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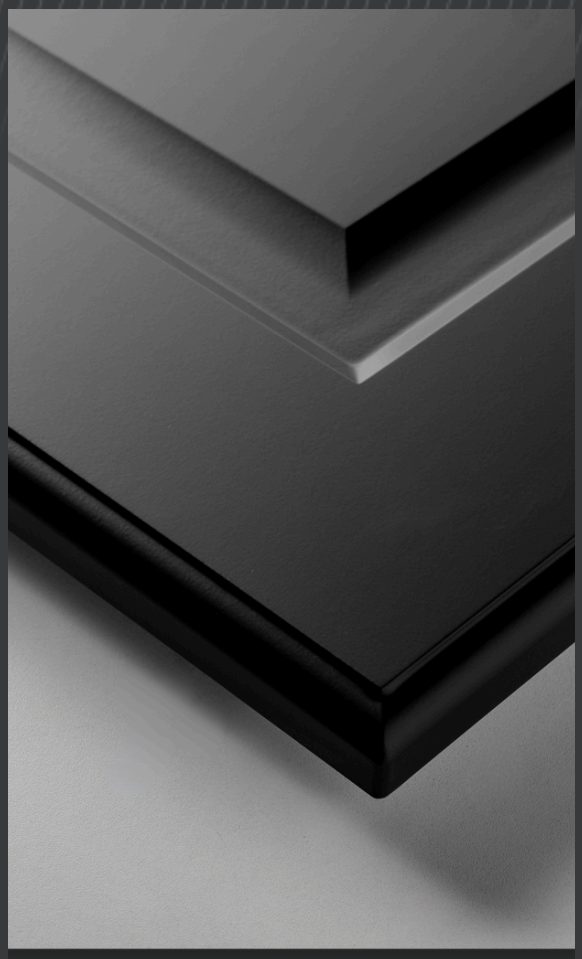

3D-Door Manufacture

Quality Guide

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Foreword

Three-dimensionally thermo-coated furniture fronts, known as 3D fronts, are used in all types of furniture, primarily in bathroom and kitchen areas, as well as in living room and bedroom furniture, worldwide.

Innovative developments in the formulation of the materials used, along with a very high degree of automation in 3D-foil coating, including the pre- and post-treatment of the workpieces in the manufacturing process, have led to a highly complex body of expertise. This knowledge is essential for users to handle these materials and master the production process.

For this reason, leading companies from across the entire process chain, from raw material manufacturers to processors, have joined forces in an initiative group. Their goal is to consolidate this wealth of information and expertise into a Quality Guide and make it available to users.

The objective is to ensure the production of high-quality furniture fronts by taking into account material-specific properties, correctly maintaining environmental conditions, and adhering to the process workflows. This enables furniture manufacturers and end users to benefit from a durable and reliable product.

Another equally important goal is the harmonization of specifications regarding material properties, storage conditions, processing parameters, and testing methods.

By consistently documenting all relevant data throughout the entire process, traceability of production batches is ensured, thereby guaranteeing the highest possible level of quality assurance.

We thank the participating companies for their close collaboration and the trust they have shown, which made it possible to document the extensive know-how of each company in this summary.

Initiativkreis 3D

1 Application

Description of Application and Purpose

Thermoplastic 3D furniture films* are high-quality surface materials for use on membrane and membrane-free thermoforming presses for three-dimensional coating of wood-based materials (MDF) for kitchen, living room, bathroom and office furniture.

Can be processed on all commercially available thermoforming presses using temperature, pressing pressure and vacuum as well as using a PUD adhesive for permanent bonding to the wood material (MDF).

2 Description of Materials - Films

2.1 Thermoplastic Furniture Foils (Rigid PVC*)

Thermoformable furniture foils for use on membrane and membrane-free thermoforming presses are impact-resistant rigid PVC-foils with a single- or multi-layer structure.

The surfaces are coated with a highly lightfast protective lacquer based on PUR/acrylate.

