Industrieverband Klebstoffe e.V.

IVK · Europe
Industrieverband Kunststoffbahnen e.V.

3D Furniture Front Production

Quality Guide

Foreword

Three-dimensional, thermally coated furniture fronts, 3D film fronts for short, represent an important segment in the furniture industry. These types of coated elements are primarily used in the bathroom and kitchen areas, but also on living room and bedroom furniture as well as smaller items of furniture.

The production of these furniture parts requires highly complex specialized knowledge with regard to the materials used as well as the overall manufacturing process in order to be able to produce high-quality workpieces. For this reason leading companies from the entire process chain, from raw material manufacturers to processors, united in 2007 to form an initiative group in order to compile this wealth of information to form a "Quality Guide", the first edition of which appeared in January 2009.

The great popularity and demand for this guide, and especially the new scientific and practical information, as well as the legislative changes and heightened requirements, have now motivated the initiative group "3D Furniture Front Production" to publish a 2nd revised and expanded edition.

The contents of the 1st edition were updated in accordance to the latest standards and requirements of the individual branches. The new chapter "Quality Assurance and Inspection of the Success of Laminations" was added to the 2nd edition. This explains to the user in detail the possibilities for inspecting manufactured parts, the informative value of the individual testing methods, and the influencing factors and dependencies of the materials used. A proper adhesive bonding process has only been conducted if a manufactured component meets the requirements in daily use and over the entire useful life of the product. In order to ensure this, appropriate quality control is essential.

The new adhesive standard DIN 2304-1 "Adhesive Bonding Technology – Quality Requirements for Adhesive Bonding Processes", which went into effect on March 2016 is another innovation. This standard is based on the "latest state of technology" and ideally supports the user as the process owner of adhesive processes. We therefore recommend that all adhesive users familiarize themselves with this new standard and its requirements and, if possible, integrate it into the existing QMS or at least adopt it as a quality assurance measure in the manufacturing plant. You can find more information on this in Chapter 6.

With these additions to the "3D Furniture Front Production Quality Guide", we describe the major aspects related to the manufacture of 3D furniture fronts and provide the users with a comprehensive informational publication.

The publishers will be happy to accept additional ideas.

April 2017

The 3D Furniture Front Production Initiative Group

The production of three-dimensional, thermally coated furniture parts requires highly complex specialized knowledge

Contents

1 Application

Description of application and purpose

Thermoplastic 3D furniture films are high-quality finishing materials that are used on thermoforming presses, with and without membranes, for three-dimensional lamination of fibreboard (e.g. MDF) for manufacture of elements/fronts for furniture and interior design.

They can be processed on all standard 3D presses which operate with heat, pressure, and vacuum, and which use a PUD adhesive to achieve a lasting adhesive bond on wood-based substrate.

2 Description of materials – 3D furniture films

2.1 Thermoplastic 3D furniture films

3D furniture films for use on thermoforming presses with or without membranes are single or multilayer film structures.

Their surfaces are protected by a light-resistant PUR/acrylate lacquer and can be optionally topped with a PE protective film (please note the reduced maximum storage period of 6 months). The adhesive formula and the adhesive strength of this protective film must be matched to the respective furniture film surfaces and tested for compatibility. The characteristics of the protective film must be optimized, especially for usability with 3D technology.

The reverse side of the furniture film should always be coated by the manufacturer with a high-quality primer to ensure secure adhesion of the 3D furniture film to the wood-based substrate.

IMPORTANT

The correct selection of film and adhesive system can greatly improve the quality of adhesion.

An even and optimum application amount for printing ink (for designs), paints, and primers on the back must be ensured by means of defined application systems.

The raw materials used and the manufacturing process are subject to constant monitoring and documentation, which are defined and documented by the respective quality management system of the manufacturer. They meet the current requirements specified by law or other regulations.

In addition, the raw materials for the film products must comply with the European Chemicals Directive "REACh" (Registration, Evaluation and Authorisation of Chemicals) No. 1907/2006.

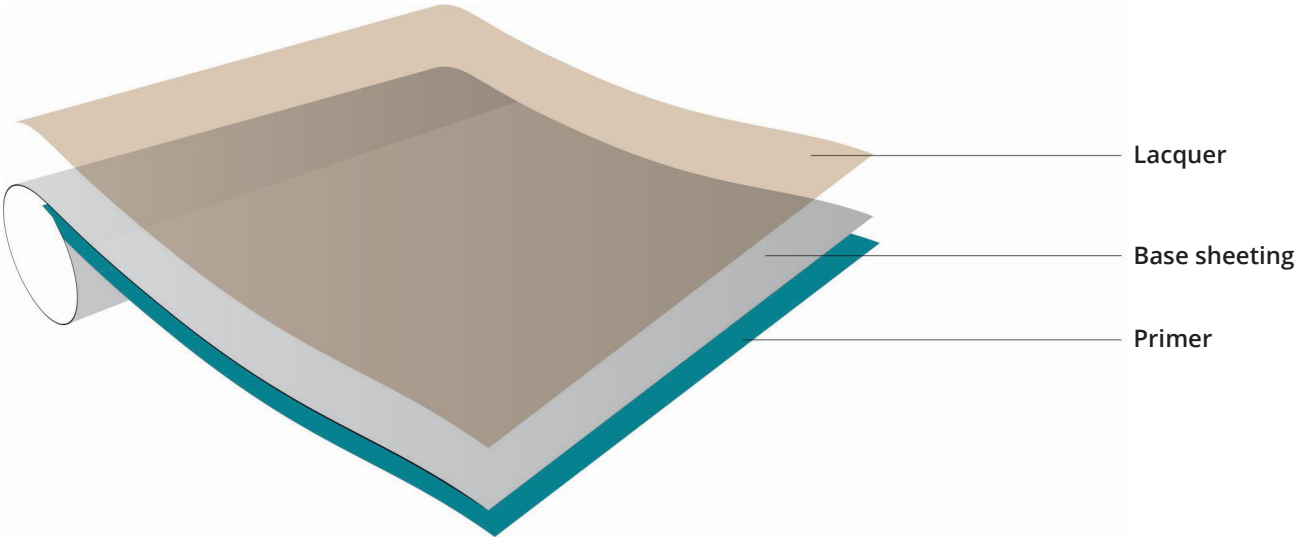
Information regarding REACh can be requested at any time from the film manufacturer.

