ICDLI

International Committee of the Decorative Laminates Industry

Technical Leaflet

Bonding and Processing of HPL on metal substrates

November, 2013

Preface

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

In addition to their physical properties, decorative laminates offer other benefits including quick and easy installation of compact laminate panels, and in renovation applications using dry construction methods, elimination of the need to remove existing wall coverings such as wallpaper, textile coverings, or ceramic tiles. The technical leaflet "*Bonding and Processing of HPL on metal substrates*" contains information on the selection of materials as well as an overview and valuable recommendations on bonding procedures and further processing. This technical leaflet is an update and an expansion of the previous version on the same topic issued in May 1989.

For more than 50 years the ICDLI has been the international representative of the interests of European laminate manufacturers. Further information about the ICDLI and the data sheets published up to now can be found at www.icdli.com

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

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

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1. General Information

Composite elements made using decorative high pressure laminates (HPL) and a metallic substrate is a special application area for specific industries, e.g., vehicle construction; road, rail and sea traffic; transport; and interior work with unique requirements. Composite elements produced using decorative laminates and a metallic substrate combine the advantages of both materials as outlined below:

- Design versatility: HPL is available in a variety of colours, patterns and surface textures that are easy to clean, and when combined with a metal substrate, provide a range of structural options.
- Freedom of design: Shaped metal surfaces can be coated with decorative laminate.
- Material efficiency: The composite elements achieve high mechanical stability relative to their weight.
- Fire behaviour: Metal sheets are classified as non-combustible in accordance with EN 13501-1. In their standard form, decorative laminates are "Euroclass D" according to the same standard and can be treated so that they are flame-retardant (type "HGF" and "VGF" in accordance. with EN 438).
- Metallic properties: The use of a metal substrate makes it possible to implement physical attributes such as moisture barrier, radiation/x-ray barrier, magnetism, electrical conductivity, and wireless communication.

Successfully producing composite elements using two materials with such fundamental differences in behavior requires knowledge of the specific properties which can have an effect on the manufacturing process. Some of these issues are:

- The different response of decorative laminate and metal substrates to moisture must be taken into account during selection and processing.
- Decorative laminates, while not absorbing liquid water, will expand slightly in wet environmental conditions and shrink in hot dry environmental conditions. Acclimatization to the environmental conditions of the end-use application, prior to bonding, can minimize potential dimensional changes and the subsequent tension between and within the layers.
- Metal sheets, conversely, do not react to liquid water or water vapor, but do expand considerably when exposed to high temperatures and contract when exposed to low temperatures. This can result in a "bimetal effect" for the composite element (e.g., when exposed to a hot, dry environment, the metal expands due to temperature, while the decorative laminate shrinks due to moisture loss), resulting in bowing or cupping of the composite element.
- Adhesive must be selected that is sufficiently flexible to accommodate the strains created by the different dimensional change of the two materials types. Metal sheets must first be mechanically or chemically pretreated in order to work successfully with the adhesive.
- Machining facilities must have the skills, equipment, and cutting tools to work with both decorative laminate and metal sheets.

2. Selection of the materials

2.1 Decorative laminates

2.1.1 Requirements

Decorative laminates according to EN 438 are suitable for the decorative coating of metallic substrates. They should generally be bonded at normal room temperature conditions.

In order to comply with fire regulations, it is often necessary to use flame-retardant decorative laminates. The decorative laminate manufacturer should be consulted for advice on proper selection of materials.

2.1.2 Conditioning

2.1.2.1 General information

The first step in minimizing problems associated with dimensional change is to provide adequate environmental conditioning. Poor conditioning will lead to warping of the composite materials and/or to stress cracking after bonding.

Decorative laminates should be pre-conditioned before processing. The relative humidity during conditioning should correspond to the environmental conditions of the end-use application as closely as possible. Subsequent changes in relative humidity creates strong stresses between the decorative laminate and the substrate which can result in an increased occurrence of cracks and warping.

Any protective film must be removed prior to conditioning.

2.1.2.2 Use in normal environmental conditions

“Normal” environmental conditions are considered to be when relative humidity is moderate to high (50 to 60% RH) and temperature is moderate to low (18 to 23°C) for the majority of the time. Lower humidity and high temperatures may occur only for short periods of time (this also applies to furniture, bathrooms, lavatories, etc.).