The reverse side is primed to ensure secure, heat-resistant bonding.

The thermoplastic 3D furniture foils essentially consist of:

- PVC, fillers such as chalk and pigments
- Stabilizers
- Very small amounts of plasticizers (no DEHP!)

The production of these foils does not involve the use of:

- Formaldehyde
- Cadmium, lead, mercury, or chromium compounds (chromium VI)
- Azo dyes or lead-containing pigments

This is in accordance with the German Consumer Goods Ordinance (last amended on August 8, 2007). Furthermore, the requirements of the German Chemicals Prohibition Ordinance (last amended on March 9, 2007) are also met.

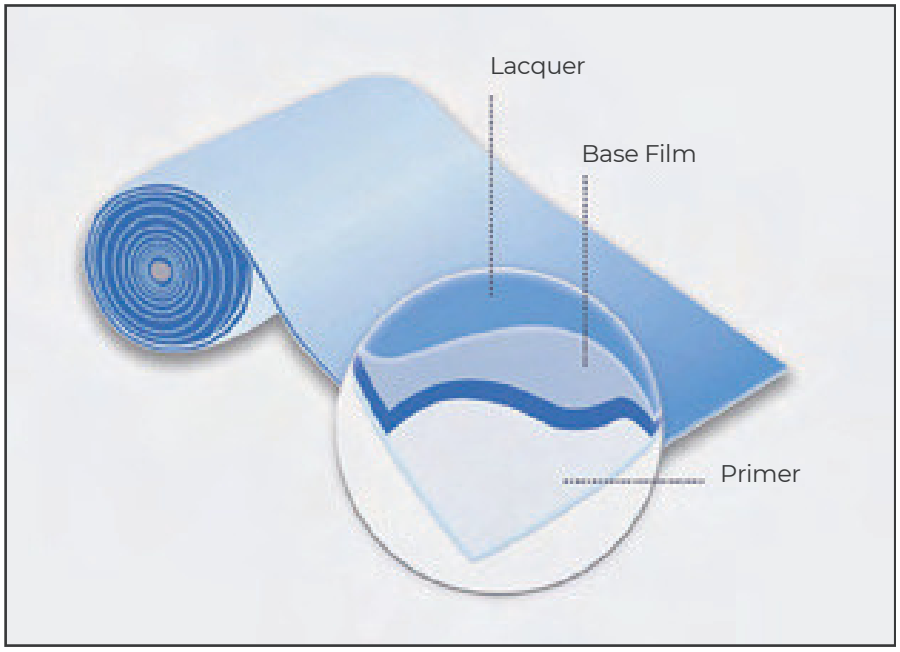
IMPORTANT!

- **Rigid PVC foil with protective lacquer and backside primer**
- **No DEHP plasticizers**
- **No components as defined by the Consumer Goods and Chemicals Prohibition Ordinances**

