EUROPEAN ASSESSMENT DOCUMENT

EAD 331433-00-0601

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INJECTED ANCHOR FOR THERMAL INSULATION BOARDS

This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1. SCOPE OF THE EAD

1.1 Description of the construction product

1.1.1 Types and operating principles

This EAD applies to injected anchors for thermal insulation boards (in the next anchor), consisting of the following parts:

- anchor body made from mesh or perforated sheet which is coiled to spiral or circular shape finished with a rim. It can be fitted with a supplementary module;

- filling material which expands after injected in the anchor body;

- (possible) supplementary module fitted to the anchor body to improve load capacity in the substrate and/or in the insulation board.

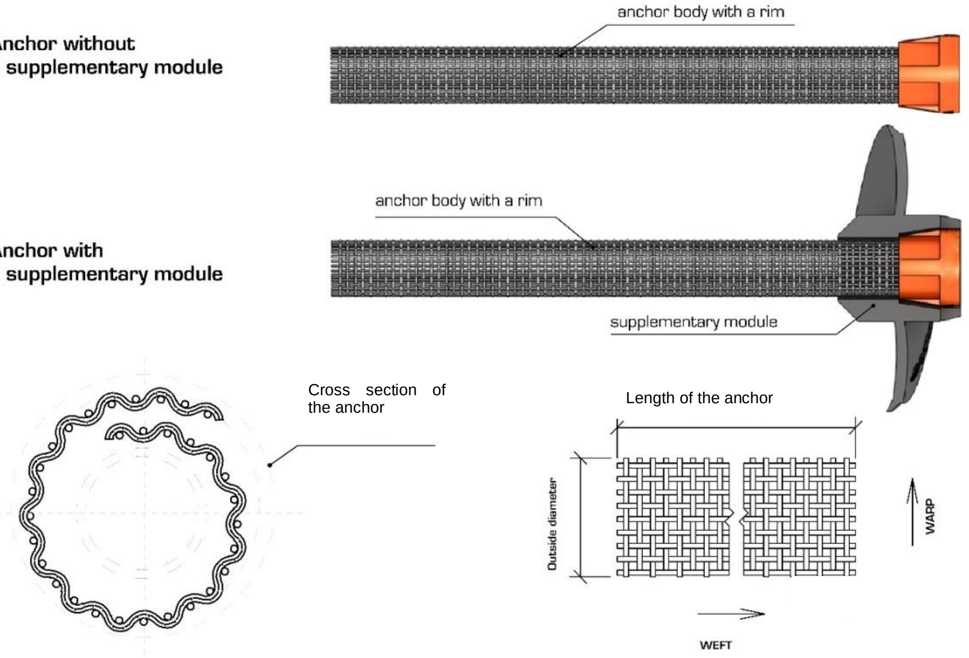

Figure 1 Components of an injected anchor

The application is carried out in the following way: A hole in the substrate and insulation board is drilled using a common drill, the dimension of the hole must comply with manufacturer’s instructions. Then, the anchor body (possibly fitted with a supplementary module) is inserted into the hole and fully injected with the filling material.

The transfer of wind suction load through injected anchors is always ensured by:

- surface friction between the anchor and thermal insulation
- surface friction between the anchor and substrate

Based on the manufacturer definition, the following can be also taken into account:

- bond strength between the expansion zone and insulation or substrate

Examples of the product and the installed product are given in Figure 1 and Figure 2.

The product is not covered by a harmonised European standard (hEN).

Concerning product packaging, transport, storage, maintenance, replacement and repair, it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual good practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.1.2 Materials

This EAD applies to the anchors in which all metal parts designed to transmit the assumed loads are made of either galvanized or stainless steel. The filling material is manufactured from polyurethane foam, MS polymers or other expanding material with significant thermal resistance. The filling material has to be capable of sufficient penetration into the base material and into possible joints between thermal insulation boards at installation temperature defined by manufacturer.

1.1.3 Dimensions

All dimensions shown in the Figure 2 shall be stated in the ETA.

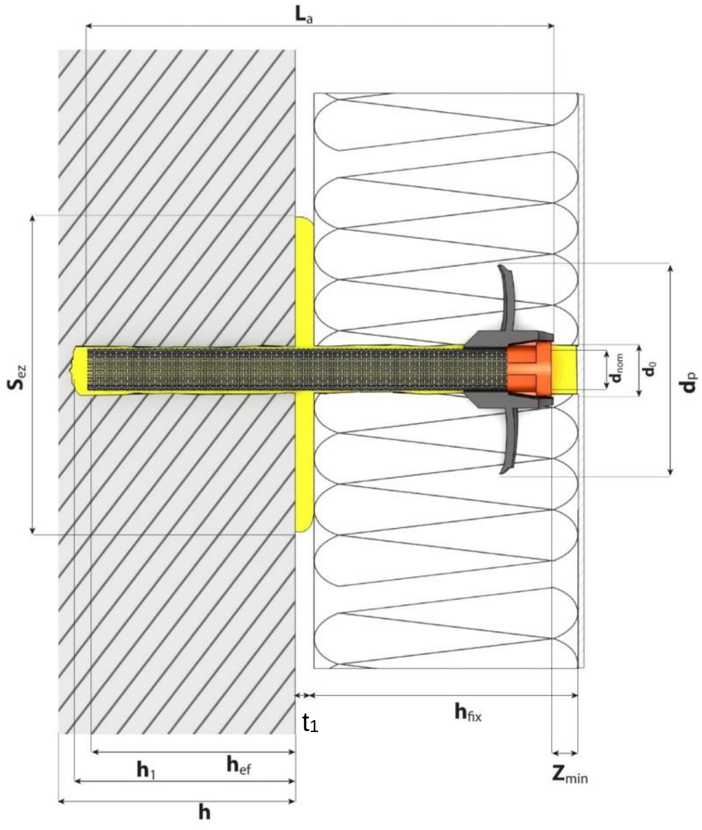

Figure 2 Installed injected anchor

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The anchors to be used for multiple fixing and stabilizing thermal insulation boards to substrate in interior and exterior. The product is intended for transmitting static and/or quasi-static loads acting vertically and/or horizontally. The following types of product application are foreseen:

- anchoring of a new insulation layer bonded directly onto a substrate

(The symbols are explained in art.1.3.2)

- anchoring of a new insulation layer bonded directly onto a previously applied insulation layer (so called “superimposition”)

- (structural) repair of a previously applied insulation layer

This EAD covers injected anchors which are not exposed to UV-radiation, during the use as they are protected by the rendering after installation.