IMPORTANT

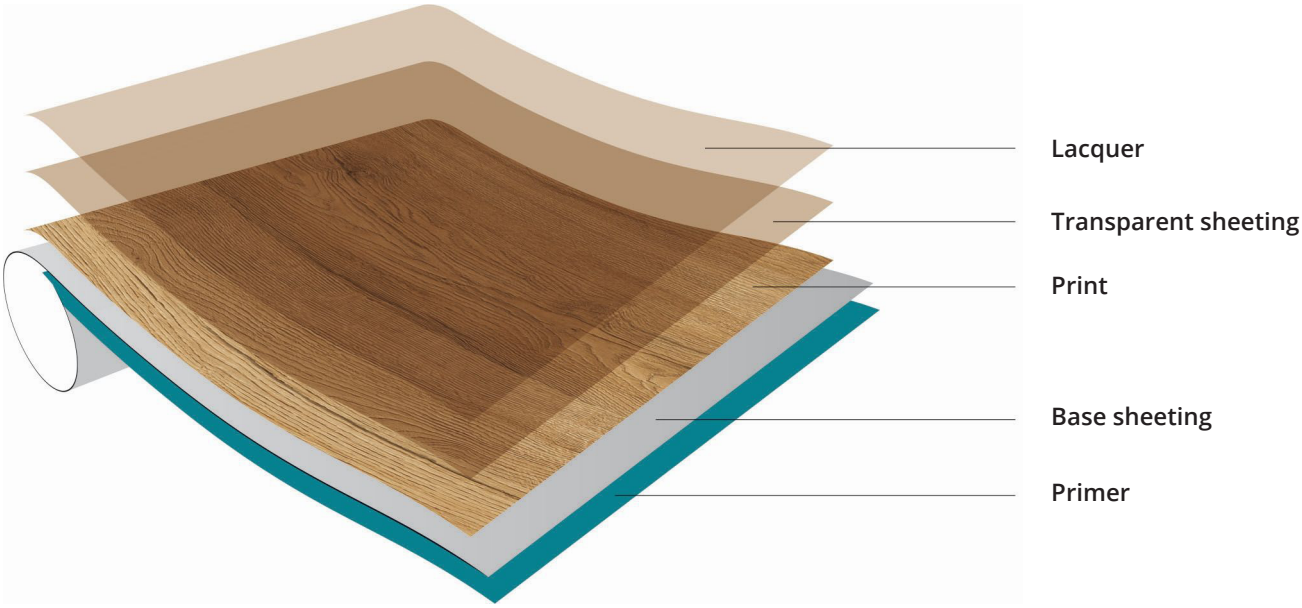
- Thermoplastic film with protective lacquer and reverse side primer
- Optional PE protective film possible
- Constant, optimum printing, painting, and primer coat with defined application systems
- Combination of film / adhesive determines quality
- Monitoring and documentation of raw materials and processes by the QM system
- Specifications pursuant to quality and testing provisions
- REACh conformity

2.1.1 Product structure of single-layer and multi-layer films

Single-layer (plain-colour) film



Multi-layer (printed design) film



2.1.2 Quality and testing provisions (mechanical characteristics)

Only films should be used for which compliance with the mechanical characteristics is monitored during the film manufacturing process and which are subject to traceable documentation. These mechanical characteristics include dimensional stability, embossing stability, and tensile strength.

The appropriate values and tolerances are specified in the quality and testing provisions pursuant to the requirement profile for 3D surfaces, listing the test methods and the respective DIN/ISO standard.

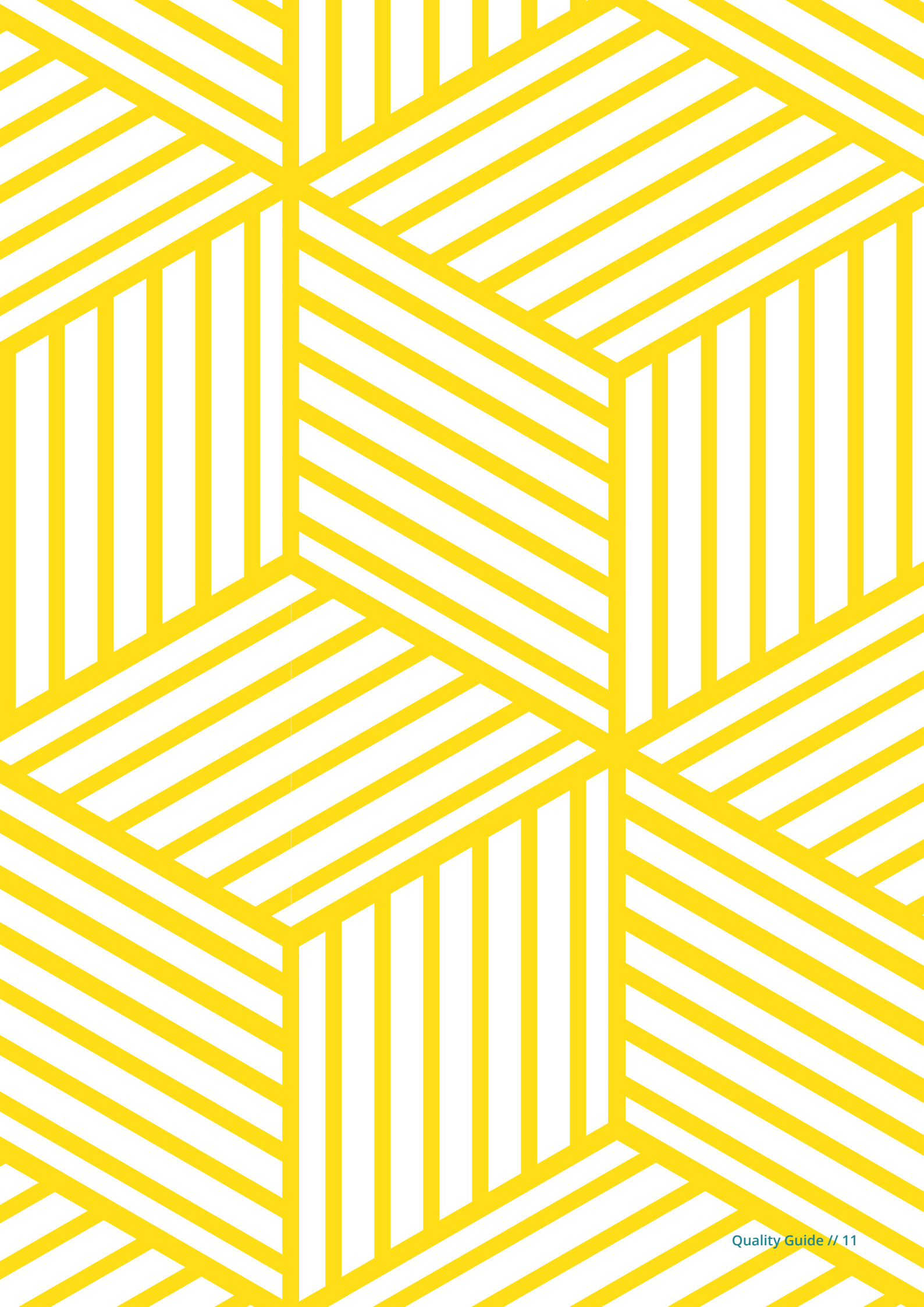
Note:
All tests are performed on non-laminated films.

