Production process of GRP sandwich panels with vacuum table
Production process of GRP sandwich panels

- Storage

- Handling and cutting fiberglass

- Cleaning GRP
Production process of GRP sandwich panels

- Sandwich-panel production
  - Vacuum-table

- Application of the glue

- Application of the foam

- Vacuum rubber foil
Production process of GRP sandwich panels

- Transport

- Cut-to-size-sawing

- Inspection of the bonding and Quality control
The following pages will give you a very detailed explanation about producing a GRP-sandwich-panel with vacuum table.
Handling and cutting fiberglass
Handling and cutting fiberglass

- Coiler- and decoiler systems (simple)
Handling and cutting fiberglass

- Coiler- and decoiler systems (simple)
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
  - Centre wind
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
  - Ascending batch winder
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
  - Saw
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
  - Delivery drive
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
  - Plate shear (company Cidan)
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
  - Winder (not necessary in case of sandwich-panel production) or table for cut sheets

Instead of the winder, you need normally a table with rollers like this.
Handling and cutting fiberglass

- Coiler- and decoiler cut-to-size-system at LAMILUX (state of the art)
  - Exhaustion
Handling and cutting fiberglass

- Coiler- and decoiler systems at LAMILUX (sophisticated)
  - Costs for machinery (based on quotation 2005/2006):
    - 1 Winder 10.000 €
    - 1 Ascending batch winder 8.900 €
    - 2 Saws plus Delivery Drive 36.840 €
    - Sawing „along“ at 2 sides:
      Exhaustion for 2 saw blades approx. 10.000 € (approx. 5.000 m³/h)
    - or Sawing „along“ only at one side:
      Exhaustion for 1 saw blade approx. 7.000 € (approx. 2.500 m³/h)
    - 1 Plate shear 20.000 €
    - + Table and roller bearings
Coiler- and decoiler systems at LAMILUX (sophisticated)
Handling and cutting fiberglass

- Recommendation for starting
  - LAMILUX recommends to start with a winder, a plate shear and a table with rollers (investment between 10,000 and 30,000 €)
Cleaning GRP
Cleaning GRP

- for the bonding process the GRP has to be free from dust, grease and oil
- possible treatments:
  - wiping the GRP (do **not** use solvents)
  - vacuum cleaning
  - blowing
    (the compressed air must be free from oil)
Vacuum table
Vacuum table

- General information
  - must have a flat and clean surface
    (it's advised to use floatglas or "marothaan®" selve levelling 2K-PU)
  - constant vacuum, adjustable between approx. 150 – 500 [mbar]
    (0.5 – 0.85 [bar] absolute atmospheric pressure)
  - meaning an adjustable bonding pressure between 15 – 50 kN/m²
Vacuum table

- **General information**
  - Modular construction: 2.100 x 3.200mm segments
  - Width: for 3.000mm sandwich-panel width
  - Length: up to 14.700mm (7 segments á 2.100mm)
  - max. panel height: 250mm
  - Required components: framework, pressing plate, vacuum pump, vacuum tank, vacuum rubber foil, clamping claws

Substructure of the table
Vacuum table

- **General information**
  - **vacuum tank:** the higher the volume of the vacuum tank, the lower the power of the vacuum pump could be the size of the vacuum tank should be in correlation with the power of the vacuum pump and the size of the vacuum table
  - **vacuum pump:** a double vacuum pump avoids pressing failures through a possible loss of pressure in case of breakdown of a pump
  - **power of the vacuum pump:** at least 1.5 kW (depending on the size of the vacuum table)
  - **placement of the vacuum pump:** should not stand directly in the processing room to avoid noise exposure to the labour
  - **vacuum:** typical values between 150 – 300 mbar (0,7 – 0,85 absolute atmospheric pressure)
  - **equivalent pressure force:** $15 – 30 \text{ kN/m}^2 = 1.500 – 3.000 \text{ kg/m}^2$
Vacuum table

- **General information**
  - vacuum rubber foil:
    
    it's a deep-drawing-foil/tarpaulin on rubber-basis
    
    the surface is coated with polyester which makes it free from pores → airproof
    
    the vacuum rubber foil guarantees a airproof pressing area between the pressing plate, the framework around the pressing plate, the compressed sandwich panel and the vacuum rubber foil
    
    more strongly and elastic “Offshore – foils” provide a more equal allocation of the press capacity
    
    weight of the vacuum rubber foil: mostly 450 g/m²
General information

- vacuum rubber foil:
  - the vacuum rubber foil mustn’t be placed over sharp edges or outlines
  (if necessary these areas should be additionally covered)
  - cleanliness of the vacuum rubber foil is very important!
  (in case of getting dirty with glue, please remove it immediately with a convenient dissolver)

