysis and it provides concrete information on environmental effects such as the greenhouse effect, the depletion of the ozone layer, acidification or the exhaustion of fossil and mineral resources. Additional indicators such as the type and quantity of waste produced are also shown. The following parameters are crucial for the environmental profile of a product:

- Global warming potential (see table: Environmental impact; GWP)
- Ozone depletion potential (see table: Environmental impact; ODP)
- Abiotic depletion potential – fossil fuels (see table: Environmental impact; ADPF)

**Table 11: Key parameters**

| Parameter | Unit | HPL | HPL-Compact |
|---|---|---|---|
| Global warming potential (GWP) | kg $CO_2$-equivalent | 3.66 | 31.2 |
| Ozone depletion potential (ODP) | kg CFC11- equivalent | $3.18 \times 10^{-9}$ | $3.3 \times 10^{-8}$ |
| Abiotic depletion potential – fossil fuels (ADPF) | MJ | 54.0 | 471 |

The most important statements of the HPL environmental product declaration are therefore as follows:

- 3.66 kg of $CO_2$ equivalent are emitted during the production of one square meter of HPL.
- Projected to the production volume, the impact of the European HPL production on the greenhouse effect is minimal compared to the European industry overall. It is only 0.08 % of the total $CO_2$ emission of the European industry in 2010.
- The impact of HPL production on the depletion of the ozone layer is very minor. With a value of $3.3 \times 10^{-8}$ kg CFC11 equivalent for thin HPL and $3.18 \times 10^{-9}$ kg CFC11 equivalent for HPL-Compact, HPL generates virtually no substances which could damage the ozone layer.
- As in all other areas of the manufacturing industry, energy consumption is a major factor in the HPL industry as well. 54 MJ (approx. 15 kWh) are required for manufacturing one square meter of HPL, and 471 MJ (approx. 131 kWh) for HPL-Compact. What is crucial, though, is the fact that the surface itself as well as HPL in combination with a substrate allow a high level of energy recovery after use through environmentally friendly incineration. This recovered energy is a positive counter item in the energy balance.

# Appendix

The following appendix provides a range of additional information to support processing and application of HPL, HPL-Compact and HPL composite elements.

- Part 1 Technical characteristics of HPL
- Part 2 Tables for chemical resistance
- Part 3 Testing and evaluating composite HPL elements
- Part 4 Processing parameters
- Part 5 General calculation of the bonding pressure for hydraulic presses
- Part 6 Panels for indoor walls
- Part 7 Panels for outdoor walls
- Part 8 Structure and physical properties of a window sill

## Part 1: Technical characteristics of HPL

### Table 12: Overview of the key characteristics

| Property | Test standard | Unit | HPL typ | |
|---|---|---|---|---|
| | | | HGS / HGP / HGF<br>HDS / HDP / HDF | CGS / CGF |
| Flexural strength, lengthwise | ISO 178 | N/mm$^2$ | ≥ 80 | ≥ 140 (*) |
| Flexural strength, crosswise | ISO 178 | N/mm$^2$ | ≥ 80 | ≥ 100 (*) |
| Flexural modulus, lengthwise | ISO 178 | N/mm$^2$ | ≥ 9000 | ≥ 14000 (*) |
| Flexural modulus, crosswise | ISO 178 | N/mm$^2$ | ≥ 9000 | ≥ 10000 (*) |
| Tensile strength, lengthwise | EN ISO 527-1 | N/mm$^2$ | ≥ 60 | ≥ 115 (*) |
| Tensile strength, crosswise | EN ISO 527-1 | N/mm$^2$ | ≥ 60 | ≥ 75 (*) |
| Impact resistance, lengthwise | ISO 179-1 | kJ/m$^2$ | | ≥ 11 (*) |
| Impact resistance, crosswise | ISO 179-1 | kJ/m$^2$ | | ≥ 8 (*) |
| Compressive strength parallel to the layers | DIN 52 185 | N/mm$^2$ | | ≥ 165 (*) |
| Delamination load | DIN 53 463 | N | | ≥ 2500 (*) |
| Brinell hardness | EN 1534 | N/mm$^2$ | | ≥ 185 (*) |
| Thermal conductivity | DIN EN 12 664 | W/(m * K) | 0,3 | CGS 0.3 (*)<br>CGF 0.5 (*) |
| Coefficient of linear thermal expansion, lengthwise | DIN 53 752 | 1/K | $9 \times 10^{-6}$ | |
| Coefficient of linear thermal expansion, crosswise | DIN 53 752 | 1/K | $16 \times 10^{-6}$ | |
| Sound reduction index | DIN EN ISO 10 140 | dB(A) | Depends on material and construction | |

(*) The values were determined in a round robin test on 10 mm compact boards at IHD Dresden in October 2014.

## Part 2: Tables for chemical resistance

### Special properties

HPL is resistant to most chemicals. Some chemicals, however, can affect the surface. Special consideration must be given to:

- concentration of the chemical
- pH value (acid/base ratio)
- exposure time
- temperature

The following lists provide – without claiming to be complete – an overview of the resistance of HPL to the most commonly used substances (in solid, dissolved or gaseous form). If chemicals other than those listed in the following are intended for contact with HPL, their compatibility must be tested.
We therefore recommend immediately removing the chemicals listed with limited or no resistance.

### Resistance

HPL is resistant to the substances listed in the following. The substances listed in this section do not cause any changes to the surface even after prolonged exposure (max. 16 h as per EN 438).

Table 13a: Chemical resistance

| | Substance | Chemical formula |
|---|---|---|
| A | Acetone | $CH_3COCH_3$ |
| | Acetic acid/glacial acetic acid | $CH_3COOH$ |
| | Acetic acid ethyl ester | $CH_3COOC_2H_5$ |
| | Acetic acid isoamyl ester | $CH_3COOC_5H_{11}$ |
| | Aldehydes | RCHO |
| | Alcohols (all) | ROH |
| | Alcoholic beverages | ROH |
| | Aluminium sulphate | $Al_2(SO_4)_3$ |
| | Alum solution | $KAl(SO_4)_3$ |
| | Amides | $RCONH_2$ |
| | Amines (all) | $RNH_2$ |
| | Ammonia | $NH_4OH$ |

| | Substance | Chemical formula |
|---|---|---|
| | Ammonium chloride | $NH_4Cl$ |
| | Ammonium sulphate | $(NH_4)_2SO_4$ |
| | Ammonium thiocyanate | $NH_4SCN$ |
| | Amyl acetate | $CH_3COOC_5H_{11}$ |
| | Amyl alcohol | $C_5H_{11}OH$ |
| | $\alpha$-naphthol | $C_{10}H_7OH$ |
| | $\alpha$-naphtylamine | $C_{10}H_7NH_2$ |
| | Arabinose | $C_5H_{10}O_5$ |
| | Ascorbic acid | $C_6HSO_6$ |
| | Asparagine | $C_4HSO_3N_2$ |
| | Asparagine acid | $C_4H_7O_4N$ |

| | Substance | Chemical formula |
|---|---|---|
| B | Barium chloride | $BaCl_2$ |
| | Barium sulphate | $BaSO_4$ |
| | Benzaldehyde | $C_6H_5CHO$ |
| | Benzidine | $NH_2C_6H_4C_6H_4NH_2$ |
| | Benzoic acid | $C_6H_5COOH$ |
| | Benzene | $C_6H_6$ |
| | Blood / blood type test serums | |
| | Boric acid | $H_3BO_3$ |
| | Butyl acetate | $CH_3COOC_4H_9$ |
| | Butyl alcohol | $C_4H_9OH$ |
| C | Cadmium acetate | $Cd(CH_3COO)_2$ |
| | Cadmium sulphate | $CdSO_4$ |
| | Calcium carbonate | $CaCO_3$ |
| | Calcium chloride | $CaCl_2$ |
| | Calcium hydroxide | $Ca(OH)_2$ |
| | Calcium nitrate | $Ca(NO_3)_2$ |
| | Calcium oxide | CaO |
| | Cane sugar | $C_{12}H_{22}O_{11}$ |
| | Carbol xylol | $C_6H_5OH\text{-}C_6H_4(CH_3)_2$ |
| | Carbolic acid | $C_6H_5OH$ |
| | Carbon tetrachloride | $CCl_4$ |
| | Caustic soda up to 10 % | NaOH |
| | Cement | |
| | Chloral hydrate | $CCl_3CH(OH)2$ |
| | Chlorobenzene | $C_6H_5Cl$ |
| | Cholesterol | $C_{27}H_{45}OH$ |
| | Citric acid | $C_6H_8O_7$ |
| | Cocaine | $C_{17}H_{21}O_4N$ |
| | Cresol | $CH_3C_6H_4OH$ |
| | Cresylic acid | $CH_3C_6H_4COOH$ |
| | Copper sulphate | $CuSO_4$ |
| | Cyclohexane | $C_6H_{12}$ |
| D | Dextrin | $(C_6H_{10}O_5)_n$ |
| | Digitin | $C_{56}H_{92}O_{29}$ |
| | Dimethylformamide | $HCON(CH_3)_2$ |
| | Dimethyl sulfoxide | $(CH_3)_2SO$ |
| | Dioxane | $C_4H_8O_2$ |
| | Dulcit | $C6_6H_{14}O_6$ |
| F | Formaldehyde | HCHO |

| | Substance | Chemical formula |
|---|---|---|
| | Formic acid up to 10 % | HCOOH |
| | Fructose/galactose | $C_6H_{12}O_6$ |
| G | Galactose | $C_6H_{12}O_6$ |
| | Gelatin | |
| | Gypsum | $CaSO_4\ 2H_2O$ |
| | Glucose | $C_6H_{12}O_6$ |
| | Glycerin | $C_3H_8O_3$ |
| | Glycocoll | $NH_2CH_2COOH$ |
| | Glycol (all) | $HOCH_2CH_2OH$ |
| | Graphite (carbon) | C |
| H | Heptanol | $C_7H_{15}OH$ |
| | Hexane | $C_6H_{14}$ |
| | Hexanol | $C_6H_{13}OH$ |
| | Hydroquinone | $HOC_6H_4OH$ |
| I | Ink | |
| | Inositol | $C_6H_6(OH)_6$ |
| | Isopropyl alcohol | $C_3H_6OH$ |
| K | Ketone (all) | RCOR |
| L | Lactic acid | $C_3H_6O_3$ |
| | Lactose | $C_{12}H_{22}O_{11}$ |
| | Laevulose | $C_6H_{12}O_6$ |
| | Lead acetate | $Pb(CH_3COO)_2$ |
| | Lead nitrate | $Pb(NO_3)_2$ |
| | Lithium carbonate | $Li_2CO_3$ |
| | Lithium hydroxide up to 10 % | LiOH (aq) |
| M | Magnesium carbonate | $MgCO_3$ |
| | Magnesium chloride | $MgCl_2$ |
| | Magnesium hydroxide | $Mg(OH)_2$ |
| | Magnesium sulphate | $MgSO_4$ |
| | Maltose | $C_{12}H_{22}O_{11}$ |
| | Mannitol | $C_6H_{14}O_6$ |
| | Mannose | $C_6H_{12}O_6$ |
| | Mercury | Hg |
| | Meso-inositol | $C_6H_6(OH)_6$ |
| | Methanol | $CH_3OH$ |
| | Methylene chloride (dichloromethane) | $CH_2Cl_2$ |
| | Mineral salts (exceptions in tables 13 b and 13 c) | |
| | Mineral oils | |