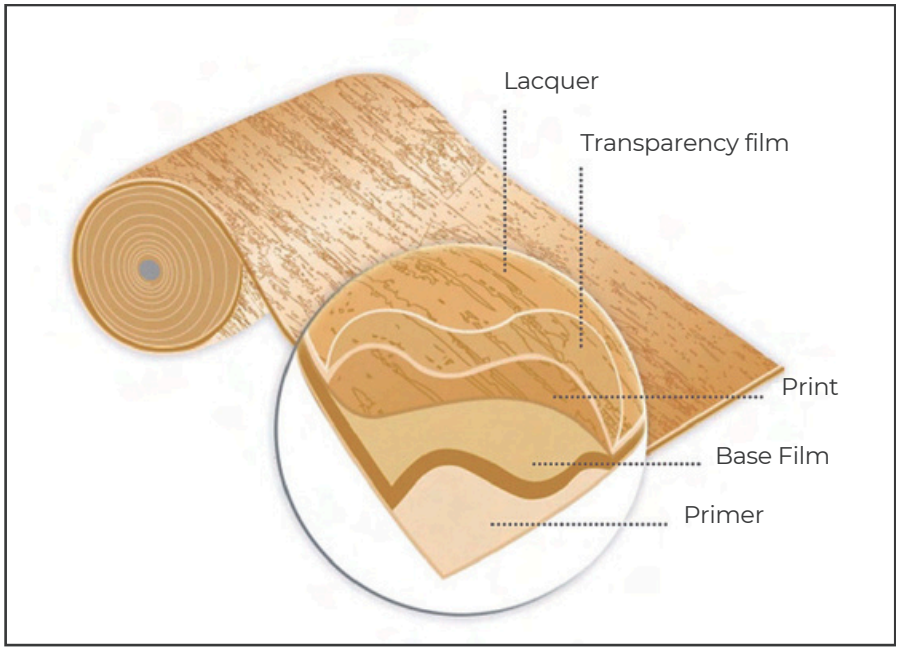
2 Description of Materials - Films

2.1.1 Product structure single-layer and multi-layer films (Standard thickness 0.30 - 0.40 mm)

Single-layer- (Uni-) Film



Multilayer- (Printed Decorative-) film



2 Description of Materials - Films

2.1.2 Primer

To ensure consistently high and secure bonding, special attention is paid to the back of the films, which is equipped with a special primer system.

- Both the raw materials used and the application process are subject to continuous monitoring.

- Ensuring a consistent and optimal application amount is achieved with defined application rollers.

- The primer is matched to the adhesive systems developed by adhesive manufacturers.

- Further special monitoring during the film manufacturing process includes compliance with mechanical properties such as dimensional stability, embossing stability, and tensile strength.

The corresponding values and tolerances are specified in the quality guidelines of the Industrial Association for Plastic Sheets, with references to test methods and respective DIN/ISO standards.

IMPORTANT!

- **Continuous monitoring of raw materials and processes**
- **Primer application with defined application rollers**
- **Coordinated primer/adhesive system**
- **Monitoring of mechanical properties**
- **Specification according to the quality guidelines of the Industrial Association for Plastic Sheets**

2 Description of Materials - Films

2.1.3 Quality Guidelines - Industrial Association for Plastic Sheets

Material specification for 3D-Films
Application Area: Furniture / Vertical Surfaces

Property / Test Method	Unit	Value / Tolerance
1. Thickness (DIN 53353)	mm	0,30 – 0,50 ± 7,5 %
2. Dimensional change (DIN 53377, 10 min., 100°C, circulating air)	%	longitudinal max. - 5% transverse max. + 2%
3. Embossing stability (10 min., 120°C, circulating air)	-	No visible changes in gloss, embossing, or color compared to standard
4. Lightfastness (DIN EN ISO 4892-2, Method B, ISO 105 B 02)	-	≥ 6
5. Chemical resistance DIN 68861, Part 1	-	Class 1 B
6. Scratch resistance DIN 68861, Part 4	N	At least class 4 D, ≥ 1,0 N
7. Heat resistance, dry DIN 68861, Part 7	°C	At least class 7 C (90 °C)
8. Heat resistance, humid DIN 68861, Part 8	°C	At least class 8 B (70 °C)
9. Abrasion resistance DIN 68861, Part 2	rpm.	At least class 2 D (50 Umdr.)
10. Tensile strength ISO 527-3-200	N/mm^2	longitudinal ≥ 40 transverse ≥ 30

Property / Test Method	Unit	Value / Tolerance
11. Gloss level tolerance DIN 67530, 60° measuring head	-	up to 15 ± 2 up to 30 ± 3 up to 50 ± 5 over 50 ± 7
12. Color tolerance uni films DIN 53236 B (10 / ≤) DIN 6174 (light colors only)	-	Δ E ≤ 0,50 Δ L ± 0,30 Δ a ± 0,20 Δ b ± 0,30
13. Color consistency printed films Original pattern comparison	-	Production and visual assessment to reference sample
14. Metamerism-index DIN 6172 (D65 – AN 10)		≤ 0,30
15. Opacity over black/white	-	Δ E ≤ 0,35
16. Defect definition	-	Optical deviations are considered defects if visible to the naked eye from 50 cm within 30 seconds under good lighting.