Exception:
The tests for dry and moist heat resistance are performed on the finished furniture part.

Only the original product descriptions of the respective film manufacturer are binding.

2.1.3 Table of quality and testing provisions

Characteristics	Test standard	Data / tolerances			
		Classic surface	Structured surface	Supermatt surface	High-gloss surface
Thickness	DIN EN ISO 2286-3	0,30 – 0,50 mm +/– 7,5 %	0,30 – 0,50 mm +/– 7,5 %	0,30 – 0,50 mm +/– 7,5 %	0,30 – 0,50 mm +/– 7,5 %
Dimensional stability	DIN 53377 100°C, 10 min	longit max. - 5 % across max. + 2 %	longit max. - 5 % across max. + 2 %	longit max. -5 % across max. +2 %	longit max. - 8 % across max. + 3 %
Embossing stability	DIN 53377 120°C, 10 min	Change in gloss level < 5 GU	Change in gloss level < 5 GU	Change in gloss level < 5 GU	-
Light fastness	DIN EN ISO 105 B02	≥ 6	≥ 6	≥ 6	≥ 6
Chemical resistance	DIN 68861-1 DIN EN 12720	1 B	1 B	1 B	1 C
Scratch resistance	DIN 68861-4 DIN EN 15186	4D (> 1,0 - ≤ 1,5 N)	4D (> 1,0 - ≤ 1,5 N)	4E (> 0,5 - ≤ 1,0 N)	4 F (≤ 0,5 N)
Heat resistance, dry heat	DIN 68861-7 DIN EN 12722	7C (100°C)	7C (100°C)	7C (100°C)	-
Heat resistance, moist heat	DIN 68861-8 DIN EN 12721	8C (55°C)	8C (55°C)	8C (55°C)	-
Abrasion resistance	DIN 68861-2 DIN EN 15185	2D (> 50 U)	2D (> 50 U)	2D (> 50 U)	2 D (> 50 U)
Tensile strength	ISO 527-3-200	longit ≥ 40 N/mm² across ≥ 30 N/mm²	longit ≥ 40 N/mm² across ≥ 30 N/mm²	longit ≥ 40 N/mm² across ≥ 30 N/mm²	-
Gloss level tolerances	DIN 67530 60° measurement angle	< 15 ± 2 ≥ 15-30 ± 3	< 15 ± 2 ≥ 15-30 ± 3	< 15 ± 2 ≥ 15-30 ± 3	90 +/-5
Colour tolerances plain colour films	ISO 11664-4 Light D65/10 ° Measurement geometry d/8	Δ E ≤ 0,5 Δ L +/- 0,3 Δ a +/- 0,2 Δ b +/- 0,3	Δ E ≤ 0,5 Δ L +/- 0,3 Δ a +/- 0,2 Δ b +/- 0,3	Δ E ≤ 0,5 Δ L +/- 0,3 Δ a +/- 0,2 Δ b +/- 0,3	Δ E ≤ 0,5 Δ L +/- 0,3 Δ a +/- 0,2 Δ b +/- 0,3
Colour tolerances design films	Prototype comparison	Manufacture and visual evaluation compared with the prototype			
Metamerism index	DIN 6172 (D65 – AN 10)	≤ 0,30			
Opacity	over black / white	Δ E ≤ 0,35			
Error definition		Optical modifications are errors when visible to the naked eye in good lightning within 30 seconds at a distance of 50 cm			



2 Description of the materials – adhesives

2.2 Polyurethane dispersions (PUD)

PU dispersion adhesives (PUD) are reactive, water-based, special adhesives especially used for the lamination of decorative, thermoplastic films (based on PVC, polyester, etc.) using presses with or without membranes on suitable wood-based material panels (primarily MDF panels). These adhesives are available and used in two different supply forms.

- Two-component products (with crosslinker added separately).
- Single-component products (with integrated cross-linker).

IMPORTANT

The correct selection of film and adhesive system can greatly improve the quality of adhesion.

Field experience has shown that major improvements can be made when the reactive products are used:

- Improved adhesion to the film
- Improved adhesion to the substrate
- Higher heat resistance levels
- Increased resistance levels to water and steam

For these reasons, we only recommend the use of reactive adhesives.

IMPORTANT

- **Reactive, water-based special adhesives based on polyurethane**
- **Combination of film / adhesive determines quality**
- **Crosslinkers increase adhesion, heat stability, etc.**

2 Description of the materials – wood-based material panels

2.3 MDF (medium density fibreboard) wood-based material panels

The MDF panel is a wood-based substrate consisting of finest soft and/or hardwood fibres that is homogenous in longitudinal and transverse direction.

The surface is sanded and polished on both sides during manufacture and is melamine-coated on one side for lamination with 3D furniture films.

MDF deep-drawing grades are highly compressed with a fine fibre structure and especially suitable for the manufacture of 3D furniture fronts for all areas of the home.

MDF deep-drawing grade (characterisation)

Moisture content (EN 322)	6 ± 2 %
Tensile strength across the panel (EN 319)	≥ 0,75 N/mm2
Peel resistance (EN 311)	≥ 1,2 N/mm2
Hydrophobic agent	≤ 2 % solids on absolutely dry wood fibre (high-molecular FT wax)
Extract contents	≤ 1 % (without hydrophobic agent) on absolutely dry wood fibre (extraction in n-hexanes, 24 hours according to Soxhlet method)

Note: The deep-drawing grade is also referred to as deep-routing grade. Both terms are commonly used to describe the same MDF panel quality level for manufacturing three-dimensional laminated furniture elements.

IMPORTANT

- **Deep-drawing grade/deep-routing grade with highly compressed core**
- **Fine fibre quality, very fine sanding and excellent surface quality**
- **Superior physical properties**
- **High-quality hydrophobic wax (Fischer-Tropsch)**
- **MDF with very little extract content**

3 Transport, shelf life, storage – materials

3.1 Storage recommendations for 3D furniture films

- Store films in a dry indoor location
- Protect from direct exposure to sun or frost
- The ideal storage temperature is between 5 and 30 °C and relative humidity approx. 50 % = (ideal conditions)

The manufacturer recommends a shelf life of max. 18 months under ideal conditions. For films covered with a protective film, the recommended shelf life is max. 6 months. The recommendations of the respective film supplier should always be followed.

The films should not be subjected to exterior pressure during storage.

Before using condition the film at room temperature (minimum 18 °C) and 50 % relative humidity (= ideal conditions) for 3 days.