| | Substance | Chemical formula |
|---|---|---|
| N | Nail varnish | |
| | Nail varnish remover | |
| | Nickel sulphate | $NiSO_4$ |
| | Nicotine | $C_{10}H_{14}N_2$ |
| O | Octanol (octyl alcohol) | $C_8H_{17}OH$ |
| | Oleic acid | $C_{18}H_{34}O_2$ |
| | Olive oil | |
| P | 1.2-propylene glycol 1.2-propanediol | $C_3H_8O_2$ |
| | p-aminoacetophenone | $NH_2\ C_6H_4COCH_3$ |
| | Paraffin oil | |
| | Paraffins | $C_nH_{2n+2}$ |
| | Pentanol | $C_5H_{11}OH$ |
| | Perchloric acid | $HClO_4$ |
| | Phenol and phenol derivatives | $C_6H_5OH$ |
| | Phenolphthalein | $C_{20}H_{14}O_4$ |
| | p-nitrophenol | $C_6H_4NO_2OH$ |
| | Potassium aluminium sulphate | $KAl(SO_4)_2$ |
| | Potassium bromate | $KBrO_3$ |
| | Potassium bromide | $KBr$ |
| | Potassium carbonate | $K_2CO_3$ |
| | Potassium chloride | $KCl$ |
| | Potassium hexacyanoferrate | $K_4Fe(CN)_6$ |
| | Potassium hydroxide up to 10 % | $KOH_{(aq)}$ |
| | Potassium iodate | $KIO_3$ |
| | Potassium nitrate | $KNO_3$ |
| | Potassium sodium tartrate | $KNaC_4H_4O_6$ |
| | Potassium sulphate | $K_2SO_4$ |
| | Potassium tartrate | $K_2C_4H_4O_6$ |
| | Propanol | $C_3H_7OH$ |
| | Pyridine | $C_5H_5N$ |
| R | Raffinose | $C_{18}H_{32}O_{11}\ 5H_2O$ |
| | Rhamnose | $C_6H_{12}O_5\ H_2O$ |
| S | Salicylaldehyde | $C_6H_4OH\ CHO$ |
| | Salicylic acid | $C_6H_4OHCOOH$ |
| | Sodium acetate | $CH_3COONa$ |
| | Sodium carbonate | $Na_2CO_3$ |
| | Sodium chloride | $NaCl$ |
| | Sodium citrate | $Na_3C_6H_5O_7\ 5H_2O$ |
| | Sodium diethyl barbiturate | $NaC_8H_{11}N_2O_3$ |
| | Sodium hydrogen carbonate | $NaHCO_3$ |
| | Sodium hydrogen sulphite | $NaHSO_3$ |
| | Sodium hyposulphite | $Na_2S_2O_4$ |
| | Sodium nitrate | $NaNO_3$ |
| | Sodium phosphate | $Na_3PO_4$ |
| | Sodium silicate | $Na_2SiO_3$ |
| | Sodium sulphate | $Na_2SO_4$ |
| | Sodium sulphide | $Na_2SO_3$ |
| | Sodium sulphite | $Na_2S$ |
| | Sodium tartrate | $Na_2C_4H_4O_6$ |
| | Sodium thiosulphate | $Na_2S_2O_3$ |
| | Sorbitol | $C_6H_{14}O_6$ |
| | Stearic acid | $C_{17}H_{35}COOH$ |
| | Styrene | $C_8H_8$ |
| | Sugar and sugar derivatives | |
| | Sulphur | $S$ |
| T | Talcum | $Mg_3Si_4O_{10}(OH)_2$ |
| | Tannin | $C_{76}H_{52}O_{46}$ |
| | Tartaric acid | $C_4H_8O_6$ |
| | Tetrahydrofuran | $C_4H_8O$ |
| | Tetralin | $C_{10}H_{12}$ |
| | Thiourea | $NH_2CSNH_2$ |
| | Thymol | $C_{10}H_{14}O$ |
| | Toluol | $C_6H_5CH_3$ |
| | Trehalose | $C_{12}H_{22}O_{11}$ |
| | Trichlorethylene | $C_2HCl_3$ |
| | Tryptophan | $C_{11}H_{12}O_2N_2$ |
| | Turpentine | |
| U | Urea solution | $CO(NH_2)_2$ |
| | Uric acid | $C_5H_4N_4O_3$ |
| V | Vanillin | $C_8H_8O_3$ |
| W | Water | $H_2O$ |
| X | Xylol | $C_6H_4(CH_3)_2$ |
| Z | Zinc chloride | $ZnCl_2$ |
| | Zinc sulphate | $ZnSO_4$ |

**Limited resistance**

HPL is not changed if it is only exposed to the substances listed in the following for a short period, max. 10–15 minutes. During this time, the surface has to be wiped thoroughly with a wet cloth and then rubbed dry.

**Table 13 b: Limited chemical resistance**

| | Substance | Chemical formula |
|---|---|---|
| A | Aluminium chloride | $AlCl_3$ |
| | Amidosulphonic acid up to 10 % | $NH_2SO_3H$ |
| | Ammonia hydrogen sulphate | $NH_4HSO_4$ |
| | Arsenic acid up to ~10 % | $H_3AsO_4$ |
| C | Caustic soda over 10 % | NaOH |
| | Crystal violet (gentian violet) | $C_{25}H_{30}N_3Cl$ |
| D | Descaler | |
| | Dyeing and bleaching agents | |
| F | Fuchsine solution | $C_{19}H_{19}N_3O$ |
| H | Hydrochloric acid up to 10 % | HCl |
| | Hydrogen peroxide 3–30 % | $H_2O_2$ |
| I | Iodine solution | $I_2$ |
| | Iron(II) chloride solution up to ~10 % | $FeCl_2$ |
| | Iron(III) chloride solution | $FeCl_3$ |
| L | Lithium hydroxide | LiOH |
| M | Mercuric chloride | $HgCl_2$ |
| | Mercury dichromate | $HgCr_2O_7$ |
| | Methylene blue | $C_{16}H_{18}N_3ClS$ |
| | Millon's reagent | $OHg_2NH_2Cl$ |
| N | Nitric acid up to 10 % | $HNO_3$ |
| O | Oxalic acid | $C_2H_2O_4$ |
| P | Phosphoric acid up to 10 % | $H_3PO_4$ |
| | Picric acid | $C_6H_2OH(NO_2)_3$ |
| | Potash lye over 10 % | KOH |
| | Potassium chromate | $K_2CrO_4$ |
| | Potassium dichromate | $K_2Cr_2O_7$ |
| | Potassium hydrogen sulphate | $KHSO_4$ |
| | Potassium iodide | KI |
| | Potassium permanganate | $KMnO_4$ |
| S | Silver nitrate | $AgNO_3$ |
| | Sodium hydrogen sulphate | $NaHSO_4$ |
| | Sodium hypochlorite (bleach) | NaOCl |
| | Sulfuric acid up to 10 % | $H_2SO_4$ |

### No resistance

Contact with the substances listed in the following must be avoided as they damage the HPL surface even after brief exposure.

### Table 13 c: No chemical resistance

| | Substance | Chemical formula |
|---|---|---|
| A | Adhesives (chemically hardening) | |
| | Amidosulphonic acid* | $NH_2SO_3H$ |
| | Aqua regia* | $HNO_3 + HCl = 1:3$ |
| C | Chromic sulphuric acid* | $K_2Cr_2O_7 + H_2SO_4$ |
| F | Formic acid* | HCOOH |
| H | Hydrochloric acid* | HCl |
| | Hydrofluoric acid* | HF |
| | Hydrogen bromide* | HBr |
| I | Inorganic acids* or arsenic acid | $H_3AsO_4$ |
| N | Nitric acid* | $HNO_3$ |
| P | Phosphoric acid* | $H_3PO_4$ |
| S | Sulphuric acid* | $H_2SO_4$ |
| * in concentrations over 10 % | | |

### Aggressive gases

Exposure to the following aggressive gases will deteriorate the appearance of HPL, but will usually not impair the functionality.

### Table 13 d: Aggressive gases

| | Substance | Chemical formula |
|---|---|---|
| B | Bromine | $Br_2$ |
| C | Chlorine | $Cl_2$ |
| F | Fuming acids | |
| H | Hydrogen peroxide approx. 35 % evaporated during 24 h for cleanroom disinfection | $H_2O_2$ |
| N | Nitrogen oxides | NOx / NxOy |
| S | Sulphur dioxide | $SO_2$ |

## Part 3: Testing and evaluating composite HPL elements

Due to its excellent usage properties, such as robustness, easy cleaning, hygiene and its many decorative design options, HPL can be found as a surface for furniture, doors, wall panels etc.. For this purpose, HPL is used primarily in combination with substrates, whereby design, HPL, substrate board and adhesive system determine the properties of the composite element. For this reason, HPL and substrates – the following considers only elements with chipboard substrates – as well as the adhesive systems which are used, have to meet the requirements for the intended application. The relevant standards are, primarily, EN 438 for HPL, EN 312 for chipboard, EN 204 for adhesives and EN 13894 for HPL elements.

Other important properties are recorded with the tests described in the following and provide additional information on the quality of the composite elements and therefore on their suitability for the intended use.

Testing on the finished elements may only be conducted seven days after manufacturing and subsequent storage, at the earliest. The actual measurements are conducted on samples which have been conditioned in a standard climate at 23 °C and 50 % relative humidity as per DIN 50014.

Table 14: Summary of the essential requirements for composite elements made of HPL and chipboard

| Property | Test method | Requirement |
|---|---|---|
| Measuring tolerances for sheets and panels | DIN EN ISO 13894-1:2015 Chapter 6 | DIN EN ISO 13894-2:2015 Chapter 5.2.2 – 5.2.4 |
| Flatness deviations | DIN EN ISO 13894-1 Chapter 7 | DIN EN ISO 13894-2 Chapter 5.2.5 |
| Surface strength | DIN EN ISO 13894-1 Chapter 9 | DIN EN ISO 13894-2 Chapter 5.3 ≥ 1 N/mm² |
| Tensile strength vertical to the sheet plane | DIN EN ISO 13894-1 Chapter 10 | DIN EN ISO 13894-2 Chapter 5.4 |
| Resistance to increased temperature (short-term exposure) | DIN EN ISO 13894-1 Chapter 11 | No damage as per 1h / 80 °C on edges (post-formed or at a right angle) and thermoplastic sealings and safety edges. Neither a deterioration of the HPL (e.g. cracks or colour changes) nor visible adhesive layer faults or a deterioration of the epoxy resin filler may occur after 1 h at 100 °C |
| Resistance to increased temperature (long-term exposure) | DIN EN ISO 13894-1 Chapter 12 | No visible changes, damage such as adhesive layer faults, colour change or crack formation in the HPL, safety edges or sealing strips |
| Resistance to steam | DIN EN ISO 13894-1 | DIN EN ISO 13894-2:2015 Chapter 13 Chapter 5.6, Appendix A.5 |
| Flexural strength | ISO 16978 | DIN EN ISO 13894-2, A.6 |
| Flexural modulus | ISO 16978 | DIN EN ISO 13894-2, A.6 |
| Axial pull-out resistance of wood screws | DIN EN ISO 13894-1 Chapter 15 | DIN EN ISO 13894-2, A.2 |
| Surface impact resistance (large-diameter ball method) | DIN EN ISO 13894-1 Chapter 17 | DIN EN ISO 13894-2 Chapter 5.7.2 ≥ 600 mm / ≤ 10mm |
| Surface impact resistance (small-diameter ball method) | DIN EN ISO 13894-1 Chapter 18 | DIN EN ISO 13894-2 Chapter 5.7.3 ≥ 15 N |
| Water resistance (edge swelling test) | DIN EN ISO 13894-1 Chapter 19 | DIN EN ISO 13894-2, A.8 |

## Part 4: Processing parameters

The following table provides guide values for machining HPL with and without substrates such as solid wood boards, veneer laminated wood, plywood, OSB, resin bonded chipboard and fibreboard.