The pre-conditioning recommended for these environmental conditions is described below:
a. Ten days in an oven with sufficient air circulation around every sheet, at normal environmental conditions of 23°C ± 2°C, 50% ± 10 % RH (see. Figure 1 and 2);
b. Three days minimum at the environmental conditions similar to that of the end-use applications, with the decorative laminate and substrate panels stacked together in the same position as they will be in when bonded (see. Figure1).

2.1.2.3 Use in continuous low humidity conditions

The recommendations in this section should be followed for applications with continuous low relative humidity and/or elevated temperature (e.g., warm heated air near radiators or in ventilation shafts). The decorative laminate should be pre-conditioned for at least three days at environmental conditions which are as close as possible to the low humidity of the end-use application (See Figure 2). These measures reduce the risk of surface cracks and/or warping of the composite element as a result of the subsequent shrinkage of the finished part in the end-use application.

Bonding must be performed immediately after conditioning and, if required, after allowing sufficient time for the parts to cool to room temperature.

Where it is not possible to immediately bond the conditioned decorative laminates, it is recommended that re-absorption of the moisture be prevented by wrapping the decorative laminates with a barrier with low water vapour transfer properties (e.g. aluminium sheet or special grades of polyethylene film) upon removal from the circulating air oven. The water vapour barrier should be left in place until immediately prior to bonding to the substrate.

Suitable protection must also be ensured during transport.