IMPORTANT

- Ideal storage temperature 5-30 °C
- Relative humidity approx. 50 %
- Store without external pressure
- Max. storage time 18 months
- With protective film max. 6 months

3.2 Storage recommendations for polyurethane dispersions (PUD)

- PU dispersion adhesives can be stored cool and dry (between 15–25 °C) in tightly closed original containers for approx. 6 months.
- The adhesive may only be exposed to lower temperatures for a short time during transport, however the temperature of the adhesive must not fall below +10 °C.
- Temperatures exceeding 35 °C during transport must also be avoided.
- When the products are supplied during the winter months, special attention must be paid to the temperature of the containers and samples which are taken to test for homogeneity. If anything out of the ordinary is noticed, a complaint must be immediately made to the shipping agent and the adhesives supplier must be likewise informed.

Goods delivered cold (<15 °C) must be warmed up for at least 48 hours at 20 ± 2 °C before use!

Note: In agreement with the adhesives supplier adhesives may be transported during the winter months using temperature indicators (ColdMarks or data loggers).

IMPORTANT

- Ideal storage temperature 15-25 °C
- Temperature during transport must be between +10 °C and +35 °C
- Max. storage time 6 months
- Check the adhesive temperature for deliveries during winter months!

3.3 Storage recommendations for MDF panels

- The moisture level with which the panels are supplied (6 ± 2 %) is maintained during storage when the standard storage conditions of 20 °C and 65 % humidity are met.
- If the relative humidity is higher, the MDF panel will absorb moisture (at 85 % rel. humidity to approx. 10 % panel moisture).
- If the relative humidity is lower, the MDF panel will dry out (at 30 % rel. humidity to approx. 4 % panel moisture).
- In general, MDFpanels must be protected against moisture.This also requires appropriate building installations (e.g. enclosed halls, no storage under lean-to roofs).
- In the event of climate changes, the acclimatization of an MDF panel will take 3–6 days depending on its thickness. If the panels are stacked, this may require at least 4 weeks.
- If panels are not correctly stacked, they may warp. The recommendations of the MDF manufacturer must be strictly observed. The number of spacers for level storage varies according to panel shape and thickness, and depends on whether or not additional cover sheets are used.

Note: The recommendations of the respective manufacturer with regard to transport and storage conditions must be strictly observed.

IMPORTANT

- **Wood moisture level 6 +/- 2 % (20 °C, 65 % rel. humidity)**
- **No outdoor storage**
- **Protect against direct exposure to sunlight, cold and moisture**
- **Store on a level surface to prevent warping**

4 Preparation of materials

4.1 Preparation – general measures

Before processing the materials, they must be checked to ensure that
- The materials meet the stated specifications.
- The materials were stored according to the conditions outlined above (temperature/humidity).
- The materials were conditioned according to the parameters outlined above (temperature/humidity).
- The climate conditions during manufacturing are controlled and maintained (temperature/humidity).

4.2 Preparation – 3D furniture films

Particular attention must be paid to ensure that
- The films meet the stated specifications.
- Decor, colour, degree of gloss and pattern of the films match the prototype.
- The primer has been applied with even coverage and full surface (visual inspection).
- The films are conditioned at ambient temperature before processing.

Notes regarding the use of standard or original samples:
The film manufacturer takes so-called original or standard samples from the first regular series production that was authorized by the customer/designer, etc., which are used as reference standards for subsequent repeat production runs in order to evaluate the visual characteristics.

The film manufacturer shall provide these original or standard samples to the customer for his incoming goods inspection, with which each newly delivered batch can be compared with respect to the visual characteristics. We recommend requesting these standard samples if these are not automatically provided to you and using them for visual incoming goods inspection.

In case of questions or any complaints, always list the **date of receipt of the delivery, material, and batch number** as these three sets of data completely ensure traceability. The material and batch numbers or the **roll ID (identification number)** is normally found on the roll label on the outside of the roll and in the centre of the roll.

Testing equipment for checking colour and gloss level

For the objective and reproducible assessment/measurement of gloss level and colour, the film manufacturers recommend the use of so-called spectral photometers. In case of printed designs, always ensure that the same section of design is selected. Here, it is helpful to coordinate the selected testing equipment with the film manufacturer.

4.3 Preparation – MDF

With regard to the wood-based material (e.g. MDF), particular attention must be paid to ensure that

- The MDF panels meet the individual specifications
- The residual moisture content of the MDF panels is correct (6 ± 2 %)
- The MDF panels are neither freshly pressed nor too warm (> 18 and < 35 °C panel temperature)

Cutting / Routing

- All tools used on MDF panels must be well sharpened.
  - Cutting on the panel saw
  - Routing on a CNC processing centre
  - Nesting machines
  - Edge profilers
  - Double-end profilers
  - Other finishing tools
- MDF panels or cuts must be worked at the defined speed in order to prevent chafing or cracked edges and profiles.
- No substances such as oil and/or products containing oil/silicone may be sprayed onto the panel or components.
- After routing, the parts must be:
  - stored level to prevent warp
  - stored in a dry and temperature-controlled room (observe ideal storage conditions!).
  - conveyed to the glue station only in a dust-free and clean atmosphere

IMPORTANT

- **Only use sharp tools**
- **Observe tooling speeds**
- **Do not use oily or silicone substances**
- **Store finished parts straight and level, clean and dry**

4.4 Preparation of the PU dispersion adhesive

With regard to adhesives, particular attention must be paid to ensure that

- The PU dispersion adhesives fulfil the stated specifications.
- A visual inspection for inhomogeneities (thickening, separation) is performed.
- The appropriate crosslinker is added to a two-component system.

4.4.1 Check of the adhesive container before use

- Perform a visual inspection for inhomogeneity, such as thickening or separation, etc. (if found, it is imperative to contact the adhesive supplier before use).
- Stirring before use is recommended, but normally not required.

4.4.2 Adding the crosslinker and homogenizing when 2-component products are used

A general differentiation is made between:

- Single-component, PU dispersion adhesives:
  - These products can be used as supplied.
- Two-component, PU dispersion adhesives:
  - Before use, the appropriate crosslinking agent must be added in the required dosage. The corresponding technical data sheet indicates which crosslinker/adhesive combination should be used.

The crosslinker must be added slowly while stirring, using a mechanical agitator until the mixture is homogenous. Foaming must be prevented.

In order to achieve a perfect blend of 500 g crosslinking agent in 10 kg PU dispersion adhesive, a mixing time of at least 5 minutes is required. Please also comply with the recommendations of the adhesive manufacturer.

- If the crosslinking agent is added too fast, mixing will be inadequate.
- The crosslinker will not be dispersed adequately if
  - The mixing unit is unsuitable or inadequate for the batch size
  - The mixing time is too short

4.4.3 Pot life considerations for 2-component products

- The reactivity of the crosslinker is adjusted to allow the processor a sufficient pot life for processing.
- As a rule, the adhesive mix should be used up within 4–6 hours after crosslinker addition.
- The optimum result may not be reached if the pot life is exceeded.