### Table 15: Guide values for processing parameters

| Work stop | Machine | Cutting speed [m/s] | Speed [rpm] | Feed [m/min] |
|---|---|---|---|---|
| Sheet cutting | Sheet cutting saws | 60 – 100 | approx. 3000 – 6000 | approx. 10 – 30 |
| Rough cutting to Size | Bench, panel and hand-held circular saw, MC (*) | 30 – 100 | approx. 3000 – 6000 | up to approx. 10 |
| Detail cutting to size | Double-end profiler, pre-scoring, cutting and machining | 40 – 60 | approx. 6000 | approx. 6 – 60 |
| Routing edges | Bench milling machine or edge machining system, MC (*) | 40 – 60 | up to 12000 | approx. 6 – 24 |
| Routing edges | Hand-held router | 10 – 25 | approx. 12000 – 27000 | approx. 3 – 8 |
| Grooves | Circular table saw, bench milling machine, MC* | 40 – 100 | capprox. 3000 – 6000 | approx. 3 – 10 |
| Grooves | Double-end profiler | 40 – 60 | approx. 6000 – 9000 | approx. 6 – 24 |
| Grooves | Router, hand-held router, MC (*) | 10 – 25 | approx. 12000 – 27000 | approx. 3 – 8 |
| Drilling | Drilling machine, dowel machine, MC (*) | | approx. 3000 – 6000 | approx. 0.5 – 3 |
| (*) MC: CNC machining centre | | | | |

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

The curves 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 read from the graph. In the same way the tool diameter can be read if rotational speed and cutting speed are given.

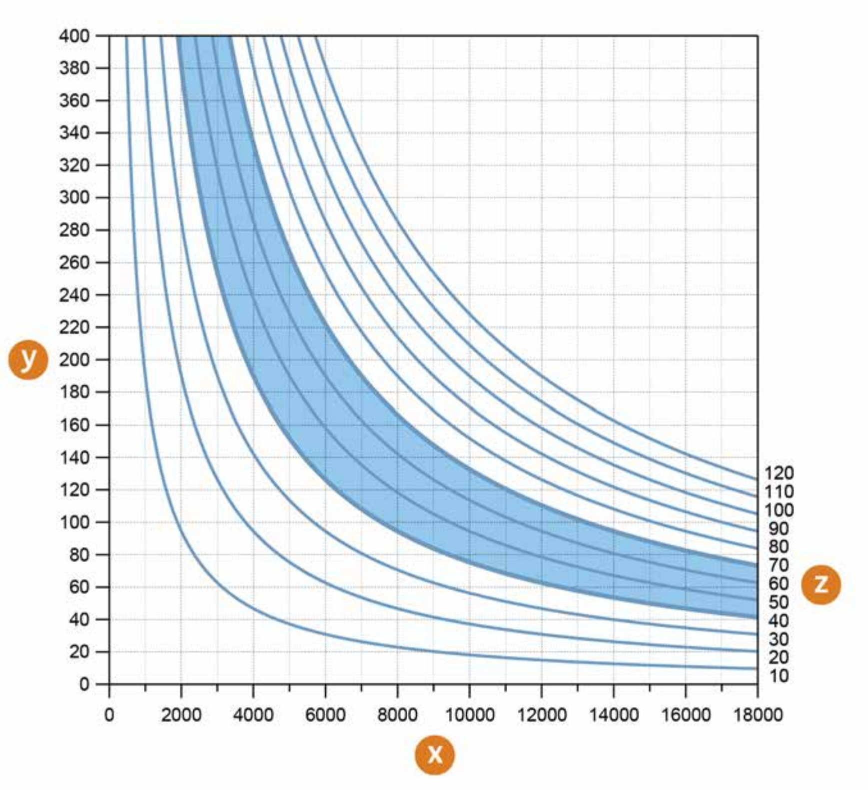



**Figure 43: Cutting speed as a function of rotational speed and tool diameter**

- x Speed n [rpm]
- y Tool diameter D [mm]
- z Cutting speed $v_c$ [m/s]

## Part 5: General calculation of the bonding pressure for hydraulic presses

For attaining the correct bonding pressure for different board sizes it is necessary to calculate the pressure exerted by the pistons and the corresponding pressure gauge pressure. Formula:

$$\frac{\text{Required bonding pressure [bar]}}{\text{Number of pistons [–]}} \times \frac{\text{sheet area [cm}^2\text{]}}{\text{piston area [cm}^2\text{]}} = \text{gauge pressure [bar]}$$

with piston area = $r^2 \times \pi$ [$cm^2$]

**Example:**

A hydraulic press is given, 6 pistons with 12 cm diameter each (i.e. radius r = 6 cm), furthermore a board to be laminated 210 cm × 80 cm. The bonding pressure is to be 3 bar.

$$\frac{3\text{ [bar]}}{6\text{ [–]}} \times \frac{210 \times 80\text{ [bar]}}{6^2\text{ [cm}^2\text{]} \times 3.14} \triangleq 74 \text{ bar pressure gauge pressure}$$

**Notes:**

- For workpieces with frame structures, only the supporting area of frame and insert (e.g. honeycombs) is to be taken into account.
- 1 bar ≙ 0,1 N/mm$^2$ ≙ 100 kPa ≙ 1 kp/cm$^2$

## Part 6: Panels for indoor walls

HPL composite elements or HPL-Compact are suitable for wall claddings. HPL-Compact are available in different thicknesses and a minimum thickness of 6 mm is recommended (standard 8 mm), so that the sheets do not sag and adequate spacing for the fastenings can be selected. In rooms with increased moisture (spray water, steam, etc.), special measures for edge protection are required for HPL composite elements. Due to the response to moisture of HPL composite elements or HPL-Compact, these products should always be installed with rear ventilation so that they are exposed to the same climate on both sides. Depending on the building situation or application, the panels should be conditioned for a certain time before installation. HPL composite elements as well as HPL-Compact have different expansion properties lengthwise and crosswise and should therefore always be installed in the same direction.

### Wall surface

The wall subsurface, especially fresh concrete walls, as well as brickwork and plaster, must be dry before installing any panels. The floor has to be strong enough to allow a solid connection to the substructure in order to absorb the weight of the panels and the distortion caused by climate influence.

### Substructure

The substructure is required due to the different expansion behaviours of the wall materials and panels. This requires the substructure to be designed to let air circulate vertically. This is usually achieved with vertical battens of at least 2 cm thickness. Required horizontal battens have to be sufficiently interrupted to allow air circulation. Battens can be made from e.g. wood or sections of composite elements or HPL-Compact, or from metal profiles. Planed wooden battens with a cross section of 24 mm × 48 mm or 30 mm × 50 mm are often used. In most cases, it is practical to install a substructure of battens (horizontal or vertical) and counter battens. The counter battens are mounted on the first set of battens rotated by 90°. This makes it easier to obtain an evenly aligned substructure. Regardless of the structure, the surface of the battens has to form one level, using adjustment blocks if required to avoid unnecessary tensions. The substructure is fastened to the wall with suitable fasteners, e.g. screws and wall anchors. The fasteners have to be selected to suit the wall and the weight of the wall panels. In dry-wall constructions, the substructure has to be anchored in the profiles.

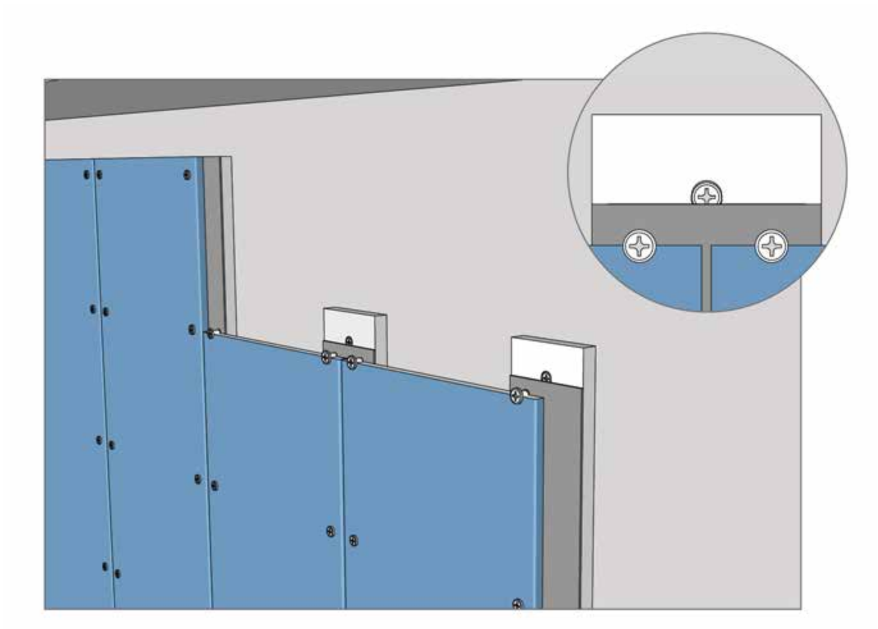


Figure 44: Wall panels with visible screws

### Fastening options for wall panels

The panels can be hung on the substructure, adhered invisibly or screwed / riveted on visibly.

### Hanging

The preferred method is to attach the wall panels by suspending them from the substructure, whereby vertical rear ventilation is ensured. The advantage of a hanging system is that the boards can be removed quickly and easily, which is important for expanding or adapting pipe and supply systems. It also allows the wall elements to be mounted without tensions. The panels can be suspended using Z-profiles made of metal (occasionally wood or HPL-Compact). Metal systems can be purchased from specialist retailers/stores. The number of suspension points results from the thickness of the panels and the application requirements. The structure has to be strong enough to bear the weight of the panels. The gap at the ceiling required for lifting and lowering the elements either remains visible as a shadow joint or is covered with a profile without impeding the rear ventilation.

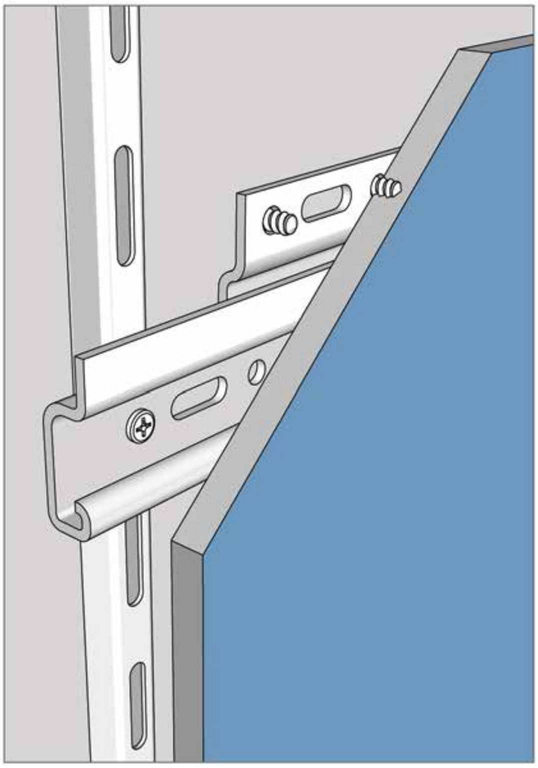


**Figure 45: Wall panels with metal profiles**

### Bonding

For bonded wall panels, vertical battens have to be attached for rear ventilation. The adhesive is applied vertically across the entire height. In addition to simple adhesive application, bonding systems with spacer tape (e.g. 2 mm thickness) are available to ensure that a minimum thickness of adhesive is applied throughout, allowing dimensional changes to be absorbed. Silane-modified polymer adhesives or PUR construction adhesives have proven successful as adhesives in this case. The technical data sheets from the adhesive manufacturers must be observed and, if in doubt, the adhesive manufacturer has to be consulted.

