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

Knauf Insulation
Dipl.-Ing, Architekt Armin Weissmueller

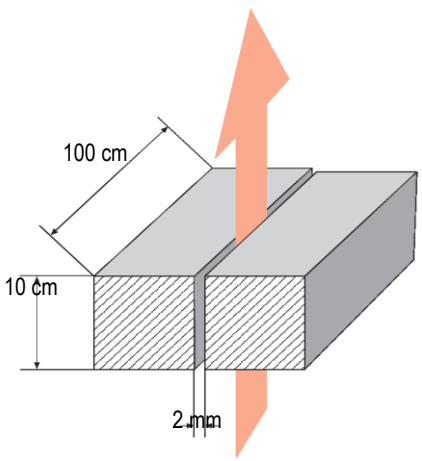
Leakages caused by unsuitable adhesive products ...

Why airtightness is so important

Evaluation of the long term durability of adhesive tapes

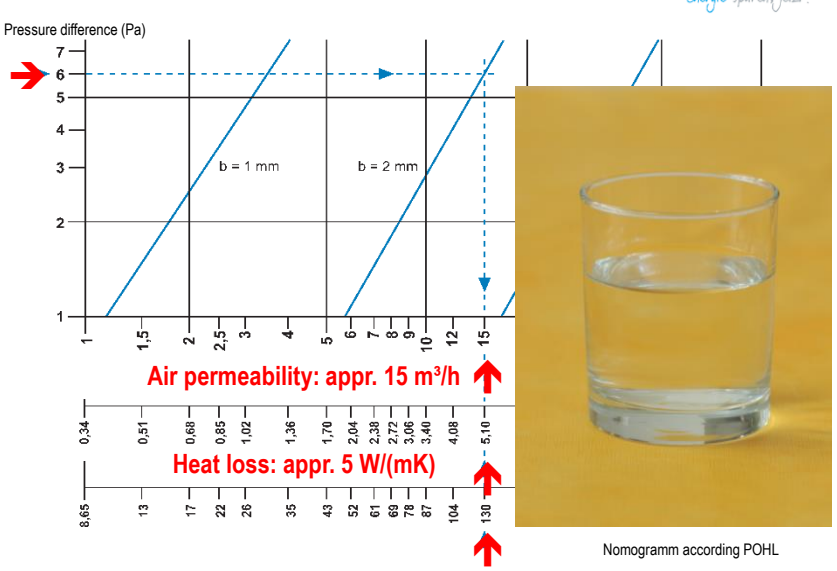
Calculation Example:

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



Why airtightness is so important

Evaluation of the long term durability of adhesive tapes



Nomogramm according POHL

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

Evaluation of the long term durability of adhesive tapes

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

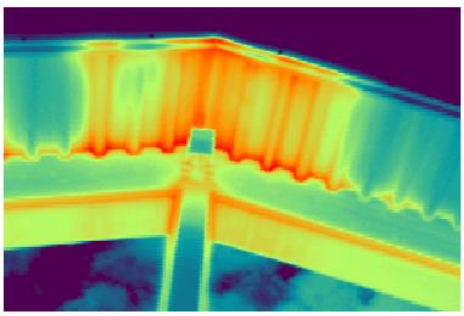
Why airtightness is so important

Evaluation of the long term durability of adhesive tapes

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



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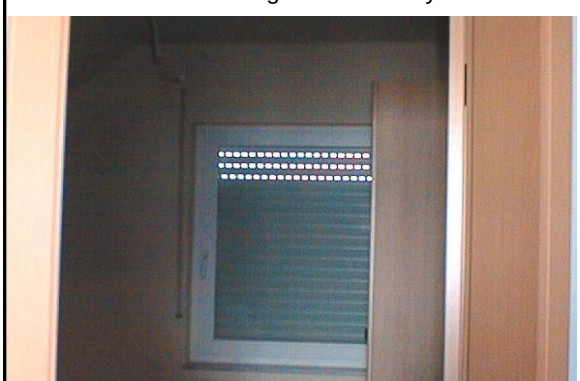
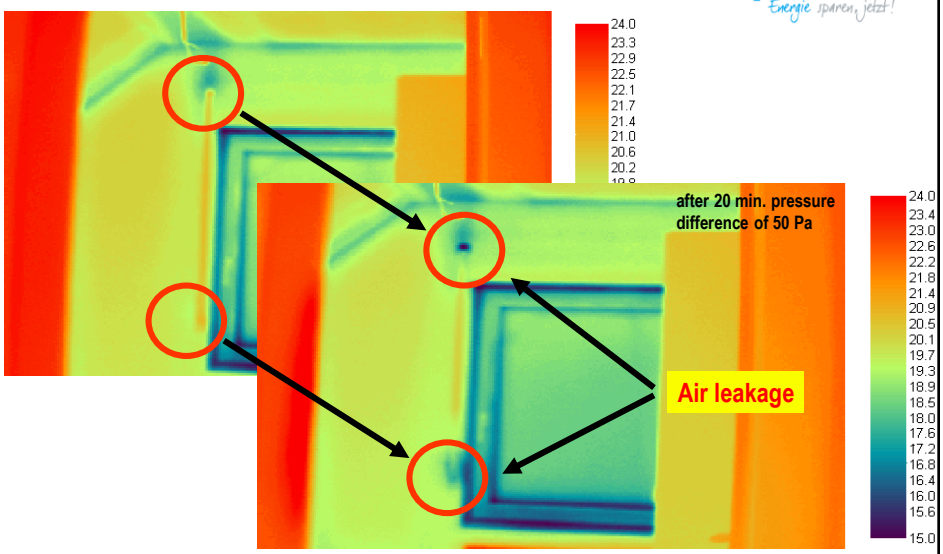


Separating thermal bridges from air leakages

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

Evaluation of the long term durability of adhesive tapes



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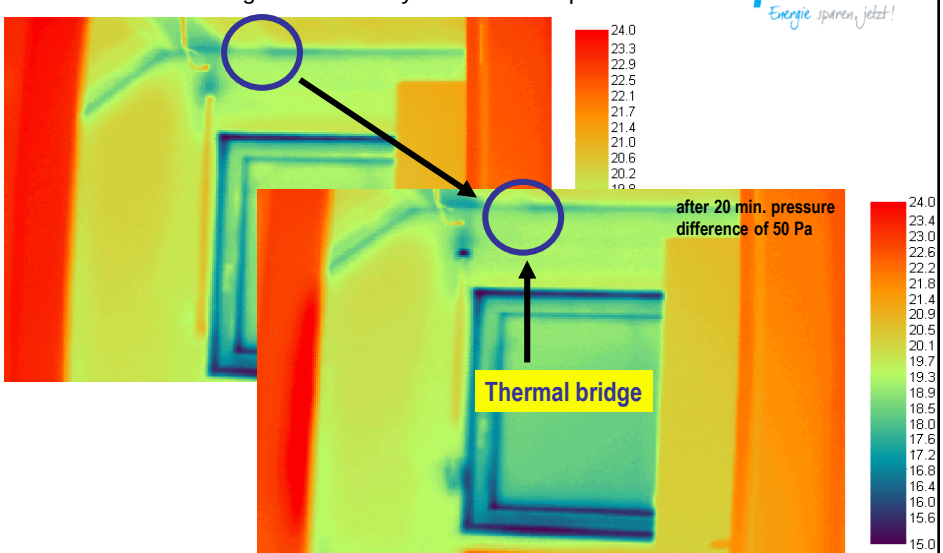


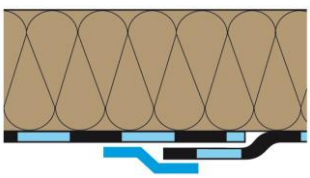
A real risk to the installer: Bad workmanship can be detected easily

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"

Source: Knauf Insulation



Products and their application

Evaluation of the long term durability of adhesive tapes

backing, carrier; kraft paper, PE

release liner; siliconized paper

modified acrylic adhesive, 260 g/m²

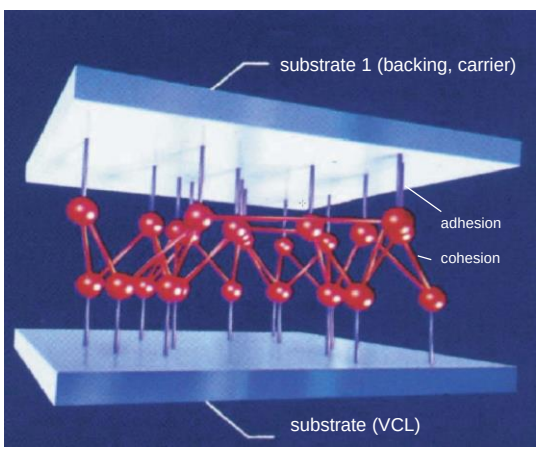
Used to create a secure and permanent seal of overlaps of membranes. Bonds overlaps between sheets of VCL and joints between wood-based panels (such as OSB). Comes supplied with release paper. Easy to tear by hand.

