

Bonds in Wooden Window Fabrication

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1 Wooden Window Fabrication

This technical information sheet shall highlight the special requirements for bonds on wooden and composite windows. Since in the German speaking area almost exclusively windows have a non-structural function according to DIN 1052-10, the special requirements for load bearing elements are not included in this context.

In 1998, an ift-guideline "Verklebung an Holzfenstern, Teil I und II" (Bonds on Wooden Windows, Part I and Part II) was published. This guideline was prepared in cooperation with the Technische Kommission Holzklebstoffe (TKH) (Technical Committee on Wood Adhesives) of Industrieverband Klebstoffe e.V. (German Adhesive Association) It describes requirements for the adhesive, taking into account the combination of temperature and moisture resistance of the bonds.

Part I of this guideline describes the requirements for lamination and finger joints of wooden window profiles. For these applications, the guideline recommends an adhesive complying with durability class D4 according to DIN EN 204 and in addition having a heat resistance of more than 7 N/mm² at 80 °C according to DIN EN 14257. In addition, the guideline describes selection of timber types as well as processing parameters, e.g. application quantity and bonding pressure.

In November of 2002, the ift-guideline HO-10/1 "Massive, keilgezinkte und lamellierte Profile für Holzfenster – Anforderung und Prüfung" (Solid, finger-jointed and laminated profiles for wooden windows – Requirements and Testing) was published. This guideline can be used as a basis for internal and external quality controls of wooden window profiles.

Part II regulates the bonding of frame joints. Alternatively, D3 or D4 adhesives according to DIN EN 204 can be used for window and frame corner joints. The adhesive system must also have a high heat resistance in accordance with DIN EN 14257 of more than 7 N/mm² at 80 °C. Construction of mortise and tenon joints as well as the individual steps for bonding are additional parts of the ift-guideline.

In order to evaluate the efficiency of frame corner joints, the ift-guideline FE-08/1 "Rahmeneckverbindungen für Holzfenster – Anforderungen, Prüfung und Bewertung" (Frame corner joints for wooden windows – Requirements, Evaluation and Testing) was published. This guideline applies to all commonly approved standard frame corner joints for wooden windows, e.g. mortise and tenon and/or dowel joints as well as for other joining systems such as detachable frame corner joints using mechanical joining elements.

The guideline defines how the applicability and durability of the frame corner joints can be determined in lab tests. With these tests it shall be evaluated to what extent the existing requirements regarding strength, permanent impermeability and dimensional stability are met in simulated aging processes. The results of these tests involve the following aspects:

- Moisture absorption,
- Joint impermeability in the corner sections,
- Bond strength of window corner before and after aging process.

The guidelines and regulations cited in this information sheet represent the current state of the art. The majority of manufacturers apply these rules to ensure usability of wooden windows.

A vital factor for the quality of the bond and consequently the window itself is correct selection and preparation of all materials, in particular the timber.

2 Laminated Profiles (Window Scantlings)

More and more frequently in wooden window fabrication, profiles are manufactured

- with laminated cross-sections,
- with longitudinal connections by finger joints. This applies for connections of the individual lamellas as well as for the overall cross-section.

The ift-guidelines intend to underline that usability of wooden window profiles is only achieved when the correct adhesives are used and the required processing

steps are complied with. The guidelines are based on experience with timber types commonly used for window fabrication, such as spruce, pine and meranti wood. For other timber types, modified woods and composite materials, the construction must be tested for usability.

2.1 Requirements for Bonds

Durability and weather resistance of the profiles determine the requirements for adhesive strength. Durable adhesive strength is a prerequisite for an adequate service life use of the window.

Lamination and longitudinal connection of finger joints result in better wood utilization and optimization of timber quality in profiles.

Construction, processing, and adhesives must meet the following requirements in order to achieve this objective:

- The individual lamellas must be safely and permanently connected. To achieve this, glue seams of lamination shall not be directly exposed to weather influences.
- The resulting glue seams must be permanently impermeable to prevent moisture entering the joints.
- The glue seams of the finger joints must be impermeable and show sufficient strength when exposed to weather influences even when not directly exposed, e.g. for middle lamellas.

Wooden window profiles, whether solid, laminated and/or finger-jointed, are essential parts of the window. Possible damage from incorrect bonding challenges the usability of the wooden window.

2.2 Requirements for Adhesives Used

Requirements for adhesives for laminated profiles and finger joints:

- Must comply with durability class D4 according to DIN EN 204,
- Heat resistance of bond $\geq 7 \text{ N/mm}^2$, test according to DIN EN 14257

2.3 Processing of Timber and Adhesive

- The timber used must be suited for window construction. For further information, please refer to VFF information sheet HO.06 Part 1 "Holzartenliste" (Timber Type List) "Holzarten für den Fensterbau" (Timber Types for Window Construction).