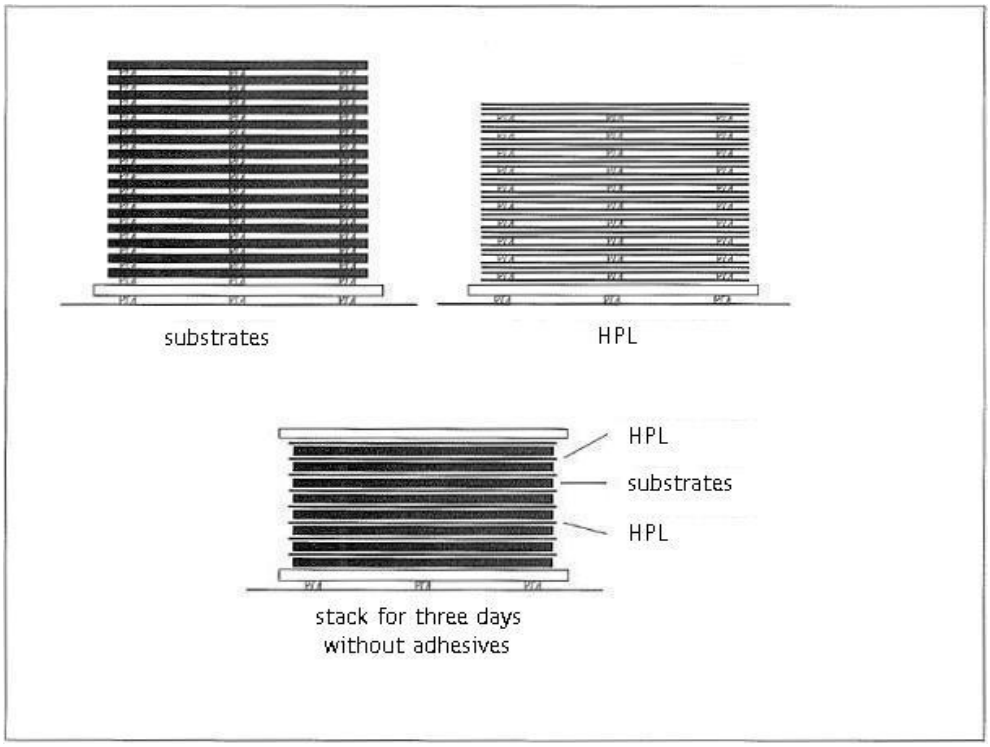

Figure 1: Conditioning

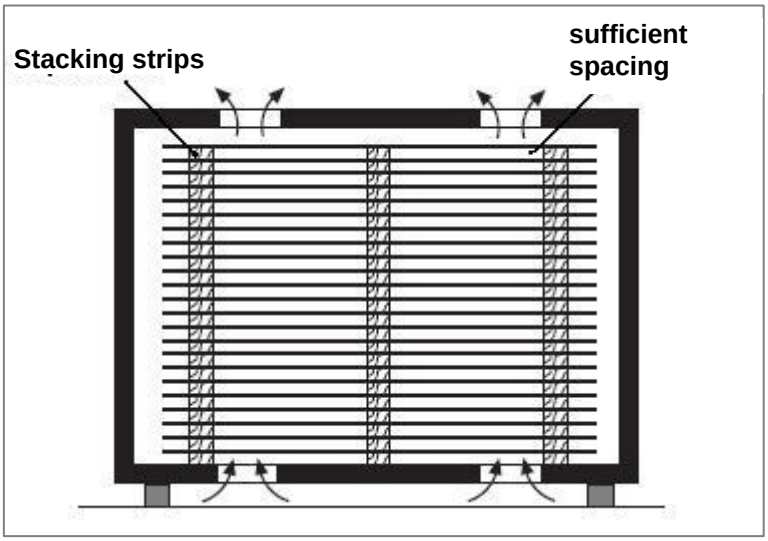

Figure 2: Diagram of conditioning decorative laminates in environmental chamber

2.2 Metal substrates

Examples of metal substrates are provided below:

- Aluminium sheets
- Aluminium composite panels (honeycombs)
- Steel sheets

Panels and sheets must be absolutely flat with no kinks, dents or other defects.

2.3 Surface treatment

The surface of metal substrates can become contaminated due to oxide or corrosion layers, grease, oil, or even processing steps such as heat-treating, acid-etching or anodization. This contamination can affect the adhesive wet-out resulting in poor quality bonding. Consequently, the surface may need to be pre-treated prior to bonding.

The time between the pre-treatment and the bonding should be kept as short as possible in order to avoid the reoccurrence of corrosion or contamination. Protective gloves should be worn when handling the treated substrate as even small fingerprints can create a poor bond.

The selection of proper pre-treatment depends on the type and thickness of the metal, available equipment and production volume. Contact the substrate supplier for recommendations on surface pre-treatments.

2.3.1 Degreasing

Prior to bonding, all metallic substrates must be completely free of grease. This can be accomplished with steam, solvents or other cleaning methods.

Steam:
Steam treatment is very effective at removing grease and oil. A properly cleaned surface exhibits a continuous film of water once the steam is turned off. The cleaned panels must be dried with hot air before stacking.

Solvents:
Manual application of solvents such as acetone, xylene and MEK (methyl ethyl ketone) can be used to degrease the surface. The general procedure is to soak a clean cloth or paper towel in the solvent, then wipe the surface carefully, changing the cloth/towel frequently. This solvent wipe is followed by rinsing with warm water and drying with hot air.

Vapour degreasing:
Vapour degreasing has been found to be the most effective procedure; however this process requires specialized handling systems. The process consists of suspending the metal panels in tanks which are filled with heated solvents; the vapours of which condense on the panels and rinse away any surface contaminates.

Note: Extreme caution must be exercised when using degreasing solvents. General occupational health and safety regulations and the manufacturers' recommendations must be followed.

2.3.2 Mechanical roughening

Mechanical roughening is used to remove layers of oxide, corrosion, etc., and simultaneously promotes enhanced mechanical attachment of the adhesive. Prior to performing mechanical roughening, ensure that the surfaces of the metal substrate are free of contamination due to grease or oil.

Mechanical roughening can be performed as follows:
- Sandpaper (P 80 to P 120 grain for steel sheets or P 320 to P 500 grain for aluminium sheets)
- Wire brushes
- Sandblasting: The abrasive medium is limited to sharp sand such as aluminium oxide (corundum); quartz (glass) and metal beads are not suitable. Note: In general, both sides of the metal substrate should be sandblasted as this reduces the risk of warping. However, sandblasting from both sides may not be suitable for thin sheets or larger sheet sizes as irreversible distortions may be created.

Following any of the mechanical roughening processes, the degreasing procedure must repeated to remove any contamination introduced during the roughening process.

2.3.3 Chemical cleaning and etching

Compared with mechanical pre-treatment, chemical cleaning and etching is even more effective as it produces a superior, easier-to-control surface quality.
The following process degreases and etches metal sheets made from aluminium alloys and degreases steel sheets as well:

- Immerse the metallic substrate in a conventional, alkaline degreasing and etching solution at approximately 50°C. The immersion time depends on the type of metal with typical durations of approximately five minutes.
- Remove the metallic substrate from the solution and rinse it thoroughly with water to remove the residual alkaline solution.
- Final rinsing is in a neutralization bath of either 5% acetic acid or a suitable brand solution using mohair paint rollers.
- Dry with hot air before stacking.