Products and their application

Evaluation of the long term durability of adhesive tapes

Factors that influence durable adhesion: Balanced adhesion and cohesion forces

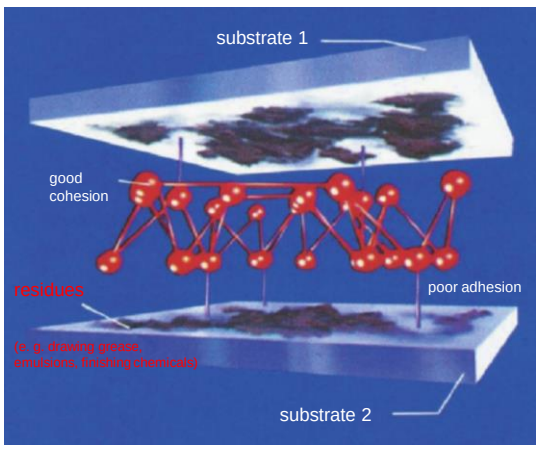
Evaluation of the long term durability of adhesive tapes



Source: „Der Loctite“ 1992

Factors that influence durable adhesion: Balanced adhesion and cohesion forces

Evaluation of the long term durability of adhesive tapes



Source: „Der Loctite“ 1992

Factors that influence durable adhesion: Balanced adhesion and cohesion forces

Evalua[illegible]e tapes

Source: Flexoplast

Within foil production (f. i. 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.

Evaluation of the long term durability of adhesive tapes

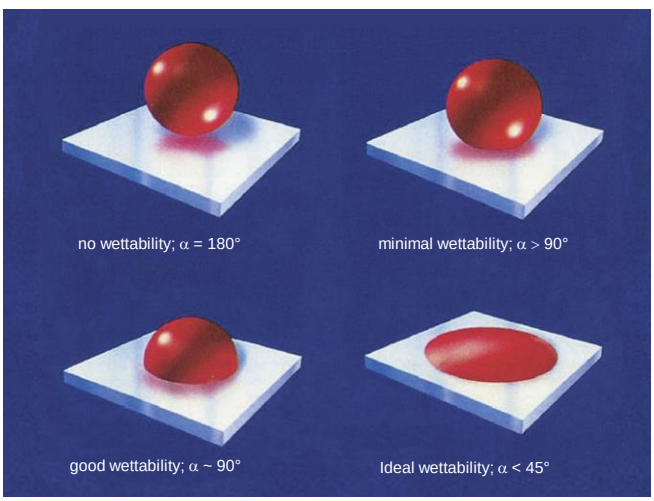
Source: Dynes-Testing

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).

Factors that influence durable adhesion: Balanced adhesion and cohesion forces

Evaluation of the long term durability of adhesive tapes

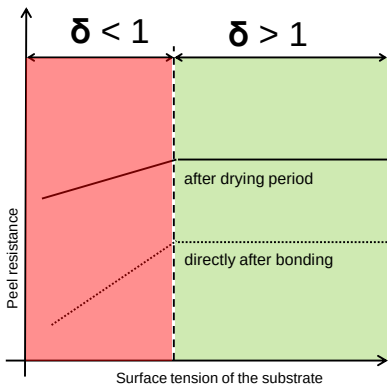


Source: „Der Loctite" 1992

Wettability and surface tension

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

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

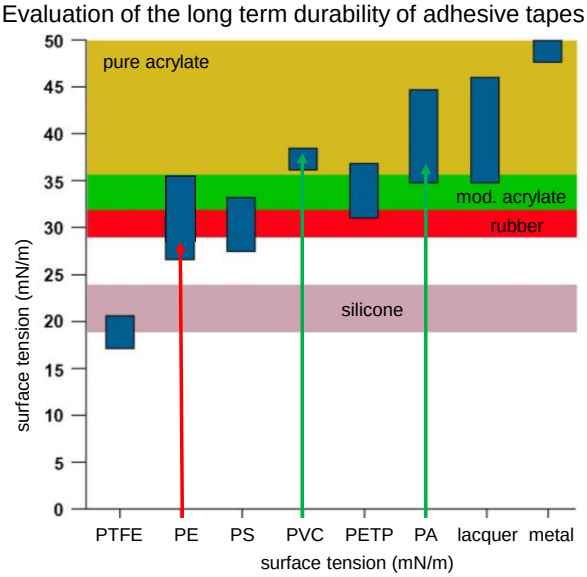
$$\sigma_S / \sigma_L = \delta$$

σ_L: surface tension of a liquid (adhesive)