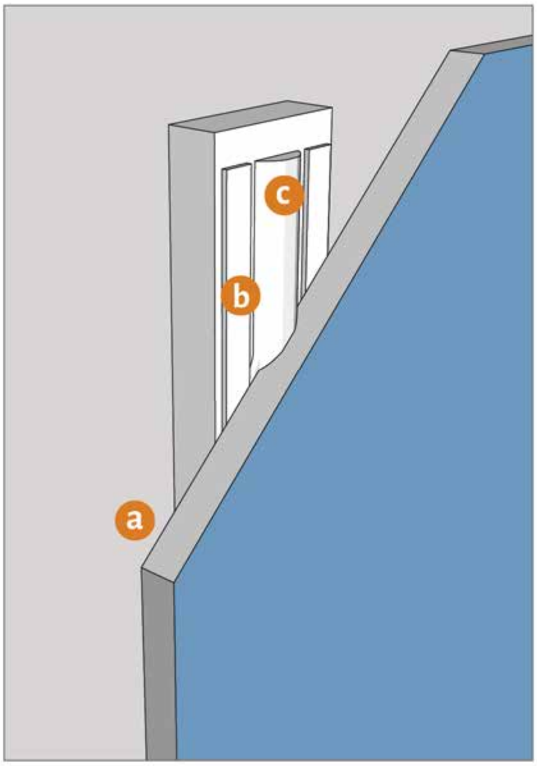



**Figure 46: Wall installation with bonding**

- a Rear ventilation
- b Adhesive
- c Installation or spacer tape

**Screws, rivets**

This visible installation method is not recommended for sophisticated wall panels for visual reasons. Direct fastening to the wall has to be declined.

Oval-head screws and countersunk screws are not suitable for direct fastening of the panels, unless appropriate washers are used. Screw and rivet heads should rest flush. Holes in the panels have to be drilled down to the attachment point, with a diameter approx. 2 mm larger than the screws (rivets), so the panels can react to climate changes. At the attachment point, the hole diameter corresponds to the screw diameter. The attachment point has to be placed as centrally as possible and is used for positioning the panels. The screws have to be applied in horizontal and vertical direction in a grid of 60 – 80 cm and only tightened finger-tight. The thicker the panels and the more balanced the climate in the panelled room, the larger the spacing can be.

The above instructions generally apply for installation with rivets. The rivet shaft should have a minimum diameter of 5 mm and the rivet should be applied with a gauge, so that the tightening force is not too high and expansions of the panels due to climate changes can be absorbed.

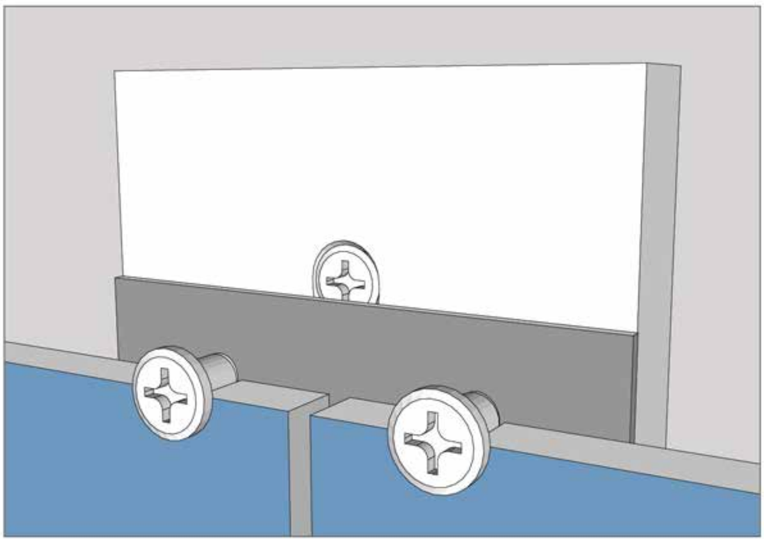


Figure 47: Options for visible screws, screw without protection

## Joints

### Lateral joints

Except for the visible fastening of the elements on the surface, it is important to install the edges securely. Loose or weak edges can result in the elements distorting along the longitudinal edges, which in turn leads to warping. There are numerous connection types and systems for implementing vertical and horizontal joints between the edges. It always has to be ensured that the joints provide the elements with room for expansion. The required expansion joints are dimensioned depending on the building situation and the sealing materials. The maximum width for installation without joints is approx. 3 m. On wall connections, the joint width should be at least 8 mm. Sealed joints have to be at least 5 mm wide. Adhesion along both flanks must be ensured. When working with sealing compounds, the technical processing information from the manufacturer has to be observed.

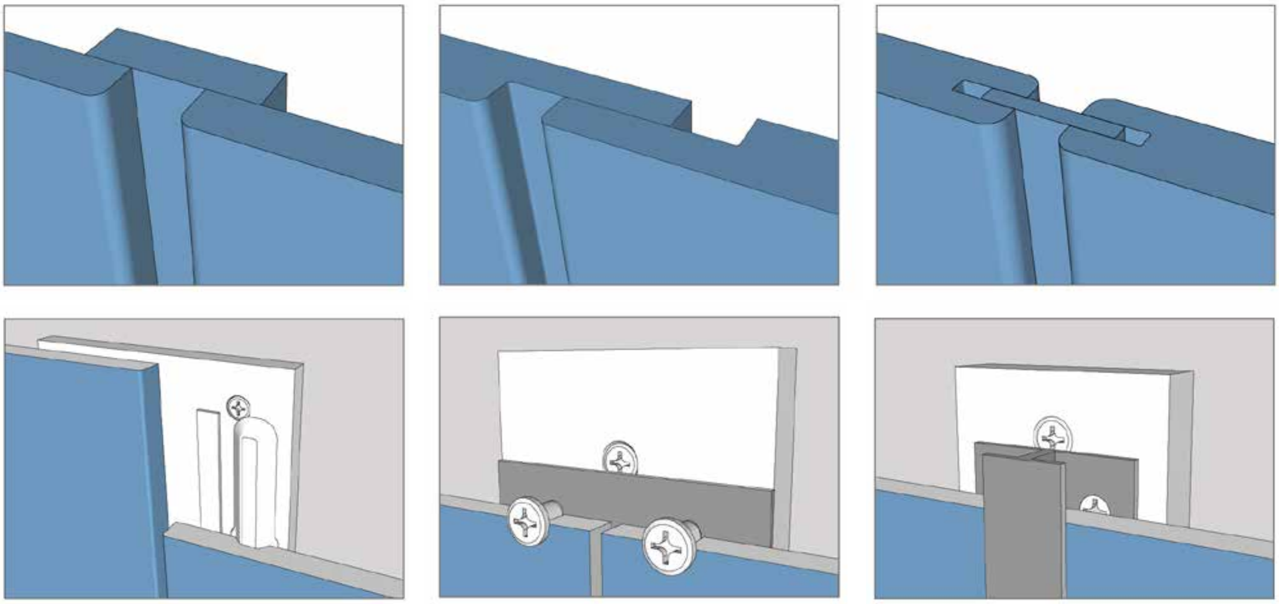


Figure 48: Examples for joints on HPL wall panels

## Corner joints

Corners and their secure fastening is of special importance for most wall panels. The elements forming the outer corners have to be securely fastened to the substructure and connected to each other so they can resist impact. For external corners, metal profiles are recommended for edge protection, especially on HPL composite elements. Compact formed parts or postforming elements are a good alternative. Depending on the structure, we recommend prefabricating corner elements. Sealed joints have to be at least 5 mm wide. Adhesion along both flanks must be ensured.

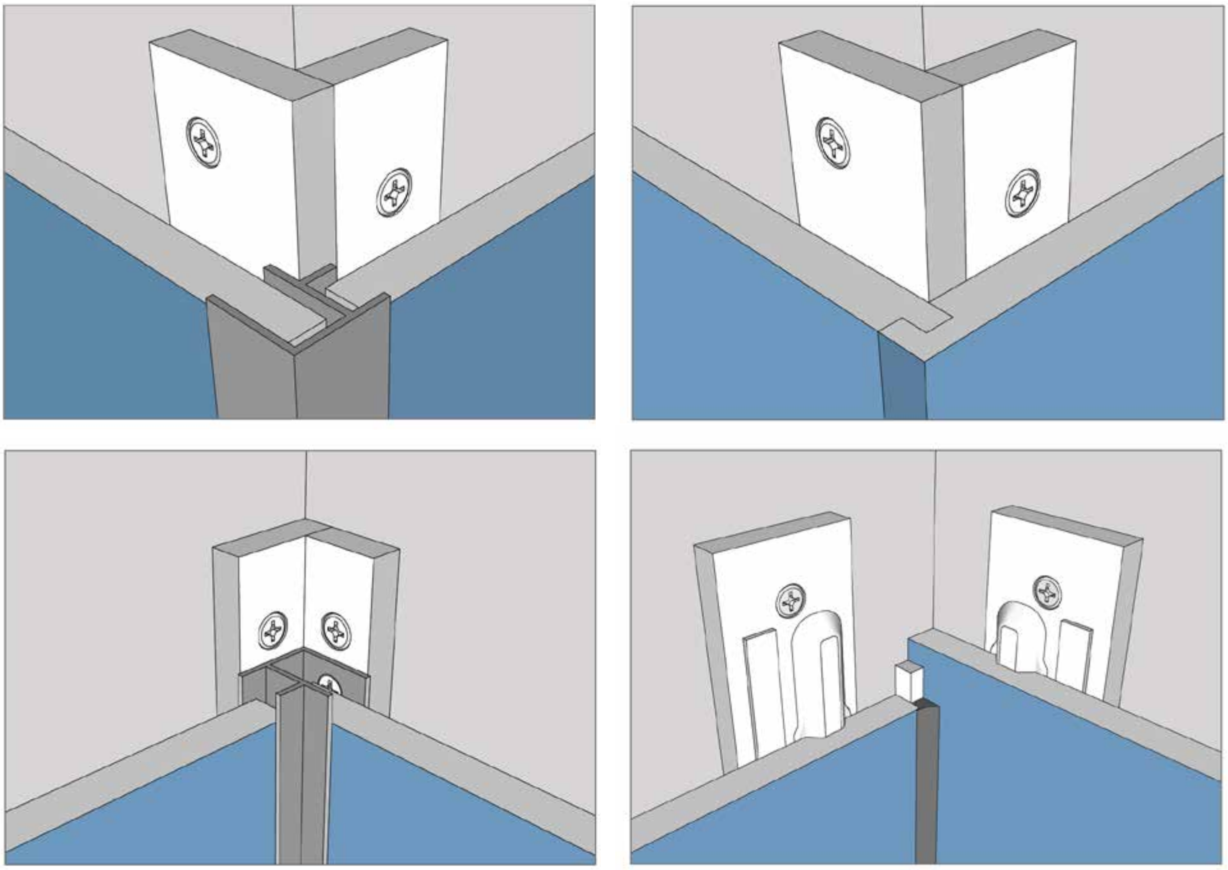


Figure 49: Examples for corner joints

**Ceiling connections**

Ceiling connections of wall panels made of HPL composite elements or HPL-Compact always require a gap of at least 1 – 2 cm to ensure rear ventilation. Installation of the wall panels with suspension systems require a certain distance between the panels and the ceiling for attaching the panels. This gap can be concealed for visual reasons or expanded to accommodate ventilation screens.

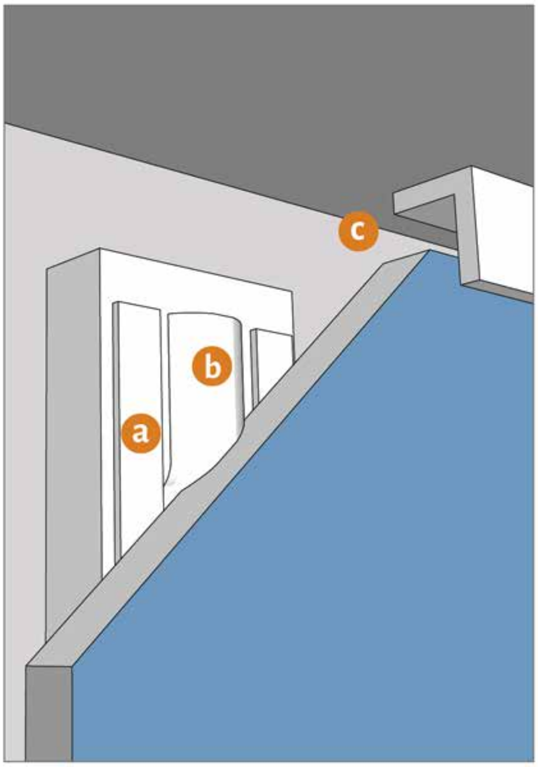



**Figure 50: Ceiling connection with trim for bonded panels**

a Installation or spacer tape | b Adhesive

c Trim with rear ventilation

### Tub connections

Tub and basin connections are subject to particularly intensive exposure to water. The prescribed sealing work therefore has to be carried out with particular care in this area. HPL-Compact is resistant to water and therefore particularly suitable for wet rooms. In addition, the installation and sealing instructions supplied by the manufacturers of the sanitary devices have to be observed and sealing compounds have to be used. Narrow areas (especially for HPL composite elements), cutouts and drilled holes have to be permanently sealed against moisture.