IMPORTANT

- **Always comply with the manufacturers' instructions with regard to storage, mixing instructions, pot life, application equipment, and instructions for use**
- **Observe pot life: use 4 - 6 hours after adding the crosslinker**
- **Mix only as much as can be used up within the pot life**
- **Check and maintain the room climate**
- **For two-component systems, add the crosslinker slowly and stir in homogenously!**
- **Ensure homogenous distribution of the crosslinker**
- **Note mixing time! Mix for at least 5 minutes for 500 g of crosslinker in 10 kg of adhesive**
- **Use a mechanical agitator**
- **Prevent foaming**
- **After the completion of the work, use water to thoroughly clean all parts and equipment that have come into contact with adhesive**

5 Processing of materials – manufacturing process

5.1 Adhesive application

5.1.1 Information on adhesive application units

- In order to minimize mechanical stress on the PUD adhesives, a pressurized vessel should be used to convey the adhesive from the supply tank to the spray gun.
- All parts exposed to the dispersion should be made of stainless steel (German standard V4A) (in accordance with DIN EN 10027 – material number 1.4571 or higher quality) or e.g. Teflon®, polyamide, PP or other inert plastics.
- Avoid contact with base metals (like zinc, brass, copper), which may cause the adhesive to coagulate, leading to uneven application and clogging of nozzles and ductwork.
  - Nozzle diameter: 1.5 – 2.2 mm
  - Material pressure: 1.0 – 3.0 bar
  - Atomizer pressure: 3.0 – 7.0 bar
  - Air cap: 2.2 – 2.5 mm
- When the product is pumped from a pressurized container, the following recommendations apply:
  - For a 4 m long hose with an interior diameter of 8 mm, the material pressure should be approx. 1 – 2.5 bar.

Note: When using two-component systems, the pressurized vessel should ideally be equipped with an agitator.

Cleaning: After work completion, use water to thoroughly clean all equipment exposed to adhesive.

5.1.2 Adhesive application – MDF substrate, temperature and adhesive amount

The MDF components must be prepared very carefully.
- The surface must be absolutely clean and free of dust.
- Even the slightest contaminations or inclusions of dust particles may show up on the film surface after lamination.
- The adhesive is usually sprayed onto the MDF substrate at room temperature (>18 °C).
- Edges and routed areas are surfaces with high absorption so the PU dispersions may penetrate more easily and become completely absorbed. This means that these areas must receive two adhesive coats, guaranteeing a continuous, closed and smooth adhesive coating.
  - The first coat (gap filling) serves solely to close the pores,
  - After an intermediate drying interval of approx. 1 minute at room temperature, a second coating is applied with the adhesive amount required for a permanent adhesive bond.

The minimum temperature for substrates and ambient air must not fall below 18 °C, while temperatures above 35 °C should also be avoided. The adhesive coating amount required depends very much on the quality of the MDF and its absorbency and should not fall below the following:
- Application to the surface:
  50 – 70 g/m² wet (20 – 30 g/m² dry)
- Application to the edge:
  80 – 130 g/m² wet (35 – 55 g/m² dry)

Note: In certain cases, the application amount may need to be increased! The adhesive coating on the substrate must spread easily when wiped with a finger. After drying, the film must appear glossy. As an added precaution, we recommend performing random weight checks and/or layer thickness measurements of the application amount at least once daily and after every change to the process parameters.

IMPORTANT

- **Surfaces must be clean and dust-free**
- **Adhesive applied to MDF conditioned to room temperature (> 18 °C)**
- **Edges and open profiles absorb more adhesive – 2x adhesive coats**
- **1st for closing the pores**
- **allow to dry for 1 minute**
- **apply 2nd coat**
- **Application amount depends largely on the MDF quality**
- **Check the application amount – visually and by means of weight checks/layer thickness measurements**

5.1.3 Drying of the adhesive coating

After adhesive application, the following factors must be observed:

- The adhesive must be allowed to dry completely under dust-free conditions. Only then can thermoactivation take place in the press.
- Depending on room conditions (temperature and humidity), the MDF parts will be dry enough to go into the press after about 30 minutes in an ambient environment (approx. 20 °C and 50 % relative humidity).
- Drying times can be reduced substantially if the precoated parts are passed through a hot air tunnel.
- When drying in a hot air tunnel, followed by storage, the surface temperature may not exceed 35 °C to prevent premature or accelerated crosslinking of the adhesive.
- With adhesives that seal at low temperatures (< 55 °C), a surface temperature of 30 °C must not be exceeded.
- The major factor to achieve fast drying is the airflow (volume) and not the temperature. This applies to the reactive two-component as well as to the single-component reactive PU dispersion adhesives.
- After drying in a hot air channel, immediate processing/laminating in the press is necessary for the reactive dispersion adhesives.
- Extended waiting times after drying must be avoided with reactive polyurethane dispersion adhesives as a premature chemical linking cannot be ruled out. Optimum bonding between the adhesive and film is only possible in a non-bonded condition.

Note: The recommendations of the adhesive manufacturer must be observed.

IMPORTANT

- **Sufficient drying under dust-free conditions**
- **Furniture fronts with glue applied are ready for pressing after about 30 minutes (at approx. 20 °C/ 50 % relative humidity) depending on ambient climate**
- **Reduction of drying time possible by using the hot air channel**
- **In case of drying in the hot air channel followed by storage, the surface temperature should not exceed 35 °C**
- **Air volume is important, not the actual temperature**
- **Immediate further processing necessary after channel drying**
- **Long waiting times before lamination must be avoided**

5.2 Pressing

5.2.1 Press systems / parameters

Below are outlined the specific characteristics of the various press systems found in the field:

- Specific characteristics for use on **presses with a membrane:**
  - The membrane serves as a medium for the transferral of heat.
  - The film is shaped by applying a vacuum and pressure onto the membrane.
  - After shaping the film is cooled and separated from the membrane by means of pressure.
- Specific characteristics for use on **presses without a membrane:**
  - In case of standard films, the heat is transferred directly from the hot plate to the film.
  - In case of films with a protective film, heat is transferred by means of radiant heat.
  - The film is shaped over the work piece only using vacuum and pressure.

5.2.2 Preparing the pressing cycle

The following parameters must be checked before processing:

- Type of film (raw materials basis, structure, condition)
- Film thickness
- Colour and type of surface (e.g. standard or high gloss)
- Adjust the press parameters under consideration of the type of film, type of adhesive and routing design of the parts
- Condition of the glued components (adequate ventilation and maintenance of the time window after adhesive application and parts temperature)

5.2.3 The laminating process

Laminating is performed in two steps:
Step 1: Preheating
Step 2: 3D forming

5.2.4 Temperature of the hotplates and/or membrane

The setting depends on the film and adhesive type.