Furthermore following use conditions in respect of installation and use can occur:

Category **d/d** - Installation and use in structures subject to dry, internal conditions,
Category **w/d** - Installation in wet substrate and use in structures subject to dry, internal conditions,
Category **w/w** - Installation and use in structures subject to other environmental conditions (e.g. wet). Use category **w/w** covers also use category **w/d**.

The injected anchor is intended to be used in conjunction with the following base materials:

- Normal weight concrete (use category A), for strength classes from C12/15 to C50/60 inclusively, according to EN 206-1[21][1], except screeds or toppings, which can be uncharacteristic and/or excessively weak concrete.
- Solid masonry units (use category B), consisting of solid units according to EN 771-1 [9], EN 771-2 [10], EN 771-3 [10], EN 771-5 [13], EN 771-6 [14], which do not have any holes or cavities other than those inherent in the material. Attention is drawn to the fact that standards for masonry are not very restrictive with regard to the details of units (e.g. type, dimensions and location of hollows, number and thickness of webs). Anchor resistance and load displacement behaviour, however, decisively depend on these influencing factors. Usually solid masonry units don’t have any holes or cavities other than those inherent in the material. However, solid units may have vertical perforation or grip holes of up to 15% of the cross section or frogs up to 20% based on the volume of the brick. Therefore testing in solid material covers units with vertical perforation or grip holes of up to 15% of the cross section or frogs up to 20% based on the volume of the brick.
- Hollow or perforated units (use category C), according to EN 771-1 [9], EN 771-2 [10], EN 771-3 [10], EN 771-5 [13], EN 771-6 [14], which have certain percentage of volume voided, and it passes through the masonry unit. Masonry units consisting of hollow or perforated units have a certain percentage of volume voided, and it passes through the masonry unit. For the assessment of injection anchors anchored in hollow or perforated units, it has also to be assumed that the anchor may be situated in solid material (e.g. joints, solid part of unit without holes) so that also tests in solid material may be required.
- Lightweight aggregate concrete (use category D), of strength class from LAC 2 to LAC 25 inclusively, according to EN 1520 [22] or LC 8/9 to LC 25/28 inclusively, according to EN 206 [21] and in lightweight aggregate concrete blocks.
- Autoclaved aerated concrete (use category E), according to EN 771-4 [12] or EN 12602 [23]. The strength class of the autoclaved aerated concrete defined in [12] has to lie between AAC 2 and AAC 7 inclusively.
- Construction boards (use category F) are materials with thickness smaller than the minimum anchorage depth as following materials:
    - Oriented strand boards (OSB, EN 300 [15])
    - Cement-bonded particleboards (EN 634-2 [16])
    - Gypsum boards with fibrous reinforcement (EN 15283-2 [17])
    - Particleboards (EN 312 [18])
    - Gypsum plasterboards (EN 520 [19])
    - Plywood (EN 636 [20])

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer’s request to take into account a working life of the injected anchor for the intended use of 25 years when installed in the works (provided that the injected anchor is subject to appropriate installation (see 1.1)). These provisions are based upon the current state of the art and the available knowledge and experience.

[1] *All undated references to standards or to EAD’s in this document are to be understood as references to the dated versions listed in clause 4.*

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee given neither by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD

1.3.1 General

Anchor	=	manufactured, assembled component for achieving anchorage between the base material and the fixture
Anchorage	=	an assembly comprising of base material, anchor and fixture
Fixture	=	component to be fixed onto the base material, in this case thermal insulation board
Filling material	=	manufactured component for the anchor, which provides the anchorage of the anchor
Supplementary module	=	manufactured component for the anchor that may be used to improve load capacity in the substrate and/or in the insulation board

1.3.2 Anchor

The notations and symbols frequently used in this EAD are given below. Further particular notation and symbols are given in the text.

t_0	=	thickness of non-load bearing layer
t_1	=	thickness of the expansion zone (adhesive)
t_2	=	thickness of base coat
t_3	=	thickness of finishing layer
c_{min}	=	minimum allowable edge distance
s_{min}	=	minimum allowable spacing
d_0	=	drill bit diameter
d_{nom}	=	outside diameter of the anchor body
d_p	=	diameter of the supplementary module
h	=	thickness of the base material
h_1	=	depth of the drilled hole in base material
h_{ef}	=	effective anchorage depth
h_{fix}	=	thickness of thermal insulation
L_a	=	total length of the anchor
S_{ez}	=	area of the expansion zone
Z_{min}	=	minimal immersion of the anchor

1.3.3 Base materials

f_c	=	concrete compressive strength measured on cylinders
$f_{c,\ cube}$	=	concrete compressive strength measured on cubes
$f_{c,\ test}$	=	compressive strength of concrete at the time of testing

2 *The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.*

f_{cm}	=	mean concrete compressive strength
f_{ck}	=	nominal characteristic concrete compressive strength (based on cylinder)
$f_{ck,\ cube}$	=	nominal characteristic concrete compressive strength (based on cube)
ρ	=	bulk density of unit
$f_{b,\ test}$	=	unit compressive strength at the time of testing
f_{bk}	=	nominal characteristic unit compressive strength
$f_{y,\ test}$	=	steel tensile yield strength in the test
f_{yk}	=	nominal characteristic steel yield strength
$f_{u,\ test}$	=	actual ultimate steel strength of tested item
f_{uk}	=	nominal characteristic steel ultimate strength

1.3.4 Assessment of tests

α	=	characteristic reduction factor
α_1	=	ultimate reduction factor
α_3	=	reduction factor from the durability behaviour
α_v	=	reduction factor of variation
C_a	=	geometric factor (dynamic wind uplift test)
C_s	=	statistical correction factor (dynamic wind uplift test)
d	=	diameter of the embedded part
h_{sl}	=	thickness of slice, measured values
k_s	=	statistical factor
n	=	number of tests of a test series
N_{rk}	=	characteristic resistance
$N_{rk,\ 0}$	=	characteristic resistance of reference tension tests
N_{Rk}	=	characteristic resistance under tensile load without the effect of the expansion zone
$N_{Rk,z}$	=	characteristic resistance under tensile load with the effect of the expansion zone
T	=	maximum shear load at displacement test
T_{Rk}	=	characteristic resistance under shear load *(on contact of the insulation board with the base material)*
T_{1d}	=	force value in kN at the displacement specified in mm of 1 mm *(in the plane of the reinforcement mesh)*
T_{3d}	=	force value in kN at the displacement specified in mm of 3 mm *(in the plane of the reinforcement mesh)*
N_{Rk}^{DW}	=	characteristic resistance at dynamic wind uplift test
$N_{Ru,\ m}^{t}$, N_{Rk}^{t}	=	mean value or 5% fractile, respectively, of the ultimate loads of test series
$N_{Ru,\ m}^{r}$, N_{Rk}^{r}	=	mean value or 5% fractile, respectively, of the ultimate load in the reference test according to Table 2, line 1
N_u	=	measured maximum load
Q_1	=	maximal load per anchor in the cycle preceding that in which the test specimen fails (dynamic wind uplift test)
req. α	=	required reduction factor
$\tau_{um\ (stored)}$	=	mean shear strength of the slices stored in alkaline fluid
$\tau_{um,\ dry}$	=	mean shear strength of the comparison tests on slices stored under normal conditions
$\chi_{(}h_{fix)}$	=	point thermal transmittance of an anchor for the insulating layer thickness according to the manufacturers specification [W/K]
ν	=	variation coefficient (≤ 20%) of the ultimate loads of the test series

2. ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 1 shows how the performance of injected anchor is assessed in relation to the essential characteristics.