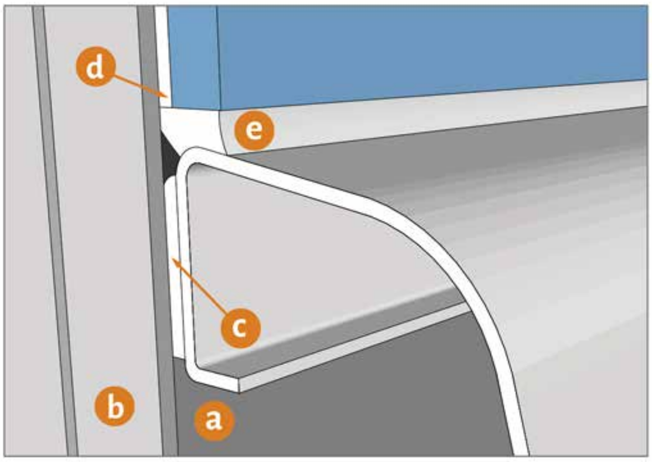



**Figure 51: Tub connection with permanently elastic sealing joint**

a Vapour barrier | b Wall surface | c Sound protection | d Wall adhesive | e Sealing compound

**Floor connections**

Depending on the subsequent intended use of the room, the wall panels can be joined to the floor in different ways. To ensure rear ventilation, a gap of at least 1 – 2 cm is required. If this is not possible for hygiene reasons, the gap can be extended to e.g. 10 cm. To protect the wall, a skirting board made from tile or a strip of HPL-Compact (e.g. 3 mm thick) should then be adhered full-surface using e.g. a universal silane-modified polymer adhesive. The skirting board has to be sealed against water towards the floor using a sealing compound. HPL-Compact is ideal for wall panels in wet rooms. If other materials are used, edges have to be protected against moisture.

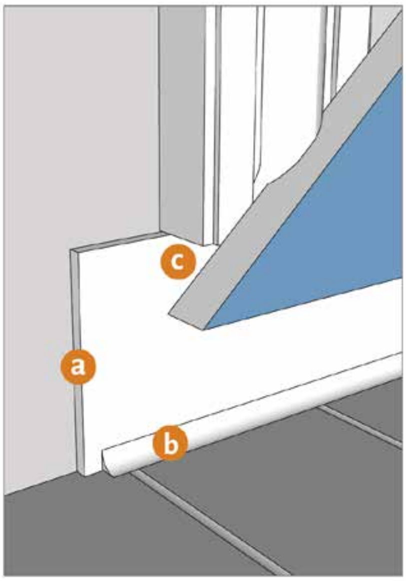



**Figure 52: Floor connection**

- a Tile plinth
- b Sealing compound
- c Air gap

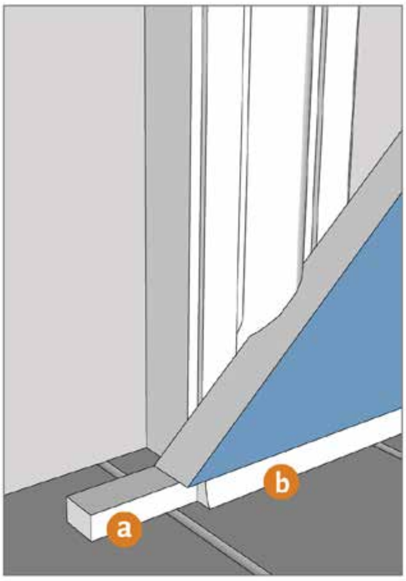



**Figure 53: Floor connection from HPL-Compact**

- a Foam sealing tape
- b Sealing compound

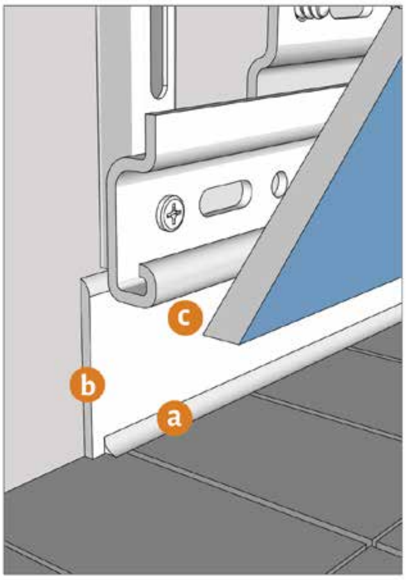



**Figure 54: Floor connection from HPL-Compact**

- a Sealing compound
- b Tile plinth
- c Air gap

**Installation through or on the panels**

In rooms with increased moisture, it is important that the structure is protected against water. As HPL-Compact has a high resistance to moisture, it is more suitable for these rooms than HPL composite elements. However, all openings in both variants have to be sealed appropriately. Different systems are available for this, e. g. water pipe openings with special permanently elastic collars. Alternatively, the diameter of the hole is adapted so that a gap of at least 5 mm is created which can be filled with sealing compound. Cold water pipes in particular have to be insulated, as condensate could be generated which would damage the wall surface. The sealing work has to be carried out with great care as the quality and service life of the structure depend on them. Direct threaded connections into the panels have to be sealed with sealing compound and permanently elastic sleeves.

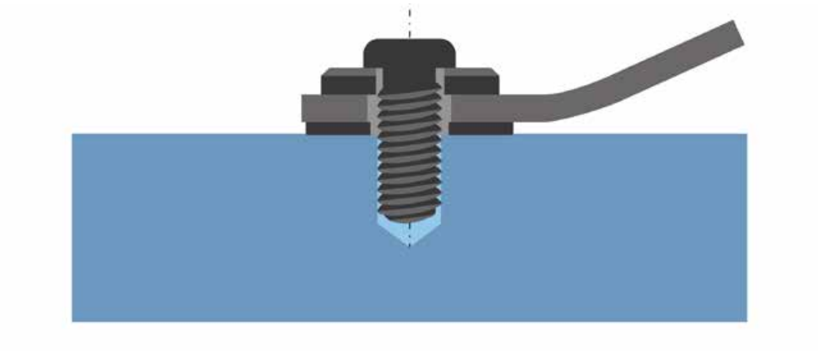


Figure 55: Threaded connection in HPL-Compact

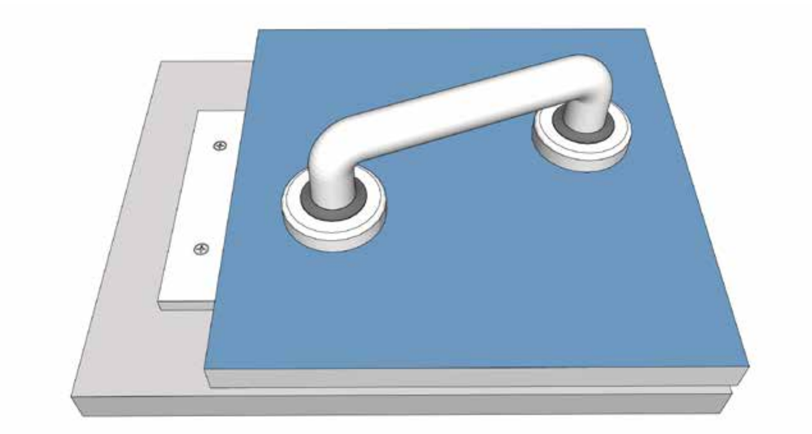


Figure 56: Threaded connection in the substructure

## Part 7: Panels for outdoor walls

The local building regulations have to be observed. Compact sheets can be used to install e.g. façade panels, balcony dividing walls and soffits in outdoor areas.

### Planning façades and façade components

Façades have to be planned by a certified professional. Particular attention has to be given to correct arrangement, dimensions and type of the substructure, arrangement and type of the panel fastening as well as the climatic conditions during subsequent use. Climate-related expansion behaviour of the substructure and of the HPL-Compact will differ. For metal substructures, the temperature-related length change plays a greater role, while the moisture-related length change is more relevant for HPL-Compact. For HPL-Compact, the climate-related expansion behaviour in crosswise direction (width of available formats) is about twice the expansion in lengthwise direction (length of available formats). Joints between sheets should be at least 10 mm. To prevent chipping, no holes should be drilled within the edge area of 20 mm. The local requirements (e.g. wind loads, building height) have to be taken into account when selecting the spacing between fasteners.

### Substructure

Substructures – usually metal-based – are available for façades with rear ventilation. Their properties as well as the necessary fastening points have to be considered for façade planning. Substructures with rear ventilation can also be made out of wood with battens or using battens and counter battens. Elastic sealing strips have to be applied to ensure that the wooden structure behind is protected against moisture. Depending on the surface area, attaching balcony panels have to be clarified individually, as there are many different options such as U-profiles, L-profiles or glass holder systems.

### Fasteners for HPL-Compact

Countersunk and oval-head screws are generally not suitable for installing HPL-Compact. For all fastening types, it has to be taken into account that temperature and humidity changes can cause the HPL surfaces to expand and contract and that swelling (< 0.3 mm) do not cause unusual tensions. Therefore, e.g. screws should be tightened finger-tight or rivets should be placed with a gauge. The diameter of the drilled holes is generally 2 mm larger than the shaft diameter of the screws or rivets, except for fixing points. Various other fastening systems are available on the market. It has to be individually clarified whether a planned structure complies with all legal requirements and the state of the art.

### Stainless steel screws

The diameter of the screw heads has to be at least 4 mm larger than the drilled hole. They can be painted or colour-matched with cover caps. The shaft thickness of the screws has to be at least 5 mm and has to be adapted to the requirements.

### Aluminium or stainless steel rivets

The diameter of the rivet heads has to be at least 6 mm larger than the drilled hole. They can be painted or colour-matched with cover caps. The shaft thickness of the rivets has to be at least 5 mm and has to be adapted to the requirements. The rivets have to be installed with a gauge to reduce the contact pressure.

### Glass holders

Depending on the requirements, glass holders can also be used for installing HPL-Compact, e.g. clamping elements with locking pin.

### Profiles (wood, metal or plastic systems)

Depending on the design and requirements, HPL-Compact can also be installed using window profiles, U-profiles or L-profiles. In addition to the strength requirements, it has to be taken into account that there is sufficient space for climate-related dimensional changes and loading/unloading openings. Seals on the HPL surface are ideally implemented with rubber seals.

### Bonding systems

For bonded façade elements, the processing instructions from the adhesive and installation tape manufacturers must be observed. Sufficient space for climate-related dimensional changes has to be ensured for this system as well.