- clamping claws:
  - in order to produce a vacuum, the vacuum tarpaulin has to be fixed at the pressing table with terminal strips and clamping claws (approx. every 500 mm)
  - therefore the vacuum rubber foil should lay smooth over the panel (without crinkles)
Safety instructions for vacuum table

- the vacuum has to be constant between the whole pressing process
- the bonding pressure should be within the recommendation of the glue supplier
- the bonding pressure shouldn’t be too high
- it’s very necessary to protect the pressing plate and the vacuum rubber foil against the leakage of the glue (mask the border area with PET-foil or something else, but no paper)
- use scored foam only – to assure a even distributed vacuum and to catch excessive glue
- keep away grease, oil and silicones from the vacuum table!
- the technical data towards the “open time” and the “conditioning time” of the glue supplier have to be strictly followed
Safety instructions for vacuum table

- it’s very necessary that the pressing plate has to be completely cleaned from dust and dirt before every bonding process in order to avoid impressions in the surface of the sandwich-panel
- do **not** use “standard” compressed air to clean the pressing table (it must be free from oil)
- example what can happen if the pressing plate is dirty

![Example of dents/impressions in the surface]
Safety instructions for vacuum table

- only use a glue which is convenient and recommended for the used materials
- for the bonding process put a frame (distance keeper) with the same height around the sandwich-panel

→ this prevents the foam of the sandwich-panel from being compressed at the edges, otherwise the edges would become round
Vacuum table
Core material - Foam
Core material - Foam

- Basically there are three different types of common used foam:
  - extruded polystyrene-foam → XPS-foam
  - expanded polystyrene-foam → EPS-foam
  - polyurethane foam → PU-foam
Core material - Foam

- XPS-foam (extruded polystyrene-foam)
  - compared to EPS- and PU-foam highest strength at comparatively low weight
  - approx. 30 % higher comprehensive strength than with PU-foam
  - often used in vehicle construction, particularly for the bottom
  - low water absorption (through diffusion)
  - used for cool trailer, mobile homes and buses
Core material - Foam

- EPS-foam (expanded polystyrene-foam)
  - also known as “Styropor®”
  - economic solution, if you don’t need a high mechanical strength and heat insulation
  - low weight
  - often used for sidewalls, bottoms and roofs of caravans and mobile homes
Core material - Foam

- PU-foam (polyurethane-foam)
  - well known for his very low heat conductivity and very good insulation properties
  - often used in vehicle construction for sidewalls and roofs of cool trailers
  - PU-foam is the result of a chemical reaction between isocyanates, polyols and a blowing agent
Types of glue
Types of glue

- Different types:
  - 1-component Polyurethane
    - often used in caravan- and mobile home industry
    - easy to handle
    - depending on type they are more or less foaming (this helps compensating tolerances in the foam and process, especially with mechanical presses)

BUT

- they need water (as second component) in the form of humidity to react
- this means that the humidity in the air and in the substrates should be at every time the same to achieve a constant and qualitative bonding
- in case of applying water to the substrates this has to be done really consistent, because too much or too less water can cause bonding defects
- depending on the glue, 1-component Up's normally need approx. 10% water (10 PU : 1 water) to react
Types of glue

- Different types:
  - 2-component Polyurethane
    - often used in vehicle construction (trailers, buses, etc.)
    - high mechanical strength in comparison to 1-component Polyurethanes
    - adhesion through chemical reaction between polyol and isocyanate
    - the countless combinations make it possible to adjust the “chemical reaction” to the production process and the needed mechanical properties
    - normally they are non foaming, this means that you get a better, more even and smooth surface than with 1-component Polyurethanes (but it doesn’t compensate tolerances in the foam as good as 1-component polyurethanes)
    - mostly preferred is a long “open time” and a short “conditioning time”
Different types:

- reactive PUR-Hotmelts
  - often used in US recreational vehicle industry with a lot of automation and mass production
  - reactive PUR-Hotmelt include, like 1-component Polyurethanes, precursors of Polyurethanes
  - in the first step the PUR-Hotmelt becomes liquid through melting at higher temperatures to achieve a good wetting on the surface
  - in the second step the liquid glue reacts with humidity in the air and/or the substrate and builds up a molecular cross linking
  - afterwards the glue could not be melted again
Gluing GRP composite panels
Gluing GRP composite panels

- Overview
  - Storage and handling
  - Required equipment
  - Preparation before bonding
  - Bonding on vacuum table
  - Inspection of the bonding
  - Problems and causes
Storage