σ_S: surface tension of the substrate

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

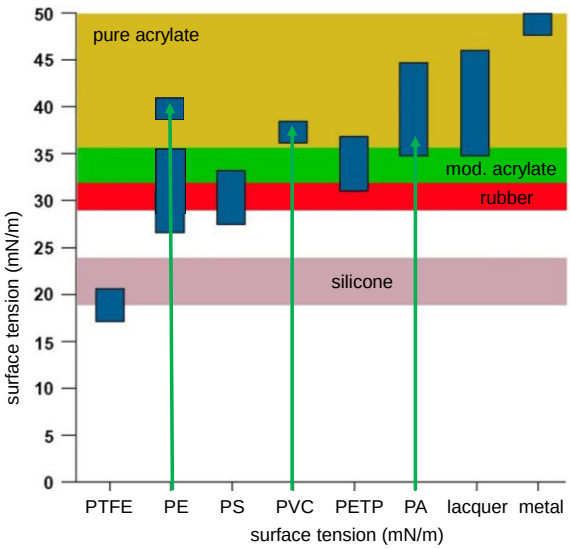
Evaluation of the long term durability of adhesive tapes



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

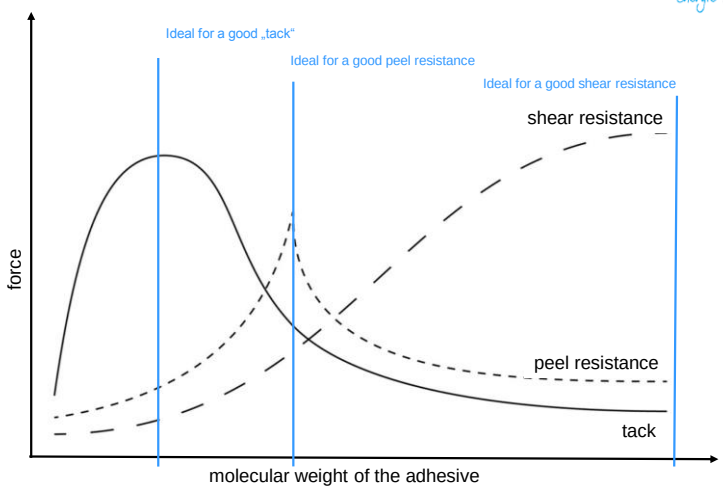
Evaluation of the long term durability of adhesive tapes



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

Evaluation of the long term durability of adhesive tapes



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

NA 005-56-93 AA N 254

DEUTSCHE NORM **12. Vorlage** 2008-02-18

Wärmeschutz und Energie-Einsparung in Gebäuden — Teil 7: Luftdichtheit von Gebäuden, Anforderungen, Planungs- und Ausführungsempfehlungen sowie -beispiele

DIN 4108-7

ICS 91.120.10

Ersatz für DIN 4108-7:2001-08

Thermal insulation and energy economy in buildings — Part 7: Airtightness of buildings, requirements, recommendations and examples for planning and performance

Protection thermique et économie d'énergie dans la construction immobilière — Partie 7: Etanchéité à l'air des bâtiments, exigences, recommandations et exemples pour la conception et la performance

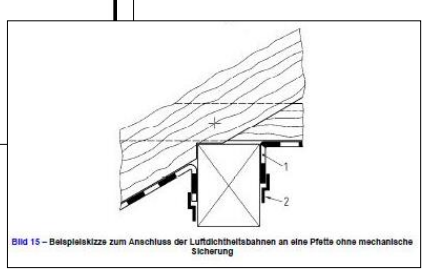


Bild 15 – Beispielskizze zum Anschluss der Luftdichtheitsbahnen an eine Pfette ohne mechanische Sicherung

Durable bonding in construction; requirements of the standards

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: Exposion 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?

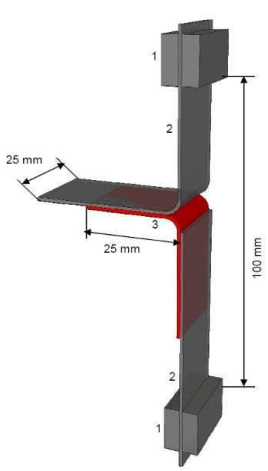
Scope of new standard DIN 4108-11

Examination of durability:

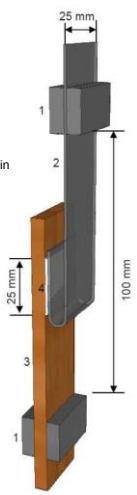
- Current draft of standard defines the minium requirements for ensuring durability of adhesive joints using adhesive masses and adhesive tapes for the manufacture of an air tight building envelope.
- The requirements of adhesives refer to the manufacture of air tight joints according to DIN 4108 part 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?