2.3.4 Priming

Some adhesive systems require priming of the metallic substrate as a pre-treatment for bonding.
The pre-treatment and priming should be performed immediately after degreasing and just prior to bonding. The primer can be applied by machine or with hand rollers in normal operating conditions.

Metallic substrates must be brought to the processing temperature (room temperature) prior to the priming, in order to avoid condensation effects.

The primer should be applied in accordance with the manufacturer's specifications to ensure there is sufficient corrosion protection.

2.4 Adhesives

2.4.1 General requirements

An adhesive must be selected that is sufficiently flexible to accommodate the strains created by the different dimensional change of the two materials types, as outlined in Section 1. Vibrations and deformations occurring during use must also be considered as they might have an effect on the integrity of the adhesive joint. For these reasons, particular attention must be paid to the selection of the adhesive. The adhesive manufacturer should be consulted for advice on proper adhesive selections and to assist in bonding trials.

2.4.2 Selection of adhesives

2.4.2.1 Reaction adhesives

Reaction adhesives should be used at room temperature to provide the best adhesive bond and to minimize warpage.

2.4.2.2 Adhesive films and pre-pregs

Pre-pregs (films pre impregnated with liquid adhesive) should be used in accordance with the adhesive manufacturer's specifications.

2.4.2.3 Contact adhesives

Contact adhesives should not be used for panels with a lateral length of more than 600 mm. Contact adhesives can be applied manually or by machine, followed by drying in normal temperature air or in a drying tunnel. The adhesive application can be performed by hand with a serrated palette knife or flat brush on smaller boards. Curing agents can be added to improve temperature resistance. Higher contact pressure with the help of roller presses or hand rollers is required.

2.4.2.4 PUR adhesives

PUR (polyurethane reactive) hot melt adhesives are very suitable for the bonding of metals with decorative laminates.

2.4.2.5 Water based adhesives

Water-based adhesives are NOT suitable for bonding metals.

3. Bonding procedures

3.1. Manual application

The manufacturing area should be maintained at a normal environmental condition. The adhesive must be pre-conditioned to normal environmental conditions prior to processing. The adhesive should be applied with a suitable, serrated palette knife.

With contact adhesives, it is extremely important that the solvent be allowed to completely evaporate before the two surfaces are attached. A hand roller with a maximum width of 75 mm is used to join the two adhesive by applying the greatest possible contact pressure.

The adhesive manufacturer should be consulted for advice on alternative application procedures.

3.2 Machine application

Machine application of the adhesive is possible with rollers, sprays or bead application depending on the adhesive. The adhesive manufacturer should be consulted for advice on the proper adhesive selections and for assistance in equipment selection and settings.

4. Processing of composite element

4.1 Sawing and milling

Composite elements manufactured with decorative laminates bonded to aluminium substrates can be processed with tungsten-tipped saws and cutting tools in the same way as decorative laminates bonded to wooden substrates. The feed rate should be slower when cutting composite elements with a metal substrate (compared to cutting an element with a wood substrate).

Composite elements manufactured with decorative laminates bonded to steel substrates can only be processed with metal saws, powered metal shears or manual metal shears.

General occupational health and safety regulations and the manufacturers' recommendations must be followed.

4.2 Punching

Composite elements with a maximum decorative laminate thickness of 1.0 mm and a maximum metal thickness of 0.8 mm can generally be punched at normal conditions. Tests must be performed to determine the suitability of the tool.

4.3 Drilling

Composite elements made with metal substrates can be drilled using a slow rotational speed and a moderate feed rate. Overheating of the tool must be avoided.

4.4 Rounding off of openings

Cut-outs must be rounded off and drilled holes must be appropriately oversized (see technical leaflet "*General recommendations for working with decorative laminates*".) It is also important that all machined edges are free from nicks and cracks. This prevents cracks from forming in these areas on the decorative laminate.