5.2.5 Preheating time and procedure

- Before the press is completely closed, it pauses briefly in order to preheat the film.
- After complete closure, the film is heated by lifting or pressing it on the upper hotplate or membrane (contact heat).
- The heat must be applied to the entire surface of the film.
- Due to radiated heat, the temperature level of the work pieces may also be raised on the surface.
- Preheating of the film can also be achieved by heat radiation.
- The temperature of the hotplate or membrane and the preheating time influence film preheating.
- The preheating time must be adjusted to accurately match the activation temperature in the glue line as recommended by the adhesive manufacturer for the particular PU adhesive.
- The glue line temperature depends on the preheating time, the temperature setting of the hotplate or the membrane, the temperature of the MDF plate and the film, and the heat capacity and heat conductivity of the film.
- The required minimum activation temperature varies by adhesive and usually is approx. 55–80 °C (temperature in the glue line).

Note: Using a suitable measuring method (temperature strips, contact reading equipment, data logger, etc.), the surface temperature of the film and the glue line at the edges and at the surface should be monitored and documented along with the other process parameters. Modern data loggers not only make temperature measurements possible but can also record contact pressure by means of pressure sensors.

If the surface or glue line temperatures are insufficient, the machine parameters (e.g. preheating time, press time, applied pressure, hotplate/membrane temperature) must be optimized and tested accordingly by the user.

5.2.6 3D forming

- The film is shaped by vacuum from below and pressure from above.
- The film can be separated from the hotplate under vacuum, directly or delayed, in order to reduce the air volume before pressing.
- 3D forming is subject to temperature, vacuum time, applied pressure, and pressing time.
- The settings of these parameters depend on the film and adhesive used as well as the design of the parts.
- The pressing time has to be adjusted in such a way that at the end of the pressing time, the temperature of the glue line is well below the softening range (usually at approx. 50 °C) of the adhesive (at least 10 °C).

Apart from the major parameters listed here, there are also additional parameters that may apply to special applications. These parameters are listed in the manuals of the individual press manufacturers; or may be obtained by contacting the individual press manufacturer.

IMPORTANT

- **Set the preheating time accurately so that the film is level and the adhesive-specific activation temperature in the glue line is reached after closing**
- **Ensure full contact between film and heat source**
- **Set the press time so that the glue line temperature before opening of the press is clearly below the softening range of the adhesive**
- **Pressing parameters depend on the films, adhesive, and design of the work pieces used and must be defined by the user for series production.**

5.2.7 Cutting and trimming

- The film excess should only be trimmed (manually or automatically) after a sufficient cooling period in order to prevent shrinkage. The time required depends upon the characteristics of the film and adhesive and must be defined by the user.
- A sharp tool must be used to prevent mechanical separation of the film from the adhesive while trimming. The film excess must be cut off with a shearing cut against the glue line.
- The adhesion of the film should be checked at regular intervals by a peel test and documented. This is done by cutting a triangular piece of film from the surface to the edge, then peeling it off and checking its strength characteristics.
- The front pieces should be stored for 3 days at room temperature before being released for shipping.

5.2.8 Crosslinking time

- Final crosslinking for the two-component as well as the single-component reactive PU dispersion adhesives is only reached after about 7 days of storage at room temperature (approx. 20 °C).
- Depending on the adhesive, type of film, film thickness, design, and shape of the MDF part and test method used, heat resistance values of 80-100 °C can be reached if all the recommendations previously mentioned are observed.

6 Quality assurance and control

Numerous companies have introduced a quality management system (QMS) in the past 20 to 25 years. The QM system that follows the stipulations of ISO 9001 is widely used. Most management systems require systematically controlled operating processes with consideration for the requirements of all parties involved. Often, these systems are oriented toward constant performance improvement (avoidance of errors, etc.) of the organisation. However only the introduced management system is certified, not the specific contents or technologies within an organisation.

As the process owner, each manufacturer of 3D furniture fronts should define quality assurance measures in ongoing production in its own interest and perform appropriate checks. This is the only way to ensure that the manufactured products meet the requirements in daily use.

Regulations and standards (such as DIN 2304-1) have already been mentioned in the foreword. The manufacturer of the 3D fronts has sole responsibility for determining which requirements a finished part must meet in detail and which test methods are appropriate to confirm these requirements. The tests listed in the following are an example of the variety of possible tests used, but in no way represent a complete list. Naturally, the 3D Furniture Front Production Initiative Group will be happy to provide advice.

We would once again like to point out the new adhesive standard DIN 2304-1 “Adhesive Bonding Technology – Quality Requirements for Adhesive Bonding Processes”, which has been in effect since March 2016. This standard supports users not only in the implementation of proper adhesion, but also offers them much more.

The most important elements of DIN 2304-1 that must be complied with are:

1. Classification of the adhesive bond by safety classes
2. Utilization of adhesive technicians and adhesive supervisors
3. Adaptation of the manufacturing environment
4. Verification management, documentation

6.1 Tests in ongoing production

6.1.1 Adhesive characteristics directly after coating (pressing procedure)

At the beginning of each shift or after each change in the press parameters, a visual test should be performed and the adhesive bonding strength of the freshly laminated film on the MDF substrate tested. The part cut from the film (individual piece) should be stored at room temperature for 10 minutes in order to cool off before testing.

In addition to a general surface evaluation (area / edge / profiled areas), the visual test should also include an assessment of the narrow surfaces in the transitional area to the rear coating wood-based material panel (film lying clearly and smoothly without noticeable shrinkage). The quality of the film reshaping and adhesive bonding around cutouts in the surface area can be checked by appropriate separation of the furniture front.

In order to check the bond strength of the created adhesive bond, the film is cut from the surface to the edge in the form of a triangle and pulled off in the direction away from the surface. Often in this test one observes a cohesive break in the not fully crosslinked adhesive film. However, this is an indication for good wetting on the backside of the film, which is a fundamental requirement for adhesion. If the film can be pulled off with adhesion breakage (the adhesive remains on the MDF substrate), the pressing parameters (such as pressure, temperature, time, etc.) should be checked and adjusted. This test should preferably be performed on all four sides of the furniture piece.

IMPORTANT

The original condition of the test units should be documented before each test. Depending upon the individual test, reference measurements (zero samples) should be performed and documented for comparative evaluation.

6.2 Tests on finished parts

IMPORTANT

All tests will only be performed after complete linking of the adhesive and storage of at least 7 days at room climate.

Complete linking of the reactive polyurethane adhesive is reached after approximately 7 days of storage at room climate (at approx. 20 °C). Conducting further tests and evaluating the performance of the adhesion is only useful after this period. The following test methods were established for various requirements and are also sometimes required or used in a country-specific context.

6.2.1 Adhesion test at room temperature

The adhesive bond strength test is performed by means of cutting out triangles as in the method previously described. However peel tests on test units with defined dimensions (e.g. on cut-out 2 cm wide sections) and subsequent peel testing at a 90° angle with a spring scale or preferably with a roll peeling device and automatic testing equipment give more objective results.