Note: All tests are performed on unlaminated film.
Exceptions: Tests 7 and 8 are performed in the laminated state.

2 Description of Materials - Adhesives

2.2 Polyurethane Dispersions (PUD)

PU dispersion adhesives (PUD) are water-based special adhesives made from polyurethane, especially for laminating decorative, thermoplastic films (based on PVC, ABS-blend, polyester, etc.) using membrane or membrane-free presses onto MDF boards. These adhesives are available or used in two different forms:

- One-component reactive products (with crosslinker already incorporated)

Practical experience shows that the use of reactive products results in significant improvements in several areas:

- Better adhesion to the film
- Better adhesion to the substrate material
- Higher heat resistance
- Greater resistance to water and water vapor

For the aforementioned reasons, only reactive adhesives are used.

IMPORTANT!

• Water-based special adhesive based on polyurethane
• One-component, reactive (crosslinker is incorporated)

2 Description of Materials - MDF Board

2.3 MDF Wood-Based Panels (Medium-Density Fiberboard)

The MDF board is a wood-based material that is equally homogeneous in longitudinal and transverse directions and consists of finely defibrated softwood and/or hardwood.

The surface is sanded on both sides during the process and one side is melamine-coated for coating with 3D furniture films.

Due to their high density and fine fiber structure, MDF deep drawing qualities are particularly suitable for the manufacture of 3D furniture fronts for all living areas.

MDF Deep Drawing Quality (Characterization)

• Moisture (EN 322)	6 ± 2 %
• Transverse tensile strength (EN 319)	≥ 0,75 N/mm²
• Peel strength (EN 311)	≥ 1,2 N/mm²
• Hydrophobic agents	≤ 2% solids on oven-dry wood fiber

Note:
Instead of "deep drawing quality", the term "deep milling quality" is also frequently used. Both terms are common and describe the same quality level for MDF boards used to manufacture three-dimensionally coated furniture elements.

IMPORTANT!

• MDF deep drawing/deep milling quality with high core layer density
• Fine fiber quality, very fine sanding and surface finish
• High physical properties

3 Transport, Durability, Storage – Materials

3.1 Storage Recommendations for PVC-Films

• Store films in a dry place and not outdoors

• Avoid direct sunlight and frost

• Ideal storage temperature: between 5–30°C with relative humidity of approx. 50% (ideal conditions)

The manufacturer recommends a maximum storage duration of 18 months under ideal conditions. For films with protective film, the maximum is 6 months.

Storage should be arranged so that the films are free from external pressure.

Before processing, the film must be conditioned at room temperature (at least 18°C) and 50% relative humidity for 3 days (ideal conditions).

IMPORTANT!

• **Ideale storage temperature**	**5-30 °C**
• **Relative humidity:**	**approx. 50%**
• **Max. storage time**	**18 months**
• **With protective film**	**6 months**

3 Transport, Durability, Storage – Materials

3.2 Storage Recommendations for Polyurethane Dispersions (PUD)

• PU dispersion adhesives can be stored for approx. 6 months in well-sealed original containers, dry and cool (15–25°C)

• Lower temperatures are permitted during transport only briefly. Adhesive temperature must not fall below +6°C

• Upon delivery in winter, special attention must be paid to the container temperature and samples should be checked for homogeneity. Any issues should be immediately reported to the forwarder and the adhesive supplier.

Cold-delivered goods (<15°C) must be stored at 20 ± 2°C for at least 48 hours before processing!

Note:
In coordination with the adhesive supplier, deliveries in winter months can be made with temperature indicators (cold marks or data loggers).

IMPORTANT!

• Ideal storage temperature	**15-25 °C**
• Transport	**min. +6 °C**
• Max. storage duration	**6 months**
• In winter, monitor container temperature!	