Table 1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.2.1	Class
Basic Works Requirement 3: Hygiene, health and the environment			
2	Content and/or release of dangerous substances	2.2.2	description
Basic Works Requirement 4: Safety and accessibility in use			
3	Characteristic resistance under tensile load - without the effect of expansion zone	2.2.3	Level - N_{Rk} [kN]
	- with the effect of expansion zone	2.2.3	- $N_{Rk,z}$ [kN]
4	Characteristic resistance under shear load *(on contact of the insulation board with the base material)*	2.2.9	Level - T_{Rk} [kN]
5	Resistance under shear load at specified displacement (in the plane of the reinforcement mesh)	2.2.10	Level - T_{1d} [kN] (force value at the specified displacement of 1 mm) - T_{3d} [kN] (force value at the specified displacement of 3 mm)
6	Surface protection of the anchor	2.2.11	- class - value [g/m^2]
Basic Works Requirement 6: Energy economy and heat retention			
7	Point thermal transmittance	Annex B	Level - $\chi_{(h_{fix})}$ [W/K] (value at the specified insulating layer thickness)

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

1) The ETA shall include information on the installation and cleaning procedures which has been used for the assessment of the product performance. Thus information could be:
2) - drilling technology (e.g. hammer drilling, rotary drilling),
3) - specifications on bore hole cleaning (removing drilling dust e.g. by blowing, brushing including size and material of brush),
4) - conditions at installation (installation temperature, product temperature range),
5) - specifications for installation as applicable (e.g. installation tools).

This EAD gives 3 methods for testing of injected anchors for thermal insulation boards in base material and behaviour of injected anchors in thermal insulation:

6) testing of individual anchor
7) testing of the anchor in conjunction with thermal insulation product without influence of expansion zone
8) testing of the anchor in conjunction with thermal insulation product with influence of expansion zone

Details of the test methods are given in Annex A.

Usually, the anchors have only one minimum anchorage depth for a base material and one for a thermal insulation product (thickness of thermal insulation product). If the anchor has more than one possible minimum anchorage depth, then tests need to be done at each specific depth. Unless the manufacturer chooses to test the most critical depth, in which case the results will also apply to less onerous depths.

On the basis of the bellow mentioned significant properties (input data), for each type of anchor body, supplementary module, filling material and insulation boards, the most unfavourable quality class of used component and insulation board can be selected as representative for further testing. Test results of these properties shall be documented in relevant test report. The tests shall be performed and subsequently values shall be defined for insulation boards in dry and/or wet conditions. If these data are not available, the tests must be carried out on all components of which the product is composed and all insulation boards for which the product is intended.

The following input data of the anchor body and supplementary module are significant for the test specimens, and shall be documented as the entry value for all tests according to Table 2 and Table 3:

- class and mechanical properties of the used steel and material of the supplementary module (reference to the relevant technical specification)
- dimensions of anchor and supplementary module (length, thickness, diameter, angle of wings)
- diameter of wire
- wires distances

The following input data of the filling material are significant for the test specimens, and shall be documented as the entry value for all tests according to Table 2 and Table 3:

- density
- bond strength at:
    a) (23 ± 2) °C / (50 ± 5) % RH with thickness of foam: (8 ± 1) mm and (15 ± 1) mm
    b) (5 ± 2) °C, no RH is required with thickness of foam: (8 ± 1) mm
    c) (35 ± 2) °C, (30 ± 5) % RH with thickness of foam: (8 ± 1) mm
- bond strength to each defined base material
- shear strength
- viscosity (if relevant)
- ability to expand at the least defined thickness

The following input data of the insulation boards are significant for the test specimens, and shall be documented as the entry value for tests according to Table 3, line 1-5 and 7-9:

- tensile strength perpendicular to the faces
- compressive strength
- density

If the anchor has more than one possible areas of expansion zone, then the tests need to be done at each specified area of expansion zone, in which case the results will also apply to the less onerous areas of expansion zone.

The anchor shall be set in accordance with the manufacturer's assembly instructions.

For the determination of characteristic resistance under tensile load with/without the effect of expansion zone, proceed in the steps as described below:

The tests according to Table 2 shall be performed with all intended base materials to determine the critical representative base material for the tests according to Table 3.

The tests according to Table 3, line 1-5 shall be performed in base material a) normal weight concrete C20/25 and in material b) (construction boards) which showed the lowest values in tests according to Table 2.

The tests according to Table 3, line 3, 4, 5 and 7 single test, shall be performed without the effect of expansion zone.

The tests according to Table 3, line 6 shall be performed in normal weight concrete C20/25, or in base material with the highest presumed alkaline attack.

The dynamic wind uplift tests according to Table 3, line 7 shall be performed in normal weight concrete C20/25 as the base material for the tests.

The single tests according to Table 3, line 7 and tests according to Table 3 line 8 shall be performed in base material a) normal weight concrete C20/25 and in material b) (construction boards) which showed the lowest values in tests according to Table 2.

The characteristic resistance under tensile load with/without the effect of expansion zone is determined by calculation according to chapter 2.3.

If the supplementary module is used, the tests according to Table 3, line 1-5, 7 and 8 shall be performed for the most unfavourable option.