- Minimum raw density:
hardwood $\geq 0.45 \text{ g/cm}^3$ at 15 % wood moisture
softwood $\geq 0.35 \text{ g/cm}^3$ at 15 % wood moisture
- The admissible wood moisture before processing is $13 \pm 2 \%$.
- Within a profile, the moisture difference in the cross-section must be limited to 3 % (according to HO.10/1).
- For finger joints, the same wood structure must be used on both sides of the connecting joint (position and size of the growth layers).
- Profiles must be constructed symmetrically. Facing lamellas shall be identical regarding thickness, timber type and wood structure (position and size of the growth layers).

Rules and Regulations for the Processing of Timber and Adhesive for Finger-joint Profiles

- DIN EN 942 Timber in joinery – General Requirements (2007-06)
- DIN EN 204 Classification of thermoplastic wood adhesives for non-structural applications (2001-09)
- DIN EN 205 Adhesives – Wood adhesives for non-structural applications – Determination of tensile shear strength of lap joints (2003-06)
- DIN 18355 Tischlerarbeiten (joinery works); VOB Part C (2006-10)
- EN 14257 Adhesives – Wood adhesives – Determination of tensile shear strength of lap joints at elevated temperature (WATT'91) (2006-09)
- ift-Guideline HO.10/1; "Massive, keilgezinkte und lamellierte Profile für Holzfenster – Anforderungen und Prüfung" (Solid, finger-jointed and laminated profiles for wooden windows – Requirements and Testing)
- VFF-Information sheet HO.06-1; "Holzarten für den Fensterbau – Teil 1: Eigenschaften, Holzarten-tabelle" (Timber types for window construction – Part 1: characteristics, table of timber types)
- VFF-Information sheet HO.06-4; "Holzarten für den Fensterbau – Teil 4: Modifizierte Hölzer" (Timber types for window construction – Part 4: Modified timber)
- Processing guidelines of adhesive manufacturer

- Since the application properties of the adhesives vary, adhesive selection, open time and pressing times must be cleared with adhesive manufacturer.
- The surfaces to be bonded must be smooth, no grooves, no crushed cell walls, no skips and no warped surfaces. Plane step shall be $< 3 \text{ mm}$.

- Thickness difference between lamellas over the entire cross-section shall not exceed 0.1 mm.
- The planed lamella must be bonded within 24 hours. With timber types high in resins, long rest times can result in resinification of the surface, impeding wetting of the surface.
- After fabrication of finger joints, the jointed lamellas must rest for 1 day before planing in order for the swelling in the area of the finger joint to decrease.
- When working with two-component systems, the hardener shall only be added to the other components while stirring the mixture. Consult adhesive manufacturer regarding mixing times and mixing ratio and strictly adhere to recommendations. When mixing adhesive and hardener, please note that in some cases, depending on the type of dosage, the weight proportions (generally indicated in datasheets) must be converted into volumes.
- After adhesive and hardener have been mixed, please take care not to exceed the (temperature dependent) pot life of the adhesive batch.
- Always apply adhesive evenly. The quantity required depends on adhesive and timber type and must be cleared with adhesive manufacturer.
- For finger joints, the adhesive must be evenly **applied** to both sides of the fingers. Thickness of the glue coat must be present on 4/5 of the fingers.
- For laminated joints as well as for finger joints, a continuous glue seam must be present after **bonding pressure** was applied. The joint must be impermeable.
- When feeding the press, the maximum limit for open and closed waiting time of the adhesive (see manufacturer's information) shall not be exceeded. Presses, which have already been closed, shall not be re-opened. Press times shall be determined by tests and cleared with the adhesive manufacturer. **When bonding timber types that are difficult to join**, modified timbers or composite materials, press times must be extended and cleared with adhesive manufacturer, taking into consideration climatic conditions on worksite.
- The required time for post-bonding rest times must be determined by tests or cleared with adhesive manufacturer.

Finger-jointing – timber preparation

Bonding shall preferably take place immediately after cutting of the fingers, since longer waiting times might result in dimensional instability under non-climatized conditions.

The fingers must fit accurately in order for the glue seam to be closed when joining the two sides.

Timber must be untreated. Bonding of treated timbers is currently only possible with inferior bond qualities.

3 Frame Connections

3.1 Requirement Profiles for Frame Connections

Frame connections for wood windows must have adequate strength and must be impermeable to prevent moisture from entering. The construction of the corner joints is vital for the durable impermeability of the bond.