6.2.2 Adhesion test in cold temperatures

The part or the sections to be tested are stored in a suitable refrigerator or freezer at a defined temperature (e.g. +5 °C or -10 °C) for 24 hours and then tested immediately.

The adhesive bond strength test is performed by means of cutting out triangles as in the method previously described. However, peel tests on test units with defined dimensions (e.g. on cut-out 2 cm wide sections) and subsequent peel testing at a 90° angle with a spring scale or preferably with a roll peeling device and automatic testing equipment give more objective results.

6.2.3 Cold-Check test

The part to be tested is subjected to constantly changing temperatures in a climate-controlled cabinet.

- 1 cycle consists of
  - 4 hours 50 °C and
  - 4 hours -25 °C.

Normally, 150 cycles are completed and then an adhesive bond strength test is performed after 24 hours of conditioning at room climate. The adhesive bond strength test is performed by means of the method previously described.

6.3 Testing heat stability

IMPORTANT

All tests will only be performed after complete crosslinking of the adhesive and storage of at least 7 days at room climate.

In Europe four country-specific test methods have been established, which are explained in more detail in the following section.

6.3.1 Germany – pursuant to the AMK method, leaflet 001

The part to be tested is subjected to the following temperatures in a suitable convection oven and visually inspected and evaluated after each hour.
• For 1 hour at 50 °C
• Then 1 hour at 60 °C
• Then 4 hours at 75 °C

6.3.2 Italy – pursuant to the CATAS method

The parts to be tested are subjected to the following temperatures in a suitable convection oven. The parts are visually inspected and evaluated after each test phase.
1st phase: 4 hours at 40 °C
- Then 5 minutes at room temperature
- Then 4 hours at 50 °C
- Then 16 hours at room temperature

2nd phase: 4 hours at 60 °C
- Then 5 minutes at room temperature
- Then 4 hours at 70 °C
- Then 16 hours at room temperature

3rd phase: 4 hours at 80 °C
- Then 5 minutes at room temperature
- Then 4 hours at 90 °C

6.3.3 Great Britain – pursuant to BS 6222 Part 3 – Clause 8.3 (FIRA method)

The part to be tested is subjected to the following temperatures in a suitable convection oven:
• 84 ± 12 hours at 40 °C
• 84 ± 12 hours at 50 °C
• 84 ± 12 hours at 60 °C
• 84 ± 12 hours at 70 °C

This test sequence is sometimes expanded by an additional 84 ± 12 hours at 75, 80, and 90 °C.
The parts are visually inspected and evaluated after each test phase.

6.3.4 France – pursuant to the CTBA method

The part to be tested is stored in a climate-controlled cabinet under the following conditions.
One cycle consists of:
- 24 hours at 25 °C and 85 % rel. humidity
- 24 hours at -12 °C
- 24 hours at 70 °C and 25 % rel. humidity
- 96 hours at 20 °C and 65 % rel. humidity

This cycle is repeated three times and the part is then visually evaluated and assessed.

6.4 Moisture and climate resistance test

IMPORTANT

All tests will only be performed after complete crosslinking of the adhesive and storage of at least 7 days at room climate.

Moisture and climate resistance are tested according to AMK leaflet 005 (Kitchen Furniture, Moisture, and Climate Resistance) which contains three modules.

6.4.1 Application of water vapour

The part to be tested is mounted into a suitable apparatus (see AMK leaflet) in water vapour for 30 minutes. The part is then dried for 30 minutes at room climate outside of the apparatus. This cycle is repeated three times and an evaluation and assessment is performed after each cycle.

6.4.2 Moist climate resistance for export (simulation for transport and extreme climates)

The test is performed in a suitable climate-controlled cabinet at 40 °C and 85 % relative humidity for a period of 14 days. Evaluation and assessment is performed after 4, 7, 10, and 14 days.

6.4.3 Resistance to alternating climate

The test is performed in a suitable climate-controlled cabinet.

One cycle consists of:
- 0.5 hours cooling to -20 °C
- 1 hour with constant temperature of -20 °C
- 0.5 hours heating to 20 °C
- 3 hours of storage at 20 °C and 85 % relative humidity
- 0.5 hours heating to 60 °C
- 3 hours of storage at 60 °C and 55 % relative humidity
- 0.5 hours cooling to 20 °C

This cycle is repeated ten times. Evaluation and assessment is performed after 3, 5 and 10 cycles.

Numerous ring trials have shown that for a recently manufactured 3D front even good (high) heat resistance and compliance with the test requirements described above are not synonymous with durability or long-term resistance of an adhesive bond. This is true especially but not solely for parts that are subject to more demanding climate conditions (increased temperature and humidity) such as kitchen and bathroom furniture or furniture in subtropical climate zones.

6.5 Long-term resistance test – simulated ageing resistance

IMPORTANT

All tests will only be performed after complete crosslinking of the adhesive and storage of at least 7 days at room climate.

In this connection, numerous studies and tests were performed during the past few years in order to simulate the interactions between the film, adhesive, and wood-based material substrate with an eye on simulating the longevity of a manufactured component. The goal of these examinations was to find a meaningful test method that delivers reproducible results in an accelerated ageing test. Here it was found that interactions between ingredients in the MDF and the adhesive particularly affect the long-term resistance of a manufactured 3D front.

With the methods listed below, clear conclusions can be drawn regarding the strength of an adhesive bond in a given lamination of MDF, adhesive, and film.

6.5.1 Long-term resistance in a changing climate

- 100 days at 40 °C switching every 12 hours between 40% and 80% relative humidity and subsequent testing and evaluation of the heat resistance
- visual inspection after 33, 66, and 100 days
- after 100 days
  1. adhesive bond strength test according to section 6.1.1
  2. heat resistance pursuant to 6.3.1 (AMK method MB 001)

6.5.2 Long-term climate resistance in a warm/moist climate

- 56 days at 50 °C and 80 - 85 % of relative humidity and subsequent testing and evaluation of heat resistance or peel strength (after 28 and 56 days)

Some evaluation and assessment plans can be found in the test provisions of the methods listed previously. With the variety of materials used (MDF, film, adhesive) and the various specific characteristics, however, a general assessment plan, which covers all possibilities from a simple 3D front, a milled frame door, or a complex deeply milled front, is practically impossible. The members of the 3D Initiative Group will be happy to support you in the introduction and interpretation of appropriate test methods in your operation and for your application.