- LAMILUX-products should be stored indoors at room temperature in a well ventilated, dry area, at least 48 hours before gluing

- the coils should stand in a vertical position and may not lay flat

- if it is necessary to store products outside, they must be covered and protected from weather and sunlight exposure.
Gluing GRP composite panels - storage and handling instructions

- **Storage**
  - the glue should be stored within 18 – 23 °C in order to achieve a good wetting
  - if wood or plywood is used in composite panels it must be stored at dry conditions and has to be dry for processing
Gluing GRP composite panels - storage and handling instructions

- Storage time
  - maximum 6 months
  - the surface tension of corona treated products should be checked with test ink (> 38 Dyn/cm) before gluing at any time
  - the surface tension of 38 Dyn/cm and higher ensures a good wetting of the glue
Gluing GRP composite panels – required equipment

- Vacuum table
- Glue (advised 2-component PU)
- Composite-materials
  - GRP
  - XPS-, EPS-, PU-foam
  - etc.
Gluing GRP composite panels – required equipment

- Application-system for the glue
  - mechanical per hand with applicator roll („Gupfo“)
  - automatically with injectorline or spray-coating

Mechanical per hand: “Gupfo”

Automatically

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Gluing GRP composite panels – required equipment

- Application-system for the glue
  - automatically with injectorline or spray-coating
  - for instance: Barkvall engineering (www.barkvall.com)
  - OEST (www.oest.de)
Gluing GRP composite panels – required equipment

- Application-system for the glue
  - automatically with injectorline or spray-coating
Gluing GRP composite panels – required equipment

- requirements on the vacuum table
  - for this see point “Vacuum table – general information”

Vacuum table with 2K-PU-Körapur 689- surface
Gluing GRP composite panels – required equipment

- requirements on the glue
  - exact type depends on
    - the materials which should be bonded
    - the production process
    - the required processing-time
    - the product
    - the mechanical and environmental demands of the application
  - for this see also point “Types of glue”
  - often used: 2K-PU-glue with a low viscosity and reactivity
    long „open time“ and a short „conditioning time“
  - attention: for bonding it’s very important to follow the manufacturers
    requirements listed in the relevant glue data sheet
  - attention: test the bonding and the adhesion concerning to the application
Gluing GRP composite panels – preparation before bonding

- the GRP should be stored at least 48 hours at room temperature
- the glue should have a temperature between 18 an 23 °C
- control and clean the vacuum table that it’s free from scratches, dust, grease and oil
  - for this also see pages 19 – 27 “Vacuum table”
Gluing GRP composite panels – preparation before bonding

- vacuum clean the GRP and make sure that it’s also free from dust, grease and oil (don’t use solvents)

- check the surface energy of the corona treated GRP, that it’s higher than 38 Dyn/cm with test ink

- the surface energy of 38 and higher ensures a good wetting through the glue
Gluing GRP composite panels – bonding on vacuum table

- for bonding put the GRP and the foam layer by layer in the right order on the top of each other (avoid asymmetric constructions)

- and apply the 2K-PU glue evenly distributed and in a correct amount between all layers which should be bonded; according to manufacturers requirement of the relevant glue

applying the glue on GRP with “Gupfo” – corona side

Gluing GRP composite panels – bonding on vacuum table

- **attention**: use a protective PET-film or something else (but no paper!) to protect the pressing table and the vacuum rubber foil against the leakage of the glue

[Image of protective-film on a vacuum table]

protective-film to protect the pressing table and the vacuum rubber foil against leakage of the glue
Gluing GRP composite panels – bonding on vacuum table

- if the sandwich is ready put a frame or piece of foam around it
- the frame should have the same height as the sandwich
- the frame prevents the foam from being compressed at the edges
- otherwise the edges would become round
Gluing GRP composite panels – bonding on vacuum table
Gluing GRP composite panels – bonding on vacuum table

- cover the sandwich with the vacuum rubber foil
  - the vacuum rubber foil mustn’t be placed over sharp edges or outlines (if necessary these areas should be additionally covered)
  - cleanliness of the vacuum rubber foil is very important
  - the vacuum rubber foil should lay smooth over the panel (without crinkles)
Gluing GRP composite panels – bonding on vacuum table

- in order to produce a vacuum, the vacuum rubber foil has to be fixed at the pressing table with terminal strips and clamping claws (approx. every 500mm)

- now turn on the vacuum between 150 – 500 mbar (depending on the manufacturing requirements of the relevant glue)
Gluing GRP composite panels – bonding on vacuum table