Table 2 Testing of the anchor in base materials

Line	Purpose of test	Base material	Number of tests	Temperature	Test according to section
1	Tests for determination of resistance in base material under tensile load	normal weight concrete C20/25	10	21 ± 3 °C	2.2.3
		solid masonry	10		
		hollow or perforated masonry	10		
		lightweight aggregate concrete	10		
		autoclaved aerated concrete	10		
		construction boards	10		

Table 3 Testing of the anchor in conjunction with thermal insulation

Line	Purpose of test	Load direction	Number of tests	Temperature	req. $\alpha^{1)}$	Test according to section
1	Characteristic resistance under tensile load <u>with</u> the effect of expansion zone	Axial	10	21 ± 3 °C	-	2.2.3
2	Characteristic resistance under tensile load <u>without</u> the effect of expansion zone	Axial	10	21 ± 3 °C	-	2.2.3
3	Tests with different setting conditions 2) - increased temperature - minimum installation temperature - in wet substrate 4)	 Axial Axial Axial	 5 5 5	 t_{max} 3) t_{min} 3) 21 ± 3 °C	 0.8 1.0 1.0	2.2.4
4	Determination of resistance after hygrothermal behaviour 2)	Axial	5	70 °C, 15 °C 50 °C, -20 °C	1,0	2.2.5
5	Determination of resistance after relaxation 2)	Axial	5	21 ± 3 °C	1,0	2.2.6
6	- Alkali resistance of the filling material	Axial	10 + 10	21 ± 3 °C	-	2.2.8
7	Determination of resistance after repeated loading - single test 2) - dynamic wind uplift test	 Axial Axial	 3 1	 21 ± 3 °C 21 ± 3 °C	 1.0 1.0	2.2.7
8	Characteristic resistance under shear load *(on contact of the insulation board with the base material)*	Axial + perpendicular to face	3	21 ± 3 °C	-	2.2.9
9	Resistance under shear load at specified displacement *(in the plane of the reinforcement mesh)*	Axial + perpendicular to face	3 or 5	21 ± 3 °C	-	2.2.10
10	Surface protection of the anchor	-	5	21 ± 3 °C	-	2.2.11
11	Point thermal transmittance	Axial	1	ΔT = 35K (θ_{se}=-15°C; θ_{si}= 20°C)	-	Annex B

1) req. α value according to table 2.3 of EAD 330196-01-0604 was taking into account
2) The tests shall be performed in such a way that the effects of expansion zone is eliminated.
3) t_{min} = 5°C and t_{max} = 40°C, or the temperature range at which the anchor shall be installed based on manufacturer declaration can be used.
4) This test is not required for condition d/d (dry)

2.2.1 Reaction to fire

The product shall be tested, using the test method(s) relevant for the corresponding reaction to fire class, in order to be classified according to Commission Delegated Regulation (EU) No. 2016/364 and EN 13501-1 [24].

The metal parts of anchors is considered to satisfy the requirements for performance class A1 of the characteristic reaction to fire, in accordance with the provisions of Commission Decision 2000/605/EC without the need for testing on the basis of its listing in that Decision.

2.2.2 Content, emission, and/or release of dangerous substances

The performance of the filling material related to the emissions and/or release and, where appropriate, the content of dangerous substances will be assessed on the basis of the information provided by the manufacturer[3] after identifying the release scenarios (in accordance with EOTA TR 034 [3]) taking into account the intended use of the product and the Member States where the manufacturer intends his product to be made available on the market.

The description of the content, emission, and/or release of dangerous substances or no dangerous substances based on this assessment shall be stated in ETA.

The identified intended release scenarios for this product and intended use with respect to dangerous substances are:

- IA3: Product with no contact to indoor air
- S/W3: Product with no contact to soil, ground and surface water

2.2.3 Tests for determination of the characteristic resistance under tensile load of individual anchor, anchor with and without the effect of expansion zone

The test result is expressed as graphic chart with performance curve and value of characteristic resistance in tensile strength. Minimum edge distances c_{min} and spacing s_{min} shall be:

$c_{min} \geq 100$ mm and $s_{min} \geq 100$ mm

The 5% fractile of the ultimate loads in test series shall be calculated according to equation (4) or/and (5).

2.2.3.1 Tests for determination of the characteristic resistance under tensile load of individual anchor

Tensile test of individual anchor shall be carried out according to Annex A. The number of tests for each series is showed in Tables 2. The following values shall be recorded:

- type of test (according to Annex A)
- type of the anchor
- type, dimensions and compressive strength of the used base material
- relationship of force and displacement of the anchor to the upper surface of base material
- failure loads
- description of failure

2.2.3.2 Tests for determination of the characteristic resistance under tensile load of anchor with and without the effect of expansion zone

Tensile test of anchor with and without the effect of expansion zones hall be carried out according to Annex A. The number of tests for each series is showed in Tables 3. The following values shall be recorded:

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3 *The manufacturer may be asked to provide to the TAB the REACH related information which he must accompany the DoP with (cf. Article 6(5) of Regulation (EU) No 305/2011 [1]). The manufacturer is **not** obliged:*

- *to provide the chemical constitution and composition of the product (or of constituents of the product) to the TAB, or*
- *to provide a written declaration to the TAB stating whether the product (or constituents of the product) contain(s) substances which are classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the SGDS. Any information provided by the manufacturer regarding the chemical composition of the products may not be distributed to EOTA or to TABs.*

- type of test (according to Annex A)
- type of the anchor and used supplementary module
- thickness, type, tensile and compressive strength of the used insulation material
- relationship of force and displacement of the anchor to the upper surface of insulation material
- failure loads
- description of failure

Where the characteristics of the insulation product could deteriorate by exposure to humidity, the test for determination of the characteristic resistance shall be carried out in wet conditions. The size of the test samples depends on the type of insulation product and should be identical to the test in dry conditions. The testing is performed after exposed of test samples to heat moisture actions at (70 ± 2)°C and (95 ± 5) % RH in a climatic chamber for at least 28 days followed by a drying period at (21 ± 3)°C and (50 ± 5) % RH until constant mass is achieved. The mass is considered constant when the mass difference between two measurements carried out at intervals of 24 hours is within 5 %.

2.2.4 Tests with different setting conditions

<u>Tests with increased temperature:</u>

The anchor shall be installed at t_{max} [°C] (anchor and base material) specified by the manufacturer or 40 °C. The test samples shall be prepared according to Figure A2. The pullout tests shall be performed according to Annex A after hardening of the expanding filling material at t_{max} [°C].

<u>Tests with minimum installation temperature:</u>

The anchor shall be installed at minimum installation temperature (anchor and base material) specified by the manufacturer, or 5 °C. The test samples shall be prepared according to Figure A2. The pullout tests shall be performed according to Annex A after hardening of expanding filling material at minimum installation temperature.

The test result is expressed as graphic chart with performance curve and characteristic resistance in tensile strength value. Method of assessing is documented in section 2.3.

<u>Tests in wet substrate:</u>

The anchor shall be installed in wet substrate. However the substrate in the area of anchorage shall be saturated with water to a constant weight (at least for 24 hrs), when the hole is drilled, cleaned and the embedded part is installed. The test samples shall be prepared according to Figure A2. The pullout tests shall be performed according to Annex A after hardening of the expanding filling material.

