Evaluation of the long term durability of adhesive tapes and its substrates: Requirements and testing

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Evaluation of the long term durability of adhesive tapes

Leakages caused by unsuitable adhesive products ...

Why airtightness is so important
Evaluation of the long term durability of adhesive tapes

Calculation Example:

Precondition:
Air temperature: 20°C
rel. humidity: 50%

Why airtightness is so important

130 g water in roof construction caused by condensation of water vapour.

Nomogramm according Pohl
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Registered damages caused by wood-decaying fungi (Serpula lacrimans) in Germany: 200 Mio Euro/a

Why airtightness is so important

The blower-door fan is temporarily sealed into an exterior doorway using the door-panel system. The blower door fan is used to blow air into or out of the building, creating either a positive or negative pressure differential between inside and outside. This pressure difference forces air through all holes and penetrations in the building enclosure. The tighter the building (e.g. fewer holes), the less air is needed from the blower door fan to create a change in building pressure. Typically, only depressurization testing is performed.

A real risk to the installer: Bad workmanship can be detected easily
Evaluation of the long term durability of adhesive tapes

A real risk to the installer: Bad workmanship can be detected easily

Separating thermal bridges from air leakages

A real risk to the installer: Bad workmanship can be detected easily
Evaluation of the long term durability of adhesive tapes after 20 min. pressure difference of 50 Pa

A real risk to the installer: Bad workmanship can be detected easily.
Evaluation of the long term durability of adhesive tapes

A typical pressure sensitive adhesive tape designed for sealing joints in air tightness layers:

“60 mm wide, single-sided adhesive tape for sealing overlap seams in membranes. Specially designed for use with LDS membranes. Adhesive amount: 260 gramm/m²”

Products and their application

Evaluation of the long term durability of adhesive tapes

Used to create a secure and permanent seal of overlaps of membranes. Bonds overlaps between sheets of VCL and joints between wood-based panels (such as OSB). Comes supplied with release paper. Easy to tear by hand.

Products and their application
Factors that influence durable adhesion: Balanced adhesion and cohesion forces

Source: „Der Loctite“ 1992
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Factors that influence durable adhesion: Balanced adhesion and cohesion forces

Within foil production (e.g. PE film extrusion), separating agents and lubricants are used to accelerate the process.

Their use have a negative impact on surface tension, wettability and adhesion.
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Factors that influence durable adhesion: Balanced adhesion and cohesion forces

Easy testing of the existence of residues / wettability of films:

When a test pen is applied to the surface, the liquid will either form a continuous film on the surface or pull back into small droplets. If the test fluid remains as a film for 3 seconds, the substrate will have a minimum surface energy of that ink value, expressed in mN/m (dynes).

Source: Dynes Testing

Factors that influence durable adhesion: The right balance of surface tension of adhesive and substrate

Wettability and surface tension

Sources:
- Source: “Der Locher” 1980

Diagram:
- no wettability: $\alpha = 180^\circ$
- minimal wettability: $\alpha > 90^\circ$
- good wettability: $\alpha = 90^\circ$
- ideal wettability: $\alpha < 45^\circ$

Source: Dynes Testing
Evaluation of the long term durability of adhesive tapes

**Basic rule:**
The surface tension of the adhesive must be lower than or equal to the surface tension of the substrate.

\[
\frac{\sigma_S}{\sigma_L} = \delta
\]

- \(\sigma_L\): surface tension of a liquid (adhesive)
- \(\sigma_S\): surface tension of the substrate

Factors that influence durable adhesion: The right balance of surface tension of adhesive and substrate.

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The design of durable material connections requires extensive knowledge of the manufacturing technology of the substrate materials and the interactions of the adhesives with the substrates.

Factors that influence durable adhesion: The right balance of surface tension of adhesive and substrate.
Once the surface tension of PE can be increased to 36 to 40 mN/m, a good bonding of modified acrylates is likely.

Factors that influence durable adhesion: The right balance of surface tension of adhesive and substrate

Beneath the surface tension essential in the development of acrylic bonding components: the specification of a reasonable balance between the relevant adhesive properties

Factors that influence durable adhesion: The right balance of tack, peel- and shear resistance
Evaluation of the long term durability of adhesive tapes

Durable bonding in construction; requirements of the standards
Evaluation of the long term durability of adhesive tapes

Requirements of the Guideline for European Technical Approval of Timber Frame Building Kits

„(d) Working life (durability) and serviceability
The provisions, test and assessment methods in this guideline or referred to, have been written, based upon the assumed intended working life of the timber frame building kit for the intended use of 50 years for the loadbearing structure and for non-accessible components and materials, and 25 years for repairable or replaceable components and materials like claddings, roofing materials, exterior trims, and integrated components like windows and doors, provided that the kit is subject to appropriate use and maintenance (cfr. ch. 7). The use of components and materials with shorter intended working life must be clearly stated in the ETA. These provisions are based upon the current state of art and the available knowledge and experience.“

ETAG 007
Edition April 2001; GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL OF TIMBER FRAME BUILDING KITS

Durable bonding in construction; requirements of the standards

Evaluation of the long term durability of adhesive tapes

Accelerated ageing of bonding samples: Exposure to climate 65°C/80% relative humidity for 60 weeks in climate chamber at Fraunhofer IBP/University of Kassel, Germany

How to assess the durability of adhesives, substrates and component connections?
Evaluation of the long term durability of adhesive tapes

Scope of new standard DIN 4108-11

Examination of durability:
- Current draft of standard defines the minimum requirements for ensuring durability of adhesive joints using adhesive masses and adhesive tapes for the manufacture of an air tight building envelope.
- The requirements of adhesives refer to the manufacture of air tight joints according to DIN 4108 part 7.
- Examination of reference samples 48 h after bonding to substrate
- Examination of samples after accelerated ageing of 80 and 120 days at 65 °C und 80 % r.h.
- The assessment of adhesives designed for permanent exposition to outdoor climate and permanent exposition to UV radiation is not in the scope of this standard.