7 Glossary

additive
auxiliary agent

adhesion
adhesive force between contact surfaces of two materials

AMK
Arbeitsgemeinschaft Die Moderne Küche e.V

application process
process or method of application/coating

coagulation
agglomeration, lumping of the adhesive

conditioning
storage until weight is balanced (constant weight) by water absorption in normal climate

crosslinker
material for forming intermolecular bonds of polymer chains and increasing rigidity

data logger
temperature and/or pressure measuring equipment, particularly for thermoforming presses

degree of gloss
measurable value of surface gloss

filler
auxiliary in film formula

FT wax
Fischer-Tropsch wax

glue line
layer between bonded (glued) materials

hard PVC film
PVC film without or with low proportions of plasticizers

heat stability
resistance of a bond when subjected to heat at a set temperature, stress, and stress period

homogeneity
perfect mix of different substrates

hotplate
structural component in the thermoforming press to create heat

hydrophobing agent
water-repellent agent

inhomogeneity
uneven mix of various substances

IVK
Industrieverband Kunststoffbahnen/
Industrieverband Klebstoffe

metamerism
distinction of equal colours under different types of light

MDF/MDF panel
medium density fibreboard

normal climate
defined conditions: temperature/humidity
(20 °C / 50% rel. humidity or 23 °C / 65% rel. humidity)

opacity
transparency of materials

original sample
original, initial, or standard sample

peel strength
adhesive bond strength between different layers
pot life time period, in which a multi-component adhesive must be used up after mixing primer
material to improve adhesion and/or strength of an adhesive bond

protective film
PE-film for protecting the film surface

PU dispersion = PUD
water-based adhesive

PVC = polyvinylchloride
amorphous, thermoplastic synthetic material

quality management system
method for ensuring process and product quality

REACh
European Chemicals Directive

relative humidity (RH)
water vapor content in the air at a particular temperature

room climate
room climate determined by humidity, air temperature, plus surface temperature of the walls

separation
segregation, substances splitting apart

softening range
condition, in which an adhesive transitions from a solid into a soft state

specifications
product description with defined characteristics

spectral photometer
measuring equipment for checking colour and gloss levels

stabiliser
additive for the resistance of chemical compounds
thermoplastic material polymer or copolymer that softens when heated and hardens when cooled

transverse tensile strength
tensile strength across superficial expansion
wood moisture percentage of water in wood cells with regard to dry wood mass

8 Legal information

Disclaimer

The information contained in this Quality Guide has been compiled to the best of our knowledge and based on practical experience. It reflects the actual state of the art.

It does not represent any guarantee of product properties and does not substantiate any contractual legal relationship.

The processor must test the products for suitability before using and processing in his factory.

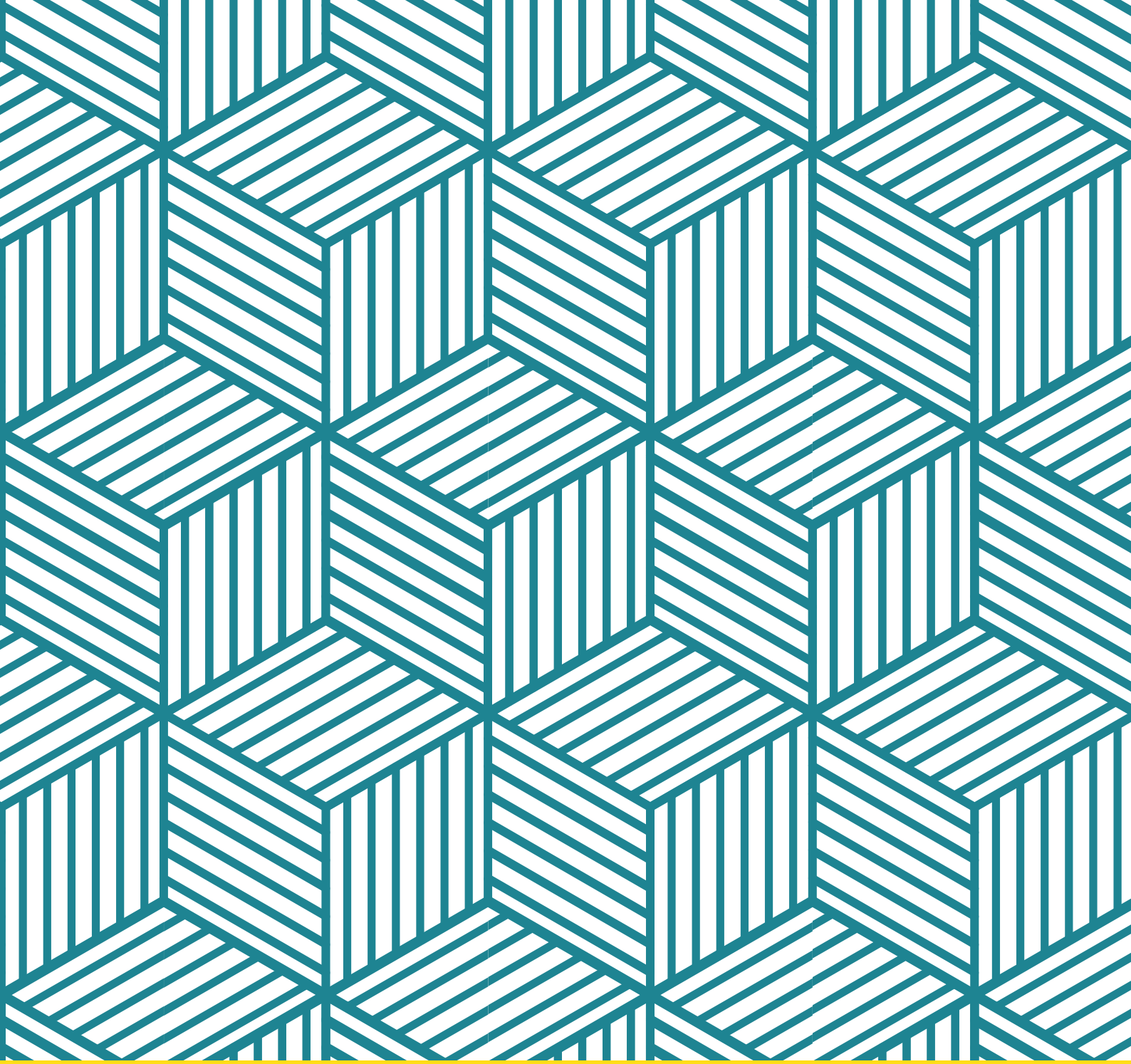
We reserve the right to improve the material properties and processing parameters.

Any use of the products on substrates and for areas of application other than those listed above must be tested in each case and their suitability must be agreed upon prior to use with the individual supplier/ manufacturer.

The recommendations or instructions concerning transport and storage of the materials, including those concerning mixing and processing, as provided by the respective manufacturers of the described materials, technologies and services, must be observed unconditionally.

We are not liable for completeness and accuracy of the contents. We assume no liability.

Our thanks go to all partner companies who lent their support in compiling this Quality Guide.



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