2.2.5 Determination of resistance after hygrothermal behaviour

The anchor shall be installed at standard installation temperature (anchor and base material). The test samples shall be prepared according to Figure A2. . Free sides of the thermal insulation must be protected appropriate waterproofing layer. The pullout tests shall be performed according to Annex A after hygrothermal cycles:

- <u>Heat-rain</u>

Specimens are subjected to a series of 80 cycles, comprising the following phases:

1) heating to 70 °C (rise for 1 hour) and maintaining at 70 ± 5 °C and 10 to 30 % RH for 2 hours (total time of 3 hours)
2) spraying for 1 hour (water temperature 15 ±5 °C, amount of water 1l/m^2 per min)
3) leave for 2 hours (drainage)

- <u>Heat-cold</u>

After 48 hours of subsequent conditioning at temperatures between 10 and 25 °C and at minimum RH of 50 %, the same test rig is exposed to 5 heat/cold cycles of 24 hours comprising the following phases:

1) exposure to 50 ± 5 °C (rise for 1 hour) and maximum 30 % RH for 7 hours (total of 8 hours)
2) exposure to -20 ± 5 °C (fall for 2 hours) for 14 hours (total of 16 hours)

Base on manufacturer definition, the conditions according to EN 16383 [29] can be used.

The test result is expressed as graphic chart with performance curve and characteristic resistance in tensile strength value.

Method of assessing is documented in section 2.3.

2.2.6 Determination of the resistance after relaxation

The anchor shall be installed at standard installation temperature (anchor and base material). The test samples shall be prepared according to Figure A2. The pullout tests shall be performed according to Annex A after relaxation at standard installation temperature. The duration of relaxation determined on the basis of stabilization of the filling material. The minimum duration of relaxation shall be 2000 hours.

The test result is expressed as graphic chart with performance curve and characteristic resistance in tensile strength value.

Method of assessing is documented in section 2.3.

2.2.7 Determination of resistance after repeated loading

<u>Single test:</u>

The anchor shall be installed at standard installation temperature (anchor and base material). The test samples shall be prepared according to Figure A2. The pullout tests shall be performed according to Annex A after 10^5 load cycles with maximum frequency of 6 Hz. During each cycle the load shall follow a sine curve between max N and min N:

$$\min N = 0{,}25 \times N_{Rk,(z),0} \qquad (1)$$

$$\max N = 0{,}60 \times N_{Rk,(z),0} \qquad (2)$$

where:

$N_{Rk,(z),0}$	characteristic resistance (5 % fractile of the failure load) from the test in the normal weight concrete in conjunction with thermal insulation according to the equations (4) / (5).

The test result is expressed as graphic chart with performance curve and characteristic resistance in tensile strength value.

<u>Dynamic wind uplift test:</u>

The anchor shall be installed at standard installation temperature (anchor and base material). Example of setting of the insulation boards and anchors is on Figure A4. The test sample shall be built with the insulation product corresponding to the lowest thickness and the lowest strength according to the tensile test perpendicular to the faces. Maximum thickness of the used insulation product shall be 120 mm. Then the test sample is subjected to dynamic wind uplift test.

The test equipment consists of a suction chamber which is placed over the tested ETICS. The depth of the pressure chamber shall be sufficient for a constant pressure to be exerted on the tested ETICS irrespective of its possible deformation. The pressure chamber is mounted on a rigid frame which surrounds the tested ETICS, or on the ETICS itself. The rendering serves as the seal between the pressure chamber and the environment. The connection between the rendering and the chamber shall be sufficient to allow a realistic deformation of the tested ETICS under the influence of simulated wind uplift.

The loads shown in Figure 3 are applied, each gust having the profile shown in Figure 4. The maximum suction of each cycle is W100% and is defined in the following figures and Table 4.

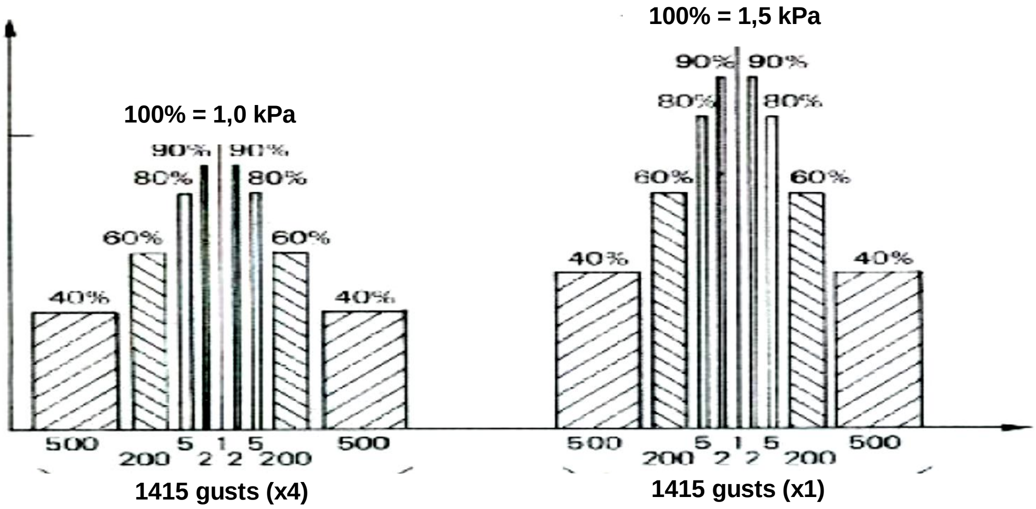


Figure 3: loads to be applied

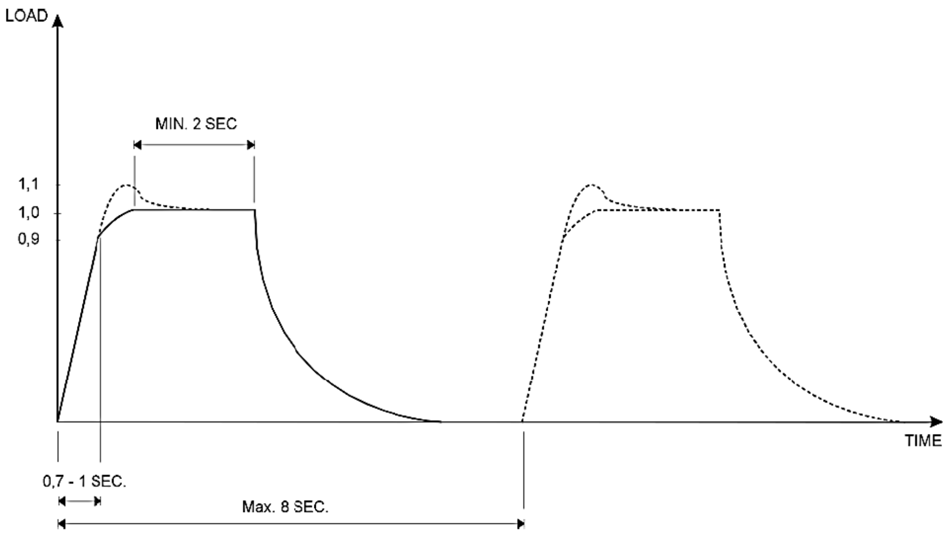


Figure 4: pressure/time profile of cyclic loads

Table 4 - Maximum suction of the cycles W100%

Number of cycles	Maximum suction in kPa
4	1,0
1	1,5
1	2,0
1	2,5
1	3,0
1	3,5
1	4,0
1	etc...