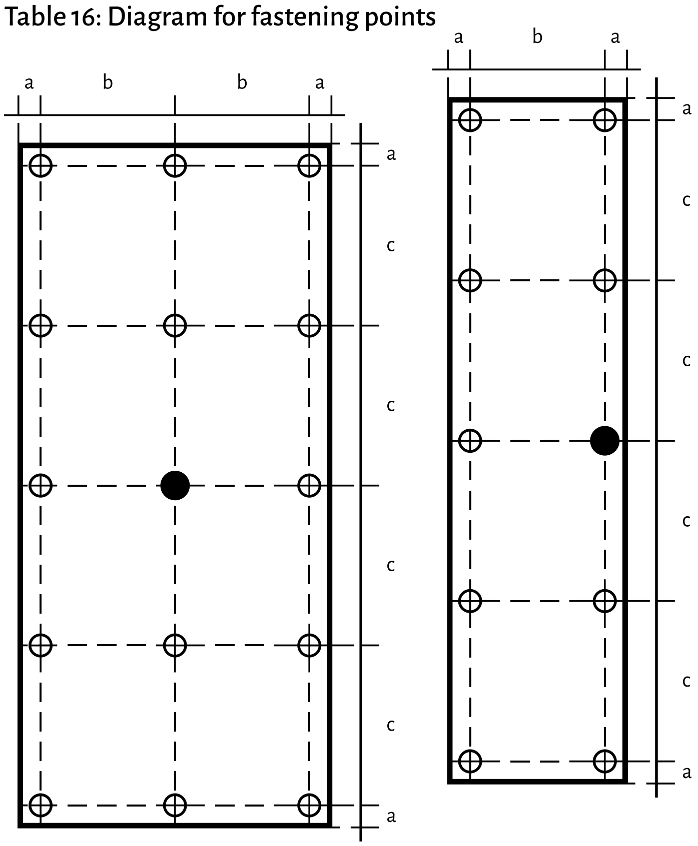
### Concealed fasteners

Undercut anchors, threaded inserts (screwed inserts) or self-tapping screws and clamps can be used for concealed fastening of façade panels. The requirements for the elements (wind load, supporting strength, etc.) have to correlate to the strength properties (pull-out force) of the anchors or inserts and their spacing. The manufacturer's instructions for use have to be observed.

### Fastening points

Examples for fastenings points on 8 mm HPL-Compact. For thicker HPL sheets, b and c can be up to 15 % larger; and up to 25 % smaller for thinner sheets. For high wind loads above 1 kN/m², b and c have to be reduced:

**Table 16: Diagram for fastening points**




- ● Fixed point – at the centre of the sheet if possible.
  The drilled hole diameter corresponds to the diameter of the fastener. This is also achieved by using corresponding fixed point sleeves.
- ⊕ Glide point
  The drilled hole diameter has to be adapted to the expected expansion. This is usually 2 – 3 mm larger than the screw or rivet diameter.
- a Hole spacing from the edge at least 20 mm, max. 10 times of the sheet thickness.
- b/c Maximum fastening spacing as per manufacturer's information

**Sheet joints for façade panels**

Sheet joints have to have 10 mm wide gaps to absorb climate-related length changes. Expansions of 2.5 mm/m are expected. As HPL-Compact can easily be processed with wood tools, sheet joints can also be created with different profiles, e. g. grooves or rabbets. A sufficiently wide expansion joint and sufficiently thick edges must be ensured for these joints. This also applies to the use of profiles, usually made of aluminium, which allow additional options for designing sheet joints.

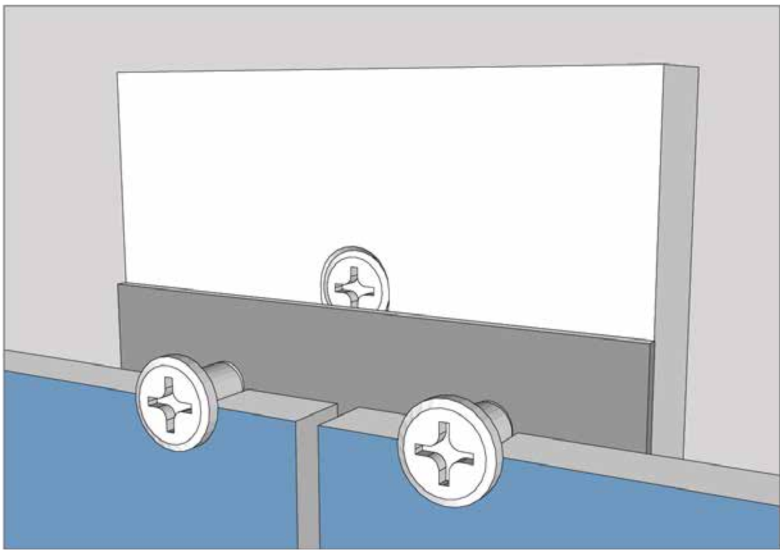


**Figure 57: Edge fastening of HPL on sheet joint**

Backed with sufficiently wide joint tape

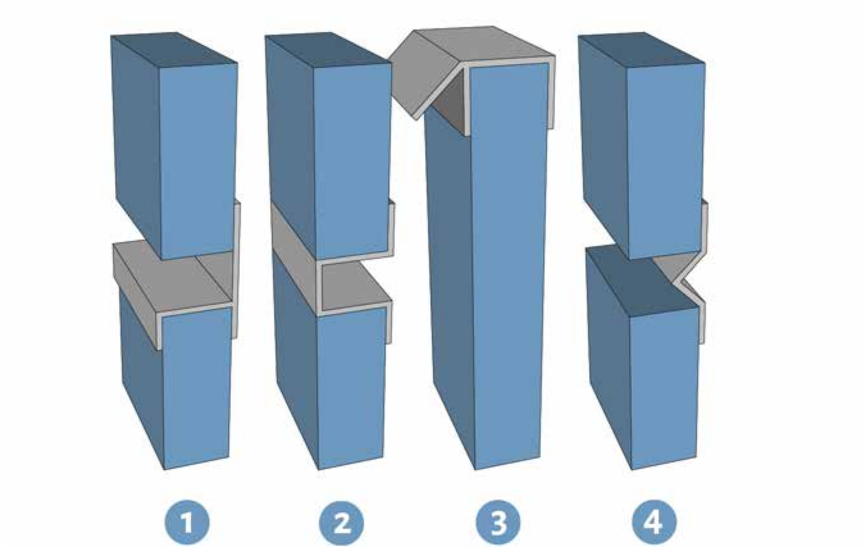



**Figure 58: Horizontal joints**

1 "Rain-protected" horizontal joint for timber substructure with PVC or aluminium joint profile. Caution: Note required space for movement!

2 Rain-proof horizontal joint with non-overlapping aluminium joint profile

3 Horizontal sheet end – e. g. underneath window sills – with rain deflection profile on wooden substructure

4 Joint backed with aluminium joint tape, reinforced with a bead

## Part 8: Structure and physical properties of a window sill

**Structure of a window sill**

Window sills with HPL on wood substrates are suitable for use in wet rooms, depending on the model. Suitable window sills made from HPL-Compact, compact forming elements or HPL composite elements made of HPL and low-swelling substrates are available for wet rooms.

Window sills with HPL are usually composite elements. The excellent surface properties are determined by the coating. The static and building physics properties, on the other hand, are primarily determined by the substrate (e. g. chipboard or plywood) and the bonding of the individual components.

The rear edge can be sealed with an edge finishing material. As the window sills are available by the metre and are cut individually to the required lengths, the lateral edges also have to be sealed. Depending on the application and the expected exposure, a tension-absorbing balancing has to be applied to the underside of the window sill.

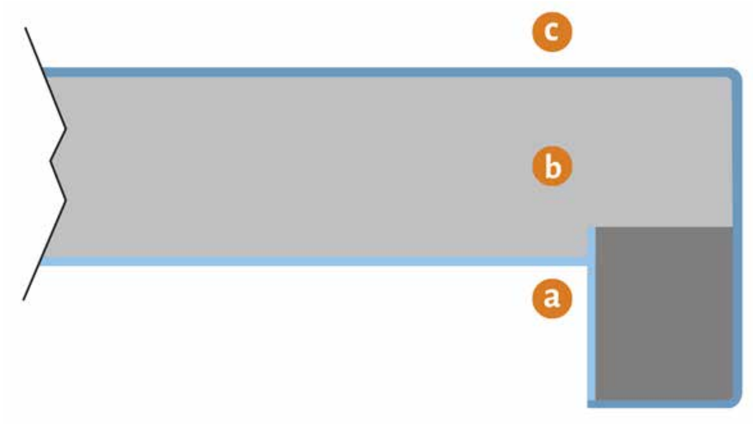



**Figure 59: Window sill with HPL with postforming profile and upstand**

a Balancing | b Substrate | c HPL

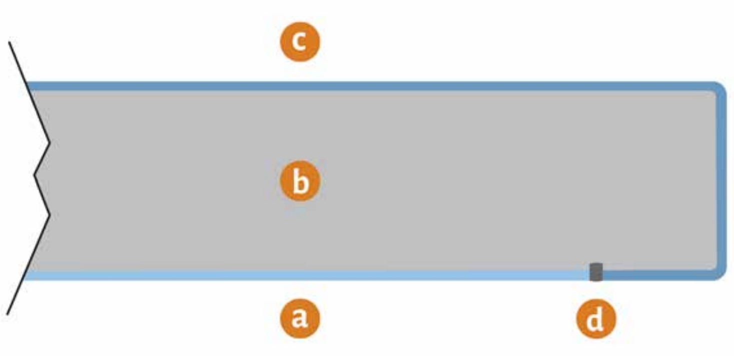



**Figure 60: Window sill with HPL, postforming profile and butt joint sealing**

a Balancing | b Substrate | c HPL | d Sealing compound

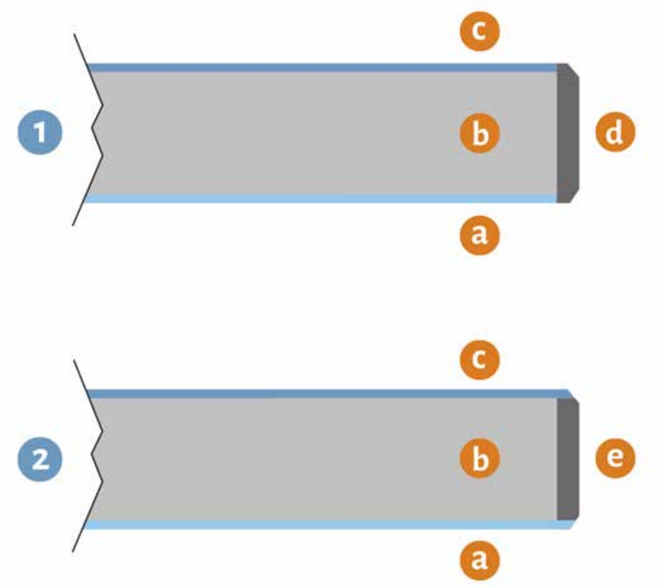



**Figure 61: Window sill**

1 with edge banding | 2 with inset edging tape

a Balancing | b Substrate | c HPL | d Edge banding | e Inset edging tape

As window sills are structural elements, it is absolutely necessary for preventing any structural damage to the building to observe certain principles during planning, element machining and window sill installation.

**Mechanical stress**

The window sill has to be sufficiently supported depending on the load case. It should always be inserted under the window frame, as otherwise tilt stability will not be ensured. If it is not possible to insert the window sill under the frame, a U-profile or L-profile has to be attached to the frame or to the side of the inner face.

It is recommended to rest the window sill full-surface in a bed of mortar, on the brickwork or – for renovations – on the old window sill. If this is not possible, it has to be fastened to brackets, consoles or battens. The defined support span has to be observed depending on the load bearing capacity of the material. The following diagrams provide orientation for selecting the spacing of the fastenings with different loads. Generally, a support span of 600 – 800 mm is sufficient for a 20 mm thick window sill. On 20 mm thick material, the projection of the window sill to the front should not exceed 100 mm, referring to the last point of support.

**Moisture**

To prevent moisture damage, the following always applies for installation: "more sealing inside than outside". This means that no moisture can condensate at the dew point on sensitive points such as the narrow surface on the rear. A moisture proof installation is achieved by inserting a suitable vapour barrier and with targeted permanently elastic sealing in the joint areas towards the interior.

**Thermal insulation**

Cold bridges should always be avoided. Among other things, this minimises the risk of condensation while preventing unnecessary energy losses. While timber substrates or HPL-Compact already have a low thermal conductivity, thermal insulation is still recommended especially in the rear edge area, which is especially at risk. This can be achieved by inserting foam sealing tape, PUR foam or PS foam. A combination of insulation and vapour barrier is ideal.