Evaluation of the long term durability of adhesive tapes



crosshead speed 10 mm/min and 100 mm/min

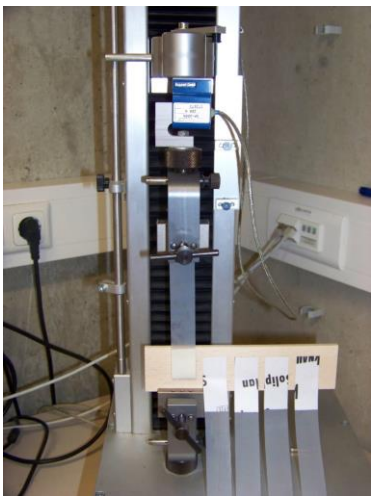


T-peel test according to EN 11339

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



Included in draft DIN 4108 part 11: 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

Durability tests of adhesive tapes (a brief summary of the definitions of the current draft DIN 4108 part 11

Test Description	Reference test	Pre-conditioning of components	Thermal load/ Moisture load during sample production	Minimum duration of ageing	Thermal load/ Moisture load during artificial ageing	Thermal load/ Moisture load during test	Test speed
Peeling forces	PET with PET	24 h 23±1 °C 50±5 % r. h.	23±1 °C 50 ± 5 % r. h.	-	-	23±1 °C 50±5 % r. h.	10 mm/min; 100 mm/min
Peeling forces after artificial ageing	PET with PET		23±1 °C 50 ± 5 % r. h. 48 h conditioning	80/120 d	65±1 °C 80 % r. h.		
Static peel strength 90°	Beech with PET		23±1 °C 50 ± 5 % r. h.	-	-	24 h 40±1 °C	-
Dynamic loads?	PET with PET		23±1 °C 50 ± 5 % r. h. 48 h conditioning	?	65±1 °C 80 % r. h.	23±1 °C 50±5 % r. h.	

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

Evaluation of the long term d

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“

UNIKASSEL VERSITÄT

Fachbereich 6 – Architektur, Stadtplanung, Landschaftsplanung
Fachgebiet Bauphysik
Univ.-Prof. Dr.-Ing. Gerd Hauser

Zertifikat

Thermisches Alterungsverhalten von Haftklebebändern LDS SOLIFLEX und LDS SOLIPLAN

Auftraggeber:	KNAUF INSULATION GmbH D-65232 Taunusstein
Prüfstelle:	Universität Kassel, Fachgebiet Bauphysik.
Gegenstand der Prüfung:	Gegenstand der Prüfung ist die Dauerhaftigkeit der Verklebungen von Folien und Spinnvliesbahnen. Die von KNAUF INSULATION GmbH vertriebenen, einseitig klebenden Bänder LDS SOLIFLEX und LDS SOLIPLAN werden auf zwei verschiedenen Substraten - der diffusionsoffenen Vordeck-/Unterspannbahn Thermolan® LDS 0,02 (die Oberflächenbeschaffenheit des Spinnvlieses ist laut Angaben des Auftraggebers identisch mit der Dampfbremse Thermolan® LDS 2) - der Dampfbremse Thermolan® LDS 100 /DIN 4102-B2 (PE-Folie) hinsichtlich ihrer Dauerhaftigkeit überprüft, indem sie einer künstlichen Alterung ausgesetzt werden. Die dazu verwendeten Proben werden im Liegen verklebt und mit 20 N angepresst. Die Probenbreite beträgt 25 mm, die Verklebung erfolgt über eine Länge von 75 mm. Die Verklebungen werden dem T-Peel Test (Folien) unterzogen.
Künstliche Alterung:	Die Durchführung der Versuche erfolgt in einem Aufbau gem. ASTM D 3611 bei einem Klima von 65 °C und 80 % rel. Luftfeuchte. Die Versuchsdauer wird auf 56, 112, 168 und 350 Tage festgelegt. In Satas (Satas, D. (ed.) „Handbook of Pressure Sensitive Adhesive Technology" Van Nostrand Reinhold, New York, 2nd Edition, 1989, S. 247 –249.) ist für die Umrechnung von Versuchsdauer auf die natürliche Alterung das Verhältnis von 7 Tagen zu ca. 1 Jahr angegeben. Für die genannten Versuchsdauern entspricht dies Zeiträumen von 8, 16, 24 und 50 Jahren.
Prüfergebnisse:	Die Belastung der Verklebungen durch thermische Alterung hat bei keinem der untersuchten Klebebänder und Substrate bei der gewählten Untersuchungsmethodik zu einem selbständigen Versagen der Verbindung geführt
Prüfbericht:	PB SO-126/02 vom 4. August 2003, Thermische Alterung von Verklebungen, 21 Seiten.