The sample is tested until failure. The failure is defined by any of the following events:

- the insulation panel is pulled off the anchor
- the anchor is pulled out of the substrate

The resistance at dynamic wind uplift test shall be calculated according to equation (3).

$$N_{Rk}^{DW} = Q_1 \times C_s \times C_a \qquad (3)$$

where:

N_{Rk}^{DW} resistance at dynamic wind uplift test
Q_1 maximal load per anchor in the cycle preceding that in which the test specimen fails,
C_s statistical correction factor (for ≥ 4 fasteners per panel and minimum 4 panels in the test box) Cs = 0,99
C_a geometric factor (for ETICS C_a = 1)

The test result is expressed as graphic chart with performance curve and characteristic resistance in tensile strength value. Method of assessing is documented in section 2.3.

2.2.8 Alkali resistance of the filling material

Evaluation of the durability of the expanding filling material and accessories shall be made under consideration of the effect in an alkaline liquid as well as for the intended use. The slice tests as follow shall be used.

The slice tests shall be carried out in concrete. The concrete compressive strength class shall be C20/25. The diameter or side length of the concrete specimen shall be equal to or exceed 150 mm. The test specimen may be manufactured from cubes or cylinders or may be cut from a larger slab. They can be cast or diamond core concrete cylinders from slabs can be used. One anchor (medium diameter) to be installed per cylinder or cube on the central axis in dry concrete.

Based on type of expanding filling material the thickness of slices shall be equal to h_{ef} or height of 30 mm. In the case of testing a “soft” filling material in which the cutting of the slices could cause the sample break (for example a polyurethane foam), the height of the slice shall corresponds to h_{ef}. In other cases the concrete cylinders or cubes are carefully sawn into 30 mm thick slices with a diamond saw. The top slice shall be discarded.

The 10 slices are stored under standard climate conditions in a container filled with an alkaline fluid (pH = 12,5). All slices shall be completely covered for 2000 hours. The alkaline fluid is produced by mixing water with KOH (potassium hydroxide) powder or tablets until the pH-value of 12,5 is reached. The alkalinity of pH = 12,5 shall be kept as close as possible to 12,5 during the storage and not fall below a value of 12,5. Therefore the pH-value shall be checked and monitored at regular intervals (daily). For comparison tests 10 slices stored under normal climate conditions (dry/21°C±3°C/relative humidity 50±5%) for 2000 hours are necessary. After the storage time the thickness of the slices is measured. The slices thickness of h_{ef} shall be tested according to Figure A1. The slices thickness of 30 mm are placed centrally to the hole of the steel rig plate and pushed out of the slice. If slices are unreinforced, splitting may be prevented by confinement. Care shall be taken to ensure that the loading punch acts centrally on the anchor.

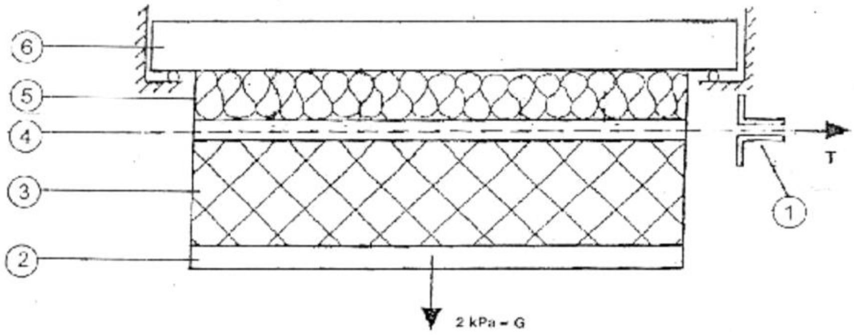
The test result is expressed as coefficient α_3, according to equation (11). Method of assessing is documented in section 2.3.

Remark:
Slice tests in an alkaline liquid are required only for applications in structures subjected to external environmental conditions (use category w/w according to section 1.2.1) if the injection anchor is installed in:
- *masonry from normal weight or lightweight concrete masonry units*
- *joints of masonry made from clay or calcium silicate units filled with non-carbonated cementitious mortar*

Slice tests may be omitted for applications in masonry made from normal weight or lightweight concrete masonry units if the characteristic resistance is calculated with α_3 = 0,3

2.2.9 Resistance under shear load

Resistance under shear load on contact of the insulation board with the base material is presented as a force acting perpendicular to the axis of anchors under the continuous action of the specified axial load simulating wind suction. The anchors shall be tested in conjunction with insulation board (displacement test). The test shall be performed at each, or at the highest thickness of either one layer sample or double layer sample (simulating the so called “superimposition”). The tests shall be performed with effects of expansion zone using spacer rings. Example of setting of the insulation boards and anchors is at Figure A5. Principle for preparation of specimens is at Figure 5. The sample is loaded at a constant rate of 1 mm per minute.



1 – Clamping jaws
2 – Plywood panel
3 – Foam block
4 – Reinforcement
5 – Insulation product
6 – Reinforced concrete slab

Figure 5: Principle for preparation of specimens

Each test result is expressed as graphic relationship between the average displacement of the insulating board measured in the each corner of test specimen in plane of the reinforcement mesh and the load T [kN] applied in the plane of the reinforcement mesh (Figure 6).

The resistance values are calculated per 1 anchor.

Characteristic resistance under shear load on contact of the insulation board with the base material shall to be expressed as 5% fractile of the ultimate shear loads (characteristic shear resistance), calculated according to (15). Minimum three tests shall be performed.