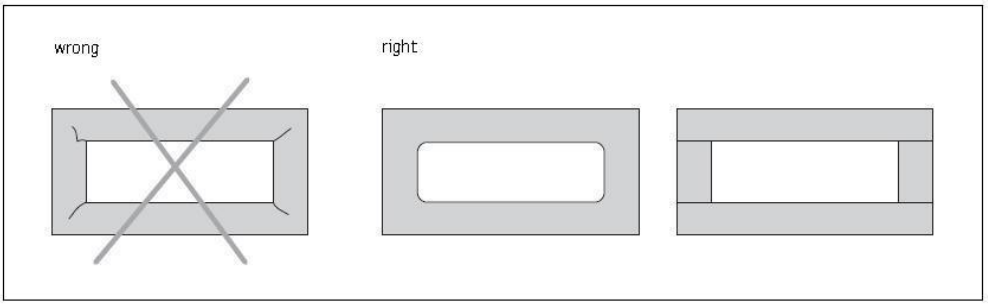

Figure 3: Internal opening in decorative laminate / metallic substrate element

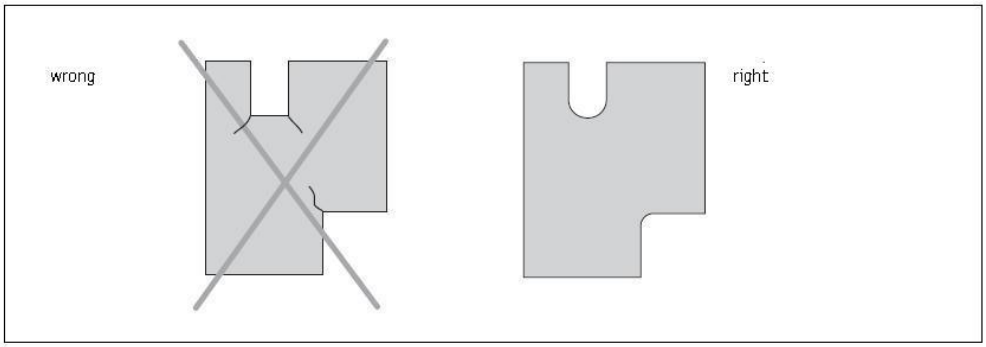

Figure 4: Openings in decorative laminate / metallic substrate element

4.5 Mounting and Attachment

Composite elements must not be installed rigidly. The design of the installation must allow for dimensional changes (expansion and contraction) using techniques such as the following:

- Oversized holes,
- Washers under screw heads, and
- A sliding film between the components.

For external applications or in cases in which narrow surfaces or surfaces of the metallic substrate are exposed to moisture or corrosion, these parts must be adequately protected.

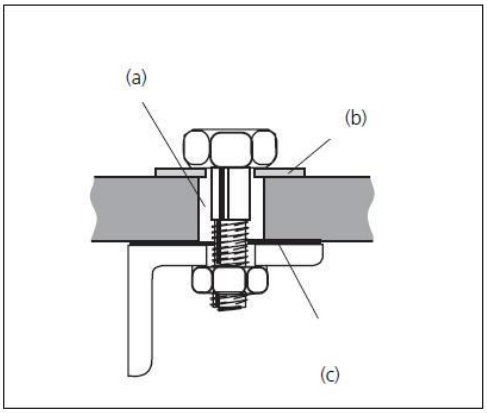

Figure 5: Fastening of visible screw connection

On composite panels made with decorative laminate on one side, fasteners can be spot-welded on the exposed metal on the rear of the substrate (e.g., stud welding with tip ignition). On metallic substrates with decorative laminate on both sides, the decorative laminate must be removed at the point where the bolt is welded. The minimum thickness of the metal substrate must be 1.5 mm. In addition, composite elements can also be fastened with adhesive.

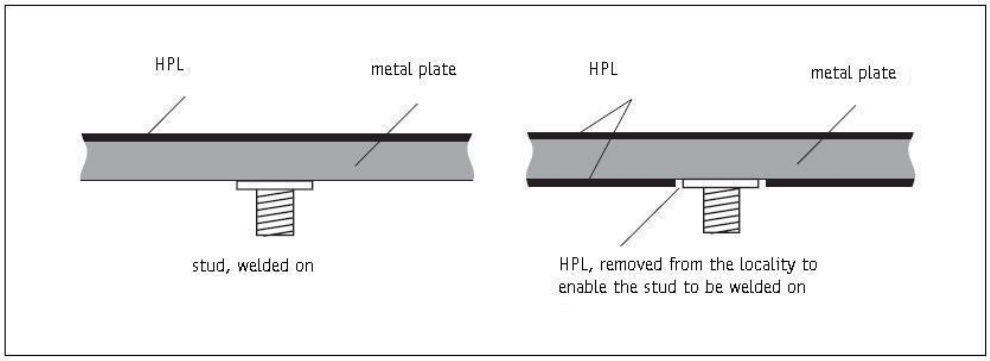

Figure 6: Attaching a bolt

In order to prevent galvanic corrosion, different type metals should not come into contact with each other.