3 Transport, Durability, Storage – Materials

3.3 Storage Recommendations for MDF Boards

· The factory-set moisture content (6 ± 2%) is maintained under storage conditions where the absolute board moisture content corresponds to the standard climate (20°C and 65% relative humidity).

· If relative humidity is higher, the MDF board absorbs moisture (approx. 10% at 85% rel. humidity).

· If relative humidity is lower, the MDF board dries (approx. 4% at 30% rel. humidity).

· MDF boards must be protected from increased moisture. Structural measures (e.g., enclosed halls, no storage under overhangs) are required.

· When climate conditions change, adjustment through the entire board thickness takes 3–6 days for individually stacked boards depending on thickness, and at least 4 weeks in stacked piles.

· Improper stacking causes warping. Always follow supplier instructions. The number of support battens varies with board size, thickness, and whether top boards are used.

Note:
The manufacturer's instructions regarding transport and storage conditions must be strictly followed.

IMPORTANT!

- **Wood moisture 6 +/- 2% (20 °C, 65% rel. humidity)**
- **Do not store outdoors**
- **Protect from direct sunlight, cold, and moisture**
- **Store flat and without distortion**

4 Preparation of Materials

4.1 General Preparations

Before further processing the materials, ensure that:

- The materials meet the respective specifications.
- The materials have been stored under the previously described conditions (temperature/humidity).
- The materials have been conditioned under the previously described conditions (temperature/humidity).
- The climate conditions during the production process (temperature/humidity) are monitored and maintained.

In particular, ensure that:

- The MDF boards meet the respective specifications.
- The MDF boards have the permissible residual moisture content (6 ± 2%).
- The MDF boards are not too fresh or too warm (> 18 and < 35 °C board temperature).

- The films meet the respective specifications.
- The decor, color, gloss level, and texture match the agreed reference sample.
- The primer is applied evenly and over the entire surface (visual inspection).
- The films are conditioned at room temperature before processing.

- The PU dispersion adhesives meet the respective specifications.
- A visual inspection is performed for inhomogeneity (thickening, separation).

IMPORTANT!

• Manufacturer specifications must always be observed for storage, mixing instructions, pot life, application devices, and processing instructions
• Check and maintain room climate
• If necessary, consult the respective manufacturer.

4 Preparation of Materials

4.2 Cutting / Milling

• Only process MDF boards with sharpened tools.

- Cutting on panel saw
- Milling on CNC machine
- Machining center
- Edge milling machines
- Double-end profilers
- Other processing machines

• Process MDF boards or cut parts only at the prescribed speed to avoid burns or chipping on edges and profiles.
• Do not spray agents such as oil and/or oil- or silicone-based substances onto the boards or workpieces.

• After milling, the parts must be:

- Stored flat and without warping.
- Kept in a dry and temperature-controlled room (observe ideal conditions!).
- Passed on for gluing free of dust and clean.

IMPORTANT!

• Use only sharp tools
• Observe processing speeds
• Do not use oil- or silicone-based substances
• Store processed workpieces flat, without warping, dry, and clean

4 Preparation of Materials

4.3 Preparation of PU Dispersion Adhesive (PUD)

Checking the adhesive container before use

- Perform a visual inspection for inhomogeneity such as thickening, separation, etc. (in case of such issues, consult the adhesive supplier before use).

- Stirring before use is recommended but generally not required.

5 Material Processing – Production Process

5.1 Adhesive Application

5.1.1 Information on Adhesive Delivery Equipment and Application Systems

• To minimize mechanical stress on the PUD adhesives, it is recommended to transport them from the storage container to the spray gun using a pressure vessel.

• All parts that come into contact with the dispersion should be made of V4A (stainless steel) or materials such as Teflon, polyamide, PP, or other inert plastics.

• Contact with base metals (e.g., zinc, brass, copper) must be avoided.