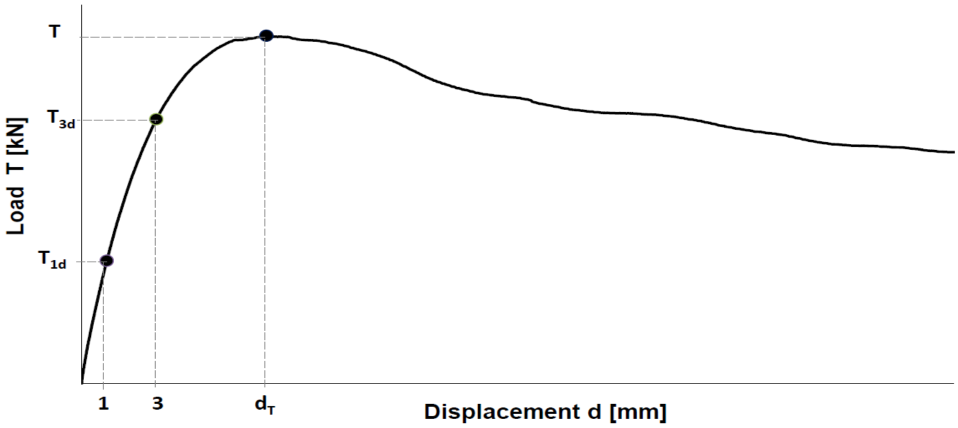


Figure 6: Load/displacement curve

2.2.10 Resistance under shear load at specified displacement

Resistance under shear load at specified displacement in the plane of the reinforcement mesh is presented as a force acting perpendicular to the axis of anchors at specified displacement corresponding to 1 and 3 mm displacement, under the continuous action of the specified axial load simulating wind suction. The anchors shall be tested by displacement test according to 2.2.9.

Three or five tests shall be performed. In terms of usability, the loads T_{1d} and T_{3d} corresponding to 1 and 3 mm displacement shall be defined. Test result is expressed as the minimum value of the three test results. If a variation coefficient of these three results is greater than 20 %, the values T_{1d} and T_{3d} can be defined as the average value of the five test results.

2.2.11 Surface protection of the anchor

Form of protection (material or coating) will be necessary to provide evidence in support of its effectiveness in the defined service conditions; due to the aggressiveness of the conditions concerned. The assessment/testing required with respect to corrosion resistance will depend on the specification of the injection anchor in relation to its use.

Supporting evidence that corrosion will not occur is not required if the anchors are protected against corrosion of steel parts, as set out below:

1) Injected anchor for thermal insulation boards intended for use in structures subject to dry, internal conditions (Category d/d):

No special corrosion protection is necessary for steel parts as coatings provided for preventing corrosion during storage prior to use and for ensuring proper functioning (zinc coating with a minimum thickness of 30 g/m^2) is considered sufficient.

2) Injected anchor for thermal insulation boards for use in structures subject to external atmospheric exposure (including industrial and marine environments), or exposure in permanently damp internal conditions, if no particular aggressive conditions according to 3) exist :

Metal parts of the anchor made of stainless steel material 1.4401, 1.4404, 1.4578, 1.4571, 1.4362, 1.4062, 1.4162, 1.4662, 1.4439, 14462 or 1.4539 according to EN 10088-5:2014 [26] are considered to have sufficient durability.

These anchors may also be used in 1) conditions.

3) Injected anchor for thermal insulation boards for use in structures subject to external atmospheric exposure or exposure in permanently damp internal conditions or particularly aggressive conditions such as permanent or alternate immersion in seawater or the splash zone of seawater, chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g. in desulfurization plants or road tunnels, where de-icing materials are used):

Metal parts of the anchor of stainless steel material 1.4529, 1.4565 and 1.4547 according to EN 10088-5:2014 [26] are considered to have sufficient durability.

These anchors may also be used in 1) and 2) conditions.

If injected anchor for thermal insulation boards is intended for use in wet substrate and use in structures subject to dry, internal conditions (Category w/d), supporting evidence that corrosion will not occur is required according to EN 990 [31] method 2.

If injected anchor for thermal insulation boards is intended for use in structures subject to other environmental conditions (Category w/w), supporting evidence that corrosion will not occur is required according to EN 990 [31] method 1.

The tests according to EN 990 [31] shall be carried out with injected anchors installed in AAC (use category E) with the lowest strength class according to EN 771-4 [12]. If injected anchor is not intended for use in category E, the test must be done in the use base material listed in 1.2.2 with the highest water absorption.

The Category d/d, and/or w/d, and/or w/w shall be stated in the ETA.

In the case of wire with a zinc or zinc alloy coating, the adherence and mass of the coating shall be determined according to EN 10244-2 [30]. The quality of the adherence shall be expressed as value of 1 to 5 and the mass of the protective layer shall be expressed in g/m^2.

The adherence and mass of coating shall be stated in the ETA.

2.2.12 Point thermal transmittance

The anchor shall be tested for each type of insulation layer at specified thickness, as single value according to Annex B.

The test result is in ETA expressed as point thermal transmittance $\chi_{(h_{fix})}$ [W/K] for the insulating layer thickness according to the manufacturers specification or as $\chi_{(100\ mm)}$ [W/K].

2.3 Calculation of the characteristic resistance

2.3.1 5% fractile of the ultimate loads (characteristic resistance)

The 5% fractile of the ultimate loads in test series shall be calculated according to statistical methods for a confidence level of 90%. If no exact verifications are furnished a normal distribution and an unknown standard deviation of the population shall be assumed in general.

$$N_{Rk,z,0} = \bar{F}(1 - k_s \times v) \tag{4}$$

$$N_{Rk,0} = \bar{F}(1 - k_s \times v) \tag{5}$$

where:

n = 5 tests: k_s = 3,40
n = 10 tests: k_s = 2,57

$N_{Rk,z,0}$ characteristic resistance (5 % fractile of the failure load) from the test for determination of the characteristic bond resistance with the effect of the expansion zone according to Table 3, line 1

$N_{Rk,0}$ characteristic resistance (5 % fractile of the failure load) from the test for determination of the characteristic bond resistance without the effect of the expansion zone according to Table 3, line 2

2.3.2 Assessment for characteristic resistance

In all tests the following criteria shall be considered:

a) If, in the test series, a variation coefficient of the ultimate load exceeds 20%, an additional factor α_v shall be considered for determining the characteristic loads. If variation coefficient of the ultimate load not exceeds 20%, an additional factor α_v = 1.

$$\alpha_v = \frac{1}{1 + (v(\%) - 20) \times 0{,}03} \tag{6}$$

where:

$\nu(\%)$ maximum value of the variation coefficient (>20%) of the ultimate loads of the test series

b) For the tests according to Table 3, lines 3, 4, 5 and 7 - single test, the factor α shall be defined as smaller value of Equation (6) and (7).