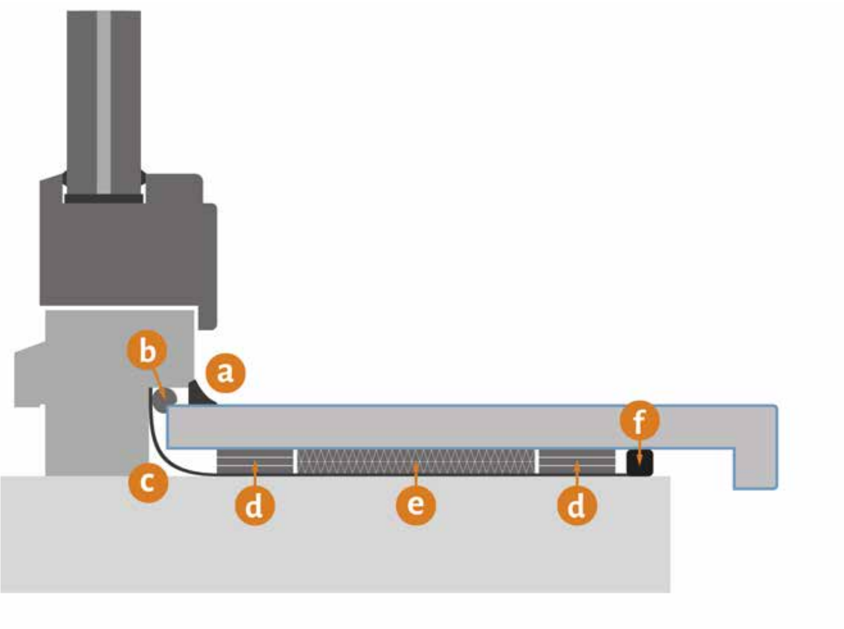



**Figure 62: Schematic diagram of an installed window sill with vapour barrier**

a Silicone sea | b Round cord | c Vapour barrier | d Support block/ spacer |
e Adhesive/expanding foam | f Joint sealing/silicone

**Temperature and humidity fluctuations**

Heating and cooling lead to expansions and contraction on virtually all materials. For this reason, window sills – especially in longer lengths – have to be installed with expansion joints. Temperature fluctuations result in length changes Δl [mm] at temperature difference ΔT [K], a material-specific, thermal length expansion coefficient $\alpha$ [$K^{-1}$] and an installation length l [mm], calculated with the following formula:

$\Delta l = \Delta T \times l \times \alpha$.

The following diagram can be used to easily determine the expansion joint, taking into account the thermal length expansion:

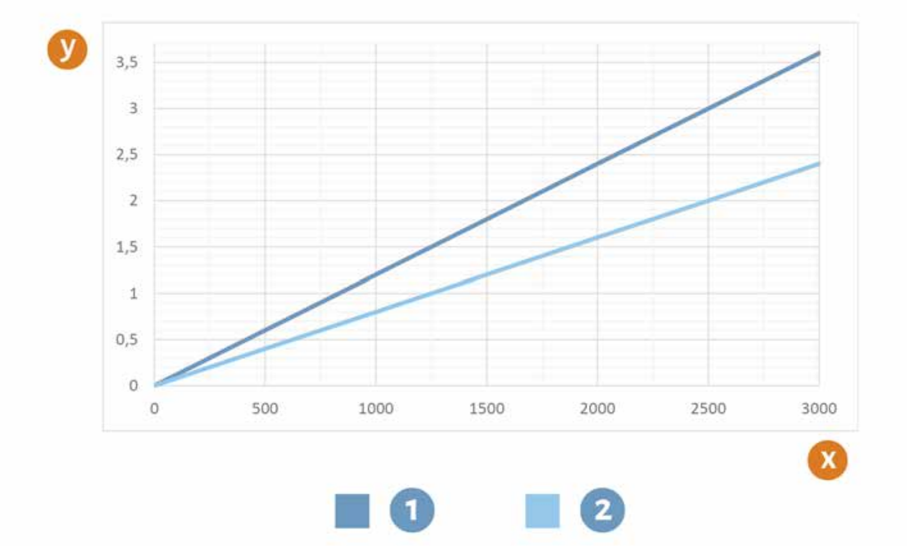



**Figure 63: Determining the expansion joint taking into account the thermal length expansion**

1 Expansion joint at 60 K temperature fluctuation

2 Expansion joint at 40 K temperature fluctuation

x Overall window sill length in mm | y Expansion joint in mm

Compared to the length changes caused by temperature fluctuations, the influence of humidity on timber materials is more important. For a chipboard bonded with melamine resin or urea resin, the swelling coefficient at sheet level is between 0.002 and 0.008 % for each 1 % of relative humidity change. The swelling coefficient of HPL is in the same range. The following diagram shows length changes as a function of the change in relative humidity. For the dimension of the expansion joints, they always have to be taken from the first diagram (fig. 63) and added to the expansion values which are caused by the temperature fluctuations.

In contrast to temperature fluctuations, humidity fluctuations only cause slow length changes in the window sill. This means that it is not short-term room climate changes which cause significant length changes, but rather the length change of the window sill with regard to the seasonal climate changes has to be taken into account. A difference of the relative humidity of 80 % is quite realistic for this.

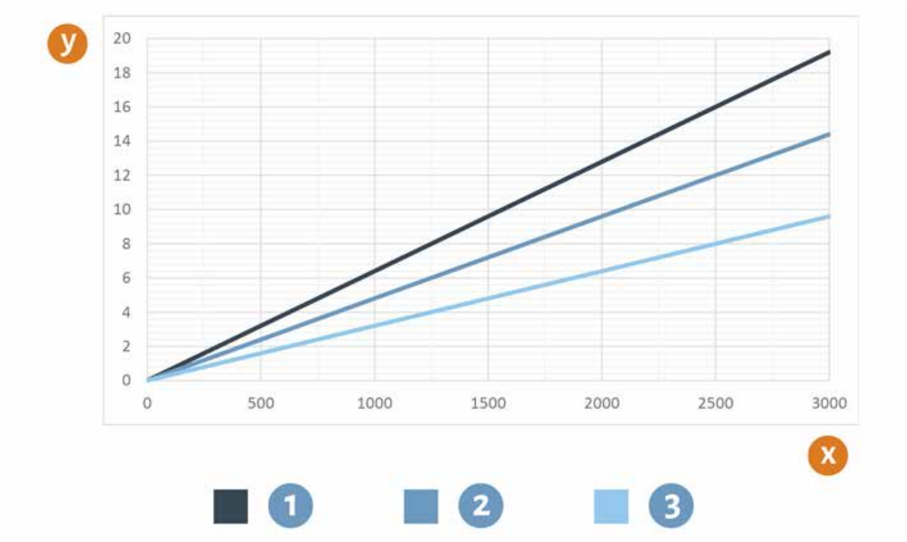



**Figure 64: Expansion joint dimensioning taking into account the length change caused by the moisture**

1 Expansion joint at 80 % rel. humidity

2 Expansion joint at 60 % rel. humidity

3 Expansion joint at 40 % rel. humidity

x Overall window sill length in mm | y Expansion joint in mm

*Calculation example:*

The following diagram is used to determine the maximum support spacing of 20 mm thick, self-supporting window sill elements with a constant point load of 1000 N, depending on the structure (with and without crosspiece) and window sill depth (20 cm and 30 cm). This is based on a maximum permissible bending between two support points of approx. 1/100 support width. A modulus of elasticity of 4000 $N/mm^2$ and a sheet density of approx. 650 $kg/m^3$ are assumed as material characteristics for chipboard with HPL (not tightly clamped on both sides). HPL-Compact window sills have a significantly greater strength at the same thickness. For a tightly clamped structure, the maximum permissible support spans increase.

The swelling coefficient at sheet level of 0.008 % for every 1 % of humidity change was used as a starting parameter.

*Example calculation for expansion joint dimensions:*

| | | |
|---|---|---|
| Window sill length 2000 mm | | |
| Maximum window sill temperature in summer: | + 50 °C | |
| Minimum window sill temperature in winter: | - 10 °C | |
| Maximum temperature difference | 60 K | |
| | | |
| Expansion coefficient taken from fig. 63 | | 2.4 mm |
| | | |
| Maximum relative humidity | 70 % | |
| Minimum relative humidity | 30 % | |
| Maximum humidity difference | 40 % | |
| | | |
| Expansion coefficient taken from fig. 64 | | 6.5 mm |
| | | |
| **Maximum possible expansion (worst case)** | | **8.9 mm** |

For an expansion joint size of 6 mm at both window sill ends (overall expansion joint = 12 mm), it is ensured for this case that the window sill has sufficient room to move and that the sealing material can be compressed.

The expansion joint should be placed towards the inner faces of the window opening (also with gliding material for elements set in plaster). For divided elements, the joint can also be placed at the separating point (the colour of the sealing material has to be adapted, or a connecting bar can be used).

### Machining and shaping window sills

The composite system of window sill with HPL allows conventional wood tools to be used. Any complex solution can be implemented resulting from requirements due to the geometry of the window inner face, ventilation screens, power sockets, cable ducts or for design reasons. This combination of simply mechanical machining and the variety of design options offer a high added value. Machining on site with the option of adapting elements to the local requirements is a particular advantage. Many other materials – especially those based on inorganic raw materials such as artificial stone, marble or granite – do not have these additional benefits. Visually appealing results can be achieved with the combination of window sill elements with other materials (edges, end strips, support bars, etc.).

### Corners and joints

Corner joints and elements joints have to be sealed. They must not be weakened by cutouts or notches. All cut edges generally have to be protected against possible influence of moisture. The elements are attached using mechanical fastening and bonding. For hygiene reasons, we recommend sealing all open edges of the substrate.

On postformed window sills, corner joints can be achieved with mitre cuts or template routing. Suitable plastic or metal cover profiles are used for butt joints. Edges have to be cleanly routed and the two elements have to be joined tightly. An exact, level transition from one board surface to the other is achieved by using springs or short springs. Short springs with or without board connectors are suitable for connections (2 for every 30 cm of window sill depth). To achieve flush surfaces, the HPL surface is selected as a reference surface for producing the grooves for loose tongues or short tongues. The tongues should have a tight fit. The sealing compound is applied directly into the board joint and also acts as an adhesive. When tightening the board connector nuts, it has to be ensured that the two window sill surfaces are aligned at the same level and that the sealing compound is emitted on all sides. Excess sealing compound has to be removed immediately. We recommend pressing the joint together horizontally (e.g. by blocking against the wall) until the sealing compound has cured.

Appropriately shaped profiles are suitable for covering a board joint. While they save accurate machining to a certain extent, they do interrupt the level, easy-toclean HPL surface. We recommend applying sealing compound – which then also acts as an adhesive – to all cut edges before attaching (screw fixing) the metal profile.

### Connecting joints

Before sealing towards the window sill and to the wall, it has to be ensured that the window sill – especially for larger, self-supporting sections – is sufficiently supported, as otherwise the sealing joints could be destroyed under load. Smooth surfaces have to be degreased with suitable cleaning agents, just as the window sills, and coated with a primer. Compatibility of the cleaning agents with the materials to be cleaned has to be ensured. Porous surfaces have to be coated with a film-forming primer. For pretreatment with primers, the instructions from the sealing compound manufacturer have to be followed closely. To prevent contamination of the element surfaces with sealing compound and to achieve an evenly wide joint pattern, we recommend masking the joint edges with tape before applying the sealing compound. It is important that the sealing compound sufficiently overlaps onto the surface of the window sill to prevent trapped moisture from entering into the rear edge. Three-flank adhesion has to be avoided. When installing the window sill, it also has to be ensured that it absolutely does not slope towards the window. This type of installation would also create excess stored moisture. At this point, we would like to point out again that all cut edges of the window sill element have to be sealed against moisture ingress from the brickwork. Smoothing the sealing compound can produce visually appealing joints. If a plastic or wood connecting profile is used for visual reasons, the connection between the window sill and the window frame and the wall also have to be sealed. When fastening wall connection strips to window sills with nails or screws, there is a risk of subsequent moisture ingress.