3.2 Requirements for bonds

Connections that are not fully bonded produce capillary seams where moisture can enter into frame construction. A permanent impermeable bond is a prerequisite for an adequate service life of the window.

The adhesives used for bonding have the following purpose:

- To connect the frame elements and to seal them permanently preventing moisture from entering the connection, thus protecting the wood.
- To strengthen the connection in order to ensure functionality of the frame for the duration of its service life.

Window frame connections are able to permanently hold together the wing and frames if manufactured accurately and constructed professionally. A bond over the entire surface prevents moisture entering into the window construction via the joints thus ensuring the usability of the window.

3.2.1 Adhesive

Requirements for adhesives for frame connections:

- Compliance with durability class D3 or D4 according to DIN EN 204,
- Heat resistance of bond ≥ 7 N/mm², testing according to DIN EN 14257.

3.2.2 Processing of Timber and Adhesive

- The timber used must be suited for window construction.
- Minimum raw density:
hardwood $\geq 0.45 \text{ g/cm}^3$ at 15 % wood moisture
softwood $\geq 0.35 \text{ g/cm}^3$ at 15 % wood moisture
- The admissible wood moisture before processing is $13 \pm 2 \%$.
- Mostly, for the fabrication of frame connections, mortise and tenon connections are used.
- The mortise and tenon connections must fit perfectly. After bonding, the glue seams shall have a thickness not exceeding 0.1 mm.
- Bonding of the connections shall be performed immediately after manufacturing of the mortises and tenons.
- The adhesive must be applied on all surfaces to be bonded - also in shoulder areas - and must squeeze out from all seams during pressing process.
- Make sure the maximum open and closed waiting time of the adhesive between application of the adhesive and pressing process is not exceeded. Please note that the related information of the adhesive manufacturer in technical datasheets has been established in laboratory tests under standardised conditions. The maximum open and closed times, however, depend on processing conditions and may vary significantly from the values in the datasheet on account of wood moisture, room temperature and humidity. This entails that installers must always determine these values for the actual processing conditions.
- The required pressing time depends on timber type, room climate, timber temperature, and adhesive properties. Please consult adhesive manufacturer.
- Stresses on the bonded frame (e.g. modification of angle) directly after bonding must be avoided in order to prevent damage to the adhesive during the critical curing phase.
- The conditioning time (rest period) between pressing process and further processing of the bonded frames depends on the construction and can be shortened, if needed, by additional stabilizing measures.
- It must be assumed that adhesive may ooze from the seams. This adhesive must not result in discolorations of the wood and must therefore be removed immediately.

Rules and Regulations for the Processing of Timber and Adhesive for Finger-joint Profiles

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- DIN EN 205 Adhesives - Wood adhesives for non-structural applications - Determination of tensile shear strength of lap joints
- DIN 18355 Tischlerarbeiten (joinery works); VOB Part C
- EN 14257 Adhesives – Wood adhesives - Determination of tensile shear strength of lap joints at elevated temperature (WATT'91)
- ift-Guideline FE-08/1; "Rahmeneckverbindungen für Holzfenster – Anforderungen, Prüfung und Bewertung" (Corner connection for wooden windows – requirements, testing and evaluation)
- VFF-Information sheet HO.06-1; "Holzarten für den Fensterbau – Teil 1: Eigenschaften, Holzarten-tabelle" (Timber types for window construction – Part 1: characteristics, table of timber types)
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- Processing guidelines of adhesive manufacturer

4 Wood-composite Windows

In modern wood window manufacturing, increasingly different materials are used in combination with wood. Some examples include different foams, cork, aluminum, and modified woods. When bonding these materials, special material-related requirements must be complied with in addition to the requirements described above. In many cases, specialized adhesive systems with different adhesion capabilities and different processing parameters are required, e.g. different setting behaviour.

In order to achieve perfect bonds between various substrates with different properties, if necessary, we recommend consulting with the adhesive manufacturer.

5 Environmental and Safety Aspects

Always observe safety, processing, and disposal information issued by the adhesive manufacturer. It may vary depending on adhesive type.

The information and specifications in this technical briefing note reflect to the best of our knowledge the current state of technology. They are only intended for information purposes and as a nonbinding guideline. As a result, they cannot be used as a basis for deriving any warranty claim.

All available leaflets of the
Technical Committee on Wood Adhesives (TKH)
of the Industrieverband Klebstoffe e.V.
can be found in the currently valid version at

**www.
klebstoffe
.com**

The information platform on the internet.