Kassel, den 4. August 2003

Dipl.-Ing. Rolf Gross (Prüfleiter)

Univ.-Prof. Dr.-Ing. Gerd Hauser (Leiter der Prüfstelle)

Evaluation of the long term durability of adhesive tapes

KNAUF INSULATION
Energie sparen, jetzt!

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Satas (Satas, D. (ed.) „Handbook of Pressure Sensitive Adhesive Technology“ is determining a ratio of **<u>one week to one year</u>** for the conversion of test duration of accelerated ageing according ASTM D 3611 into duration of natural ageing. 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

Pressure difference at VCL [Pa = N/m²]	Force per length of joint		
	[N/m]	[N/100 mm]	[N/25mm]
10	3,7	0,4	0,1
20	7,4	0,70	0,2
30	11,1	1,10	0,3
40	14,8	1,5	0,4
50	18,5	1,8	0,5
100	37	3,7	0,9
150	55,6	5,6	1,4
200	74,1	7,4	1,8
300	111,1	11,1	2,8
400	148,1	14,8	3,7
500	185,2	18,5	4,6

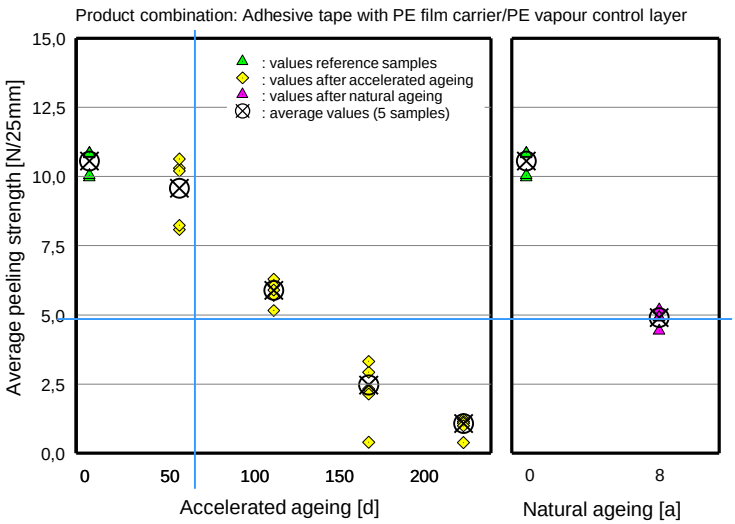
Measured wind loads; recalculation to force per length of joint

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

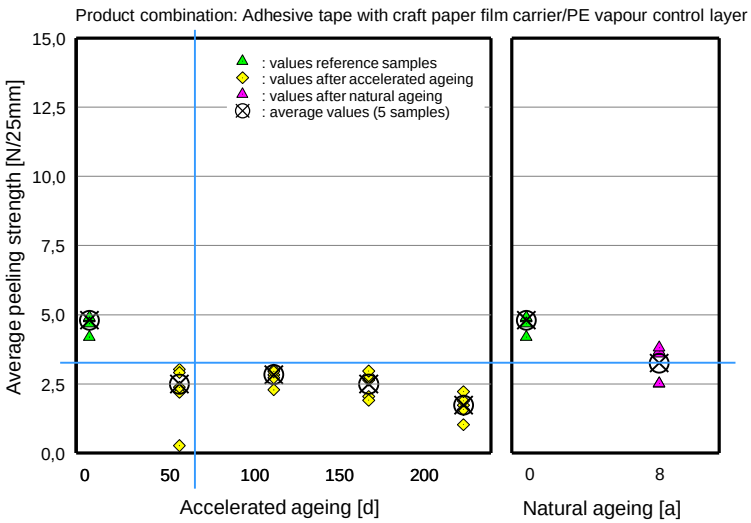
Evaluation of the long term durability of adhesive tapes

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



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



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