### Holes and cutouts

Cutouts, holes or access openings which expose the chipboard substrate have to be carefully sealed. Due to the expected movement in the window sill itself or from installed pipes, these have to be centred so that a minimum spacing of 2 – 3 mm is ensured in all locations. This is to prevent condensation from reaching the chipboard. As a rule, all parts to be attached to the window sill should be bonded if possible. If fastening is only possible by means of screws, the holes have to be drilled so that the HPL has an at least 2 mm larger diameter than the diameter of the screw (ideally approx. 4 mm larger). This is necessary to avoid tensions in the material. Due to risk of moisture damage from exposing the wood substrate, sufficient sealing always has to be ensured.

### Installation

### Cutting and sizing

For determining the length it has to be noted that the length is reduced by the required width of the expansion joints and the dimension of any rails attached to the wall. Inversely, the length increases if the window sill is set in plaster at the inner faces.

### Installing a window sill with screwed-on brackets

The bracket is fastened to the sill with wall anchors, and then the window sill from underneath.

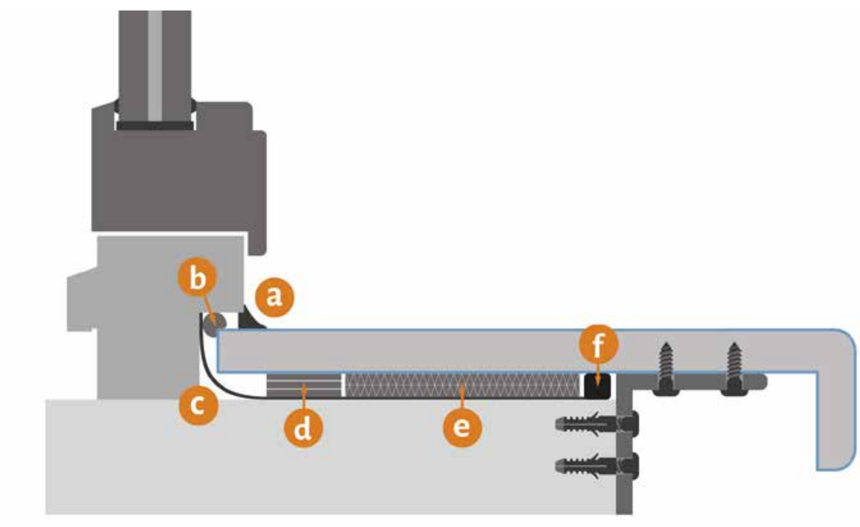



**Figure 65: Installation with screwed-on brackets**

a Silicone seal | b Round cord | c Vapour barrier | d Support block/ spacer
e Adhesive/ expanding foam | f Joint sealing/ silicone

### Bonding window sills

After cutting the correct size, the underside of the window sill has to be cleaned, degreased and primed. As an alternative, adhesive cleaner can be used which combines all these work steps. A lint-free cloth should be used for this. The surface to be bonded to has to be solid, clean and dry. The bonding described here is achieved with permanently elastic adhesives. The adhesive thickness and adhesive width differ depending on the adhesive system used. The applied quantity and the application type (beads or full-surface) are also specific to the adhesive. If required, spacers have to be used directly next to the adhesive beads to ensure that the minimum thickness of the adhesive layer is achieved and that the window sill can be aligned with weights or by clamping. The clamping time depends on the adhesive system used. To bridge larger distances, wooden strips with suitable thickness are adhered to the building sill and then the window sill is adhered to this. If an old window sill has sturdy fastenings and a smooth, intact surface, a new window sill can be adhered to it directly using construction adhesive. Tilt stability has to be ensured in particular, e.g. using profiles screwed onto the window frame. 2-component PUR adhesives can be used for bonding, for example. To achieve best possible adhesion, it is always recommended to sand the adhesion surfaces, remove any dust and then degrease them.

# Important information

The HPL Compendium is a manufacturer-independent manual for manufacturing, processing and application of HPL. It was prepared by the Technical Committee of the International Committee of the Decorative Laminate Industry aisbl with the greatest care, specialist knowledge and experience from more than six decades.

The HPL Compendium is available as a printed book and in a digital version.

Overall, the HPL Compendium represents only a summary of what can be achieved with HPL. The main elements of the HPL Compendium are based on more than 35 applications which are based on the work of the ICDLI and the proHPL association. Each of which covers a specific application topic. In addition, all current bulletins are available to interested users and installers at the ICDLI website www.icdli.com and the proHPL website www.pro-hpl.org free of charge.

All information in the HPL Compendium corresponds to the current state of our knowledge. As the conditions for using HPL can differ greatly in practical application, it is the duty of the user to independently check and decide before use whether the desired application is suitable for HPL.

Despite the greatest care taken, errors cannot be completely excluded. In this regard, the Technical Committee of the ICDLI always welcomes suggestions and criticism.

# About ICDLI

The International Committee of Decorative Laminates Industry aisbl (ICDLI) is the international representative body of HPL manufacturers. Today, it numbers 25 members from 13 countries. It is the aim of the ICDLI to establish permanently a strong and successful European community of HPL manufacturers. ICDLI offers a communication platform for manufacturers and their suppliers. The objectives of the ICDLI are to promote the knowledge on HPL and their suppliers to set new and update existing standards for HPL.

Member companies delegate their specialists to the technical commission, the public relations commission and the market research group of the ICDLI.

Since its foundation, the ICDLI has been working very closely with the proHPL association.

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Ralf Olsen
Secretary General

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### proHPL

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| | | | No. | Dispersion adhesives | | Condensation adhesives | |
|---|---|---|---|---|---|---|---|
| | | | | 1C-PVAC | 2C-PVAC | UF resin/UF resin with approx. 10 % filler | MUF/ MUPF resin |
| **classification acc. EN 204/205** | | | | D2/D3/D4 | D3/D4 | D2/D3 | D3 |
| **Temperature resistance [°C]** | | | | -20 to +100 | -20 to +100 | -20 to +150 | |
| **Wood materials** | Chipboard | | 1 | adhesive application:<br>80 – 200 g/m²<br>on HPL or substrate<br>wet life: 2 – 30 min.<br>specific pressure: approx. 2 – 5 bar<br>press temperature/time:<br>20 °C/2 – 60 min.<br>40 °C/2 – 12 min.<br>60 °C/2 – 6 min.<br>80 °C/1 – 3 min. | | adhesive application:<br>90 – 150 g/m²<br>on HPL or substrate<br>wet life: 5 – 15 min.<br>specific pressure: approx. 3 – 5 bar<br>press temperature/time:<br>40 °C / 30 – 45 min.<br>60 °C / 10 – 12 min.<br>80 °C / ca. 5 min.<br>100 °C / ca. 1 min. | |
| | Plywood and blockboard | | 2 | | | | |
| | Fibreboard MDF, HDF | | 3 | | | | |
| | Solid wood | | 4 | | | | |
| **Honeycomb sheets** | Paper honeycomb | note the thickness differences between frame and core, e. g. adapt contact pressure | 5 | | | | |
| | Aluminium honeycomb | | 6 | **NOT APPLICABLE** | | | |
| **Foam boards** | PS foam | use lower contact pressures | 7 | | | | |
| | Phenol foam | | 8 | | | | |
| | PU foam | | 9 | | | | |
| | PVC foam | | 10 | | | | |
| **Mineral substrates** | Vermiculite | | 11 | adhesive application: 110 – 150 g/m²<br>on HPL or substrate<br>wet life: max. 10 min.<br>specific pressure: approx. 2 – 5 bar<br>temperature/time: 20 °C / 30 min<br>surface treatment recommended | | surface treatment recommended<br>see lines 1 – 5 | |
| | Calcium silicate board | | 12 | | | | |
| | Cement fibre board | | 13 | **NOT APPLICABLE** | | | |
| | Cement bonded chipboard | | 14 | | | see lines 11 – 13 | |
| | Gypsum plaster board | | 15 | see lines 1 – 5 | | see lines 1 – 5 | |
| | Gypsum fibre board | | 16 | see lines 11 – 12 | | see lines 11 – 13 | |
| **Metal** | | | 17 | **NOT APPLICABLE** | | | |
| **HPL** | | | 18 | | | | |
| **PROCESSES** | | | | | | | |
| **Flat lamination with HPL** | Block press (cold), low surface pressure | | 19 | adhesive applied with roller, spray nozzle or scraper | | hardener pre-application process; adhesive application with roller | |
| | single or multi-opening presses (cold, warm, hot) | | 20 | | | hardener pre-application or addition process; adhesive application with roller or scraper | |
| | short cycle presses (warm, hot) | | 21 | | | | |
| | continuous presses (warm, hot) | | 22 | see line 20 | | | |
| **Moulding with HPL** | Forming presses | | 23 | only suitable for large radii in two dimensions | | | |
| | Vacuum membrane presses | | 24 | | | | |
| **Postforming** | Stationary | refer to Technical Bulletin “Processing postforming HPL” | 25 | applicable | applicable | | |
| | Continuous | | 26 | | D4 requires special process parameters | | |
| **Edge banding** | Stationary | | 27 | cold pressing or using a heating bar | | | |
| | Continuous | | 28 | cold adhesive activation process | | | |

| | Contact adhesives | | Hot melt | | | Reactive adhesives |
|---|---|---|---|---|---|---|
| phenol-resorcinol resin | without hardener | with hardener | EVA ethylene vinyl acetate | PA polyamide, PO polyolefin, polyamide-polyolefin | PUR polyurethane | polyurethane, polyester, epoxy adhesives |
| D3/D4 | no classification acc. EN 204/205 | | classification not applicable | | D/D4 | D3/D4 |
| | -20 to +70 | -20 to +100 | -20 to +80 | -20 to +100 | -20 to +140 | -20 to +100 |
| adhesive application:<br>100 – 180 g/m²<br>on HPL or substrate<br>wet life: 2 – 15 min.<br>specific pressure: 3 – 5 bar<br>press temperature/time:<br>20 °C/2 – 60 min<br>wet life and press temperature/time depend on the catalyst system used | adhesive application:<br>150 – 200 g/m²<br>on HPL or substrate<br>wet life:<br>depends on adhesive type and applied quantity<br>specific pressure and press time:<br>gravity of pressure sufficient, strength depends on the pressure<br>press temperature:mind. +20 °C | | adhesive application:<br>80 – 150 g/m²<br>on HPL or substrate<br>specific pressure: roller pressure<br>adhesive application temperature:<br>160 – 220 °C | | adhesive application:<br>60 – 100 g/m²<br>on HPL or substrate<br>specific pressure:<br>roller pressure<br>adhesive application temperature:<br>120 – 160 °C | adhesive application:<br>150 – 200 g/m²<br>on HPL or substrate<br>wet life:<br>depends on adhesive system<br>specific pressure:<br>stack pressure, store flat and smooth<br>pressing temperature and pressing time depend on the adhesive and catalyst system used<br>(pretreatment is absolutely necessary for metals) |
| NOT APPLICABLE | NOT APPLICABLE | | NOT APPLICABLE<br>primarily used for edge banding<br>see lines 1 – 5 | | adhesive application:<br>80 – 120 g/m²<br>on HPL<br>contact pressure:<br>roller pressure<br>adhesive application temperature:<br>120 – 160 °C | |
| applicable<br>recommended preferably for fire protection | | | | | | |
| surface treatment absolutely necessary | see lines 1 – 5 | | NOT APPLICABLE | | surface treatment absolutely necessary | |
| NOT APPLICABLE | | | | | applicable | |
| | | | | | | |
| hardener addition process; adhesive application with roller or scraper | adhesive application by spraying or spreading | | adhesive application with roller | | | adhesive application with scraper |
| | | | NOT APPLICABLE | | | only suitable for large radii in two dimensions |
| | NOT APPLICABLE | | | | | |
| | applicable | | with pre-coated edge bandings | | NOT APPLICABLE | applicable |
| NOT APPLICABLE | | | hot melt adhesive application to the substrate or edge bandings | | | |

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