This can lead to coagulation of the adhesive, resulting in uneven adhesive application and clogging of nozzles and lines.

- Nozzle size: 1,5 – 2,2 mm
- Material pressure: 1,0 – 3,0 bar
- Atomizing pressure: 3,0 – 7,0 bar
- Air cap size: 2,2 – 2,5 mm

• When processing from a pressure vessel, the following reference values apply: For a 4-meter hose with an inner diameter of 8 mm, the material pressure should be approximately 1 – 2.5 bar.

5 Material Processing – Production Process

5.1.2 Adhesive Application – MDF Substrate, Temperature, and Adhesive Quantity

Special attention must be paid to the careful preparation of the MDF substrate parts.

- The surface must be absolutely clean and free of dust.

- Even the smallest contaminants or inclusions of dust particles can become visible on the surface of the foil after lamination.

- Adhesive is typically applied by spraying onto MDF substrate material at room temperature (>18 °C).

- The edges and milled profiles are highly absorbent areas where the dispersion can more easily penetrate and potentially be absorbed excessively ("strike-in"). Therefore, a double adhesive application is required on the edges and in the milled profiles to ensure a continuous, smooth adhesive film.

- In the first pass (pre-spray), the pores are primarily sealed.
- After an intermediate drying time (1–3 minutes),
- the required amount of adhesive for a durable bond is applied in the second pass.

5 Material Processing – Production Process

The minimum temperature for the materials and ambient air should not fall below 18 °C. Similarly, temperatures above 35–40 °C should be avoided.

The amount of adhesive applied is highly dependent on the MDF quality and its absorbency, and should not fall below the following values:

- on the surface: 50 – 70 g/m² wet (20 – 30 g/m² dry)
- on the edges: 80 – 130 g/m² wet (35 – 55 g/m² dry)

Note:
In some cases, higher application amounts may be required!

After application to the substrate, the adhesive should be spreadable with a finger. After drying, the adhesive film should appear glossy.

If necessary, random weight checks should be carried out for quality assurance.

IMPORTANT!

- **Clean and dust-free surface**
- **Adhesive application on MDF at room temperature (>18 °C)**
- **Edges and milled profiles are highly absorbent – apply adhesive twice**
  - **1st application: to seal the pores**
  - **Intermediate drying: 1–3 minutes**
  - **Then apply 2nd coat of adhesive**
- **Application amount strongly depends on MDF quality**

5 Material Processing – Production Process

5.1.3 Drying of the Adhesive Layer

After the adhesive has been applied, the following must be observed:

- Sufficient drying of the adhesive under dust-free conditions must be ensured. Only then can thermal activation in the press take place.

- Depending on environmental conditions (temperature and humidity), MDF workpieces are typically sufficiently dry for pressing after approximately 30 minutes at room climate (approx. 20 °C and 50% relative humidity).

- The drying time can be significantly reduced by passing the pre-coated parts through a warm air drying tunnel.

- When drying in a warm air tunnel and during subsequent storage, it must be ensured that the surface temperature does not exceed 40 °C, in order to avoid premature or accelerated cross-linking of the adhesive.

- The decisive factor for fast drying is the air volume, not the temperature. This applies to both reactive two-component and reactive one-component PU dispersion adhesives.

5 Material Processing – Production Process

- After drying in the warm air drying tunnel, immediate further processing/coating in the press is required, especially when using reactive dispersion adhesives.

- Longer waiting times must be strictly avoided.

Note: Please be sure to follow the adhesive manufacturer's instructions.

IMPORTANT!