How to assess the durability of adhesives, substrates and component connections?

T-peel test according to EN 11339
180° peel test according to EN 1939

How to assess the durability of adhesives, substrates and component connections?
Evaluation of the long term durability of adhesive tapes

In this section, we focus on the evaluation of the long term durability of adhesive tapes, including the peel test according to EN 1939. The test describes how to assess the durability of adhesives, substrates, and component connections.

### Test Description

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Reference test</th>
<th>Pre-conditioning of components</th>
<th>Thermal load/Moisture load during sample production</th>
<th>Minimum duration of ageing</th>
<th>Thermal load/Moisture load during artificial ageing</th>
<th>Test speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peeling forces</td>
<td>PET with PET</td>
<td></td>
<td>23±1 °C 50 ± 5 % r. h.</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Peeling forces after artificial ageing</td>
<td>PET with PET</td>
<td>24 h 23±1 °C 50±5 % r. h.</td>
<td>23±1 °C 50 ± 5 % r. h.</td>
<td>80/120 d</td>
<td>65±1 °C 80 % r. h.</td>
<td>10 mm/min; 100 mm/min</td>
</tr>
<tr>
<td>Static peel strength 90°</td>
<td>Beech with PET</td>
<td></td>
<td>23±1 °C 50 ± 5 % r. h.</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dynamic loads?</td>
<td>PET with PET</td>
<td></td>
<td>23±1 °C 50 ± 5 % r. h.</td>
<td>?</td>
<td>65±1 °C 80 % r. h.</td>
<td>23±1 °C 50±5 % r. h.</td>
</tr>
</tbody>
</table>

How to assess the durability of adhesives, substrates and component connections?
Evaluation of the long term durability of adhesive tapes

Certificate confirms a long term durability of more than 50 years

Applied testing standard:
ASTM 3611; „Standard Practise for Accelerated Aging of Pressure Sensitive Tapes“

Evaluation of the long term durability of adhesive tapes

The certificate confirms a long term durability of more than 50 years. This is based on applied testing standard ASTM 3611, which specifies the standard practice for accelerated aging of pressure-sensitive tapes.

The testing period of 350 days is equivalent to 50 years of natural aging at mid-European testing conditions. The testing standard ASTM D 3611 was used for this evaluation.

Satas (Satas, D. (ed.) “Handbook of Pressure Sensitive Adhesive Technology” is determining a ratio of one week to one year for the conversion of test duration of accelerated aging according ASTM D 3611 into duration of natural aging. In terms of ageing behaviour the performed testing period of 350 days equates to a real ageing at mid-European testing conditions of 50 years.
### Evaluation of the long term durability of adhesive tapes

**Predicted loads of material joints**

<table>
<thead>
<tr>
<th>Pressure difference at VCL [Pa = N/m²]</th>
<th>Force per length of joint [N/m]</th>
<th>Force per length of joint [N/100 mm]</th>
<th>Force per length of joint [N/25mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3.7</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>20</td>
<td>7.4</td>
<td>0.70</td>
<td>0.2</td>
</tr>
<tr>
<td>30</td>
<td>11.1</td>
<td>1.10</td>
<td>0.3</td>
</tr>
<tr>
<td>40</td>
<td>14.8</td>
<td>1.5</td>
<td>0.4</td>
</tr>
<tr>
<td>50</td>
<td>18.5</td>
<td>1.8</td>
<td>0.5</td>
</tr>
<tr>
<td>100</td>
<td>37</td>
<td>3.7</td>
<td>0.9</td>
</tr>
<tr>
<td>150</td>
<td>55.6</td>
<td>5.6</td>
<td>1.4</td>
</tr>
<tr>
<td>200</td>
<td>74.1</td>
<td>7.4</td>
<td>1.8</td>
</tr>
<tr>
<td>300</td>
<td>111.1</td>
<td>11.1</td>
<td>2.8</td>
</tr>
<tr>
<td>400</td>
<td>148.1</td>
<td>14.8</td>
<td>3.7</td>
</tr>
<tr>
<td>500</td>
<td>185.2</td>
<td>18.5</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Minimum loads are defined in the standard specification, the fixed values of peel resistance are based on observations and measurements of wind loads in pitched roofs within Fraunhofer IBP research.

**Correlation of results from accelerated ageing (according to standard) and real ageing behaviour**

Good correlation between interpretation according [Satas] and the peeling strength decrease after real ageing: According Satas 56 days of test duration equates to 8 years real ageing.
Evaluation of the long term durability of adhesive tapes

Product combination: Adhesive tape with craft paper film carrier/PE vapour control layer

Correlation of results from accelerated ageing (according to standard) and real ageing behaviour