- hold the vacuum constant, without loosing vacuum, until the glue reaches his handling-strength

- after reaching the handling-strength (depending on the glue) turn off the vacuum and remove the bonded composite panel from the vacuum table

ready bonded sandwich panel
Gluing GRP composite panels – bonding on vacuum table

- handling of the sandwich-panels
  - through labour
  - with crane
  - with vacuum lifter
Inspection of the bonding and Quality control
Gluing GRP composite panels – inspection of the bonding

- check the surface if it’s wavy
- check the adhesion between the bonded materials by trying to peel it off
- look at the glued joint if there are pores or holes in it
- inspect the edges towards edge-curling or edge-shrink
Gluing GRP composite panels –
inspection of the bonding

- test the bonding under outside weathering conditions, for example:
  - storage under heat or cold (-30 °C up to + 80 °C)
  - or charging it with extreme sunlight or ultra red-light
    (surface temperatures up to 90 °C if the material has a dark
    surface or dark graphics)
<table>
<thead>
<tr>
<th>Problem:</th>
<th>Causes:</th>
</tr>
</thead>
</table>
| missing or low adhesion between the bonded materials | - dust, grease or oil on the bonded surface  
- no even distribution or correct amount of the glue  
- incorrect mixing ratio of the 2K-PU-glue  
- wrong glue  
- incorrect treatment of the 2K-PU-glue („open time“, „conditioning time“):  
  - wrong processing temperatures  
  - incorrect vacuum  
  - too minor surface energy  
  -… |
<table>
<thead>
<tr>
<th>Problem:</th>
<th>Causes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waves in the surface</td>
<td>varieties in the thickness of the core-material and the inserts or frames; uneven glue distribution; too high vacuum; incorrect mixing ration of the 2K-PU glue; uneven distribution of water or humidity in the material with the 1K-PU</td>
</tr>
<tr>
<td>Bubbles</td>
<td></td>
</tr>
<tr>
<td>Uneven surface</td>
<td></td>
</tr>
</tbody>
</table>
### Problem:
- Waves in the surface
- Bubbles
- Uneven surface

### Causes:
- gaps between core-materials

![Image of waves in the surface and uneven surface]

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13.11.2008  M. Gräf  68
# Gluing GRP composite panels – problems and causes

<table>
<thead>
<tr>
<th>Problem:</th>
<th>Causes:</th>
</tr>
</thead>
</table>
| Dents/impressions and bubbles in the sandwich-panel surface | - Dirt, dust, scratches, holes on the pressing table and the vacuum rubber foil  
- Dents in the core-material  
- Dust on the core-material surface |

![Image of dents and impressions](image1.png)

![Image of bubbles](image2.png)
### Gluing GRP composite panels – problems and causes

<table>
<thead>
<tr>
<th>Problem:</th>
<th>Causes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waviness in the panel surface</td>
<td>- inconsistent glue layer thickness</td>
</tr>
<tr>
<td>Bubbles (areas with too less glue!)</td>
<td>- uneven glue distribution</td>
</tr>
</tbody>
</table>

- inconsistent glue layer thickness
- uneven glue distribution
<table>
<thead>
<tr>
<th>Problem:</th>
<th>Causes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>rounded edges of the sandwich</td>
<td>- no frame around the sandwich on the vacuum table</td>
</tr>
</tbody>
</table>
### Gluing GRP composite panels – problems and causes

<table>
<thead>
<tr>
<th>Problem:</th>
<th>Causes:</th>
</tr>
</thead>
</table>
| vacuum rubber foil is too flexible. | - reduction of vacuum pressure  
- more stronger „off-shore-foils“ |
Cut-to-size-sawing
Cut-to-size-sawing

- Panel dividing machines
  - panel dividing machines are advisable if you cut a lot of small and different sizes out of the sandwich-panels
  - supplier for instance: Holzma (www.holzma.com)
    Schelling (www.schelling.com)
  - prices: e.g. panel dividing machine fk 4 (Schelling) depending on additional equipment between 90,000 and 140,000 €
Cut-to-size-sawing

- Panel dividing machines

Holzma
Trimming the edges
Trimming the edges

- Circular hand saw with exhaustion
Trimming the edges

- Vertical panel saws
  - e.g. Striebig (www.striebig.com)
Milling – CNC Router
Milling – CNC router

- Supplier for instance:
  - CMS (www.cms-maschinen.de)
  - Eima (www.eima-maschinenbau.de)
  - Reichenbacher (www.reichenbacher.de)
The following recommendations are based on our experience and corresponds to our current know how. The recommendations are no assurance of special process- and product-properties.