- **Ensure sufficient drying under dust-free conditions**
- **Glued fronts are ready for pressing after approx. 30 minutes, depending on room climate (approx. 20 °C / 50% relative humidity)**
- **Drying time can be reduced using a warm air tunnel**
- **During drying in the warm air tunnel and subsequent storage, do not exceed a surface temperature of 40 °C**
- **Air volume, not temperature, is the critical factor for effective drying**
- **After tunnel drying, immediate further processing/coating is required**
- **Avoid prolonged waiting times at all costs**

5 Material Processing – Production Process

5.2 Pressing Process

5.2.1 Press Systems / Parameters

Below are the specific characteristics of various pressing systems as commonly used in practice:

- Specific characteristics of membrane presses:

  - The membrane serves as a medium for heat transfer.
  - The forming of the foil is achieved through vacuum and pressing pressure applied to the membrane.

- Specific characteristics of presses without a membrane:

  - Heat transfer occurs directly from the heating plate to the foil.
  - The forming of the foil over the workpiece is achieved solely through vacuum and pressing pressure.

5 Material Processing – Production Process

5.2.2 Preparations for Pressing

At the start of processing, the following parameters must be checked:

- Type of foil (base material, structure, properties)
- Foil thickness
- Color and surface type (e.g., standard or high gloss)
- Press parameter settings, taking into account the foil type and milling geometry of the parts
- Condition of the glued parts (sufficient airing/drying and adherence to the time window after gluing, as well as the part temperature)

5.2.3 The Coating Process

The coating process takes place in two steps:

Step 1: Preheating
Step 2: 3D-Forming

5.2.4 Heating Plate and/or Membrane Temperature

Settings must be adjusted depending on the type of foil used.

5 Material Processing – Production Process

5.2.5 Preheating Time and the Preheating Process

- The foil is heated by raising it into contact with the upper heating plate or membrane (contact heat).

- Ensure full-surface contact with the heat source.

- Radiant heat also contributes to raising the temperature level of the workpieces.

- Alternatively, the preheating of the foil can also be performed using radiant heat.

- The preheating of the foil is influenced by both the heating plate or membrane temperature and the preheating time.

- The preheating time must be set so that the activation temperature specified by the adhesive manufacturer is reliably reached in the adhesive joint.

- The temperature in the adhesive joint depends on the heating plate or membrane temperature (i.e., the surface temperature of the foil) and the preheating time.

- The required minimum activation temperature is adhesive-specific and typically lies between approx. 55 to 80 °C (adhesive joint temperature).

- To achieve optimal results, the minimum activation temperature in the adhesive joint should be clearly exceeded at a pressing pressure of at least 3 bar.

Note:
Using a suitable measuring method (e.g., temperature-indicating strips, contact thermometer, T-profiler, etc.), the surface temperature of the foil and the adhesive joint temperature at the edge and surface must be measured and documented along with the process parameters.

If the surface or adhesive joint temperature is insufficient, machine parameters (preheating time, pressing time, pressing pressure, heating plate temperature) must be adjusted accordingly.

5 Material Processing – Production Process

5.2.6 3D-Forming

- The forming of the foil is achieved by vacuum from below and pressing pressure from above.

- When the vacuum is applied, the foil can be released from the heating plate immediately or with a delay in order to reduce the air volume before pressing.

- The 3D-forming is influenced by the vacuum time, pressing pressure, and pressing time.

- These parameters must be adjusted according to the type of foil used and the geometry of the workpieces.

- The minimum pressing pressure required by the adhesive manufacturer must be observed.

- The pressing time must be set so that the temperature in the adhesive joint is significantly below the adhesive's activation temperature at the end of the pressing cycle.

In addition to the main parameters listed above, there are additional parameters that may be used for special applications. These parameters are specified in the manuals of the respective press manufacturers or can be obtained directly from the press manufacturer.

IMPORTANT!

• Set the preheating time correctly to ensure the adhesive-specific activation temperature is reached in the adhesive joint.
• Ensure full-surface contact with the heat source.
• The press parameters depend on the type of foil and the geometry of the workpieces.
• Observe the minimum pressing pressure specified by the adhesive manufacturer.
• Set the pressing time so that the adhesive joint temperature is well below the activation temperature by the end of the pressing cycle.

5 Material Processing – Production Process

5.2.7 Cutting and Trimming

• After the pressing process is completed and the press is opened, the pressed and still warm parts are cut out of the foil sheet (separated) and removed from the press table, leaving a foil overhang of a few centimeters around each workpiece.

• If the foil overhang is trimmed immediately after pressing (either manually or automatically), it is important to ensure that the adhesive has sufficient cohesion/strength.

• To prevent the foil from being pushed out of the adhesive bed at the edge due to cutting pressure, a sharp tool must be used. The foil overhang should be trimmed using a pulling cut against the adhesive joint.

• The adhesion of the foil should be checked and documented at regular intervals using a tear-off test. For this, the foil is cut in a triangular shape from the surface into the edge, pulled off, and the bonding strength is evaluated.

• Ideally, the parts should be trimmed only after they have cooled down to room temperature.

5.2.8 Curing Time

• The final curing of reactive PU dispersion adhesives is achieved after approximately 7 days.

• Depending on the adhesive, foil type, foil thickness, profile geometry of the MDF substrate, and the testing method, heat resistance levels between 80 and 100 °C can be achieved — provided that the above-mentioned conditions are followed.

6 Glossary

Additive	Additives / auxiliary substances
Adhesion	Adhesive force at the contact surfaces of two materials
Application process	Coating process / application method
Filler	Additive in foil formulation
Gloss level	Measurable value of the gloss level of a surface
Rigid PVC-foil	Plastic foil made from PVC with little or no plasticizers
Heating plate	Component in the thermoforming press for heat generation
Wood moisture	Proportion of water in the wood cells relative to the dry mass of the wood
Homogeneity	Uniform mixing of various substances
Hydrophobing agent	Water-repellent agents
Inhomogeneity	Uneven mixing of various substances
IVK	Plastics Films Industry Association
Adhesive joint	Layer between bonded (glued) materials
Coagulation	Clumping or agglomeration of the adhesive
Conditioning	Storage until weight balance (weight constancy) is achieved through moisture absorption under standard climate conditions
MDF/MDF-Board	Medium Density Fiberboard – MDF
Metamerism	Distinction of identical colors under different lighting conditions
Standard climate*	Defined conditions of temperature and humidity
Opacity	Transparency of materials
PVC = Polyvinyl chloride	Amorphous, thermoplastic material
Primer	Adhesion primer or bonding agent
PU-Dispersion = PUD	Water-based adhesive
Transverse tensile strength	Tensile strength perpendicular to the plane of the surface
Relative humidity	Amount of water vapor in the air at a given temperature
Room climate	Room conditions defined by air humidity, temperature, and wall surface temperature
Thermoplastic	Plastics that can be thermally deformed within a specific temperature range
T-profiler	Temperature measuring device specifically for thermo-forming presses
Separation	Separation or discharge of substances
Specification	Product specification with defined characteristics
Stabilizer	Additive for durability
Master sample	Original, first, or standard sample
Crosslinker	Component in PU dispersion to increase adhesive strength
Wärmestandfestigkeit	Measured value of adhesive durability under thermal exposure

***Standard climate:** 23 °C and 50% relative humidity

7 Legal Notice

Disclaimer:

The information contained in this specification sheet has been compiled to the best of our knowledge based on practical experience and testing, and reflects the current state of the art.

It does not constitute a guarantee of product properties nor does it establish a contractual legal relationship.

The suitability of the products for specific applications and processing must be verified by the user.

We reserve the right to make changes for the improvement of material properties and processing methods.

Use on other substrates and for applications other than those originally described must be evaluated on a case-by-case basis and coordinated with the respective manufacturers/suppliers to ensure suitability.

The recommendations and instructions regarding transport and storage of materials, as well as the mixing and processing guidelines of the respective manufacturers of the described materials, technologies, and services, must be strictly followed.

No guarantee is given for the accuracy or completeness of the content, and any liability is excluded.

We thank all participating partner companies for their support in the creation of this Quality Guide.

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Members of the 3D-Front Fabrication Initiative Group

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