$$\frac{N_{Ru,m}^{t}}{N_{Ru,m}^{r}} \tag{7}$$

and:

$$\frac{N_{Rk}^{t}}{N_{Rk}^{r}} \tag{8}$$

c) For the test according to Table 3, line 7 - dynamic wind uplift test, the factor α shall be calculated according to Equation (9).

$$\alpha = \frac{N_{Rk}^{DW}}{N_{Rk}^{r}} \tag{9}$$

where:

$N^{t}_{Ru,m}$; N^{t}_{Rk}	mean value or 5% fractile, respectively, of the ultimate loads of a test series according to Table 3, line 3,4,5,7
$N^{r}_{Ru,m}$;N^{r}_{Rk}	mean value or 5% fractile, respectively, of the ultimate load in the reference test according to Table 3, line 1,2
N^{DW}_{Rk}	characteristic resistance at dynamic wind uplift test according to Table 3, line 7

Equation (6) is based on the test series with comparable number of test result in both series. If the number of tests in both test series differs considerably, equation (6) may be neglected in the case the variation coefficient of the test series is smaller than or equal to the variation coefficient of the reference test series (Table 3, line 1), or if the variation coefficient during the tests is $v \leq 15$ %.

The factor α_1 shall be calculated for test series according to Table 3, line 3,4,5,7 as:

$$\alpha_1 = \frac{\alpha}{req.\alpha} \leq 1{,}0 \tag{10}$$

where:

α	the lowest value according to equation (7), (8) and (9) in the test series according to Table 3, line 3,4,5,7
req.α	required value of α according to Table 3

For the tests according to Table 3, line 6, the factor α_3 shall be calculated according to Equation (11).

$$\alpha_3 = \frac{\tau_{um(stored)}}{\tau_{um,dry}} \tag{11}$$

where:

$\tau_{um(stored)}$	bond strength of the slices stored in the alkaline fluid
$\tau_{um,dry}$	bond strength of the comparison tests on slides stored under normal condition

The bond strength in the slice tests shall be calculated according to the following equation:

$$\tau_u = \frac{N_u}{\pi \times d \times h_{sl}} \tag{12}$$

where:

N_u	measured maximum load
d	diameter of the embedded part
h_{sl}	thickness of slice, measured values

If the value α_3 is less than 1,0 for the tests in alkaline fluid then the characteristic resistance N_{Rk} shall be reduced according to equation (13) and (14).

2.3.3 Characteristic resistance under tensile load

The characteristic resistance $N_{Rk,z}$ of the individual anchor shall be calculated according to equation (13) and (14).

$$N_{Rk,z} = N_{Rk,z,0} \times min_{\alpha 1,line\ 3,4} \times min_{\alpha 1,line\ 5,7} \times \alpha_3 \times \alpha_v \tag{13}$$

$$N_{Rk} = N_{Rk,0} \times min_{\alpha 1,line\ 3,4} \times min_{\alpha 1,line\ 5,7} \times \alpha_3 \times \alpha_v \tag{14}$$

where:

$N_{Rk,z}$	characteristic resistance under tensile load <u>with</u> the effect of the expansion zone
N_{Rk}	characteristic resistance under tensile load <u>without</u> the effect of the expansion zone
$N_{Rk,z,0}$	characteristic resistance 5% fractile of the failure load from the test for determination of the characteristic bond resistance <u>with</u> the effect of the expansion zone according to Table 3, line 1
$N_{Rk,0}$	characteristic resistance 5% fractile of the failure load from the test for determination of the characteristic bond resistance <u>without</u> the effect of the expansion zone according to Table 3, line 2
$min_{\alpha 1\ line3,4}$	minimum value α_1 according the equation (10), at test series according to Table 3, line 3 and 4 . In the case if $min_{\alpha 1,line3,4}$ >1,0, the $min_{\alpha 1,line3,4}$ = 1,0 shall be used.
$min_{\alpha 1\ line5,7}$	minimum value α_1 according the equation (10), at test series according to Table 3, line 5 and 7 $\alpha_1 \leq 1{,}0$. In the case if $min_{\alpha 1,line5,7}$ >1,0, the $min_{\alpha 1,line5,7}$ = 1,0 shall be used
α_3	minimum value α_3(reduction factor from the durability behaviour) according the equation (11) of all tests. In the case if α_3 >1,0, the α_3 = 1,0 shall be used
α_v	reduction factor for the consideration of a variation coefficient of the ultimate loads during the tests according to Table 3, line 1, In the case if α_v >1,0, the α_v = 1,0 shall be used

If the member of concrete or masonry of clay bricks or calcium silicate brick deviates from the reference tests according to Table 3, line 1 relating to material, strength class or geometry of cavities, the characteristic resistance shall be determined by tests on the construction works carried out in accordance with Annex A. The characteristic resistance is expressed as 60% of the mean value of the five smallest measured values at the ultimate load of 15 test specimens.

2.3.4 Characteristic resistance under shear load

The characteristic shear resistance is expressed as 5% fractile of the ultimate loads in test series according to statistical methods for a confidence level of 90%. If no exact verifications are furnished a normal distribution and an unknown standard deviation of the population shall be assumed in general.

$$T_{Rk} = \bar{T}(1 - k_s \times \nu) \tag{15}$$

where: n=3 tests: k_s = 5,31
n=5 tests: k_s = 3,40
n=10 tests: k_s = 2,57
T_{Rk} Characteristic shear resistance (expressed as 5% fractile of the failure load) from the test for determination of the characteristic shear resistance according to Table 3, line 8

3. ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD, the applicable European legal act is EC decision 97/463/ECof 27 June 1997 concerning plastic anchors for use in concrete and masonry.

The system is 2+.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 5.

Table 5 Control plan for the manufacturer; cornerstones

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method *(refer to 2.2 or 3.4)*	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	Tests for determination of the characteristics tensile resistance N_{Rk}	2.2	Laid down in control plan	10	Once a month
2	Dimensions of the anchor body *(outer diameter, inner diameter, length, etc.)* and supplementary module	Calliper and/or gauge		10	Every manufacturing batch or 100000 elements or when raw material has been changed
3	Density of expanding filling material	Annex C		5	
4	Surface protection, thickness of the protective coating	EN 10244-2 [30]		5	
5	Bond strength of expanding filling materials to substrate. *(As substrate can be used concrete or the material where the production unequal is most manifest)*	Annex C		5	
6	Shear strength of expanding filling materials.	Annex C		5	
7	Material of the anchor body - raw material specifications and properties (*tensile, yield strength)*	EN 10204 [36]		1	
8	Material of the expanding filling material- raw material specifications (*batch no., expiry date)*	Delivery sheet and/or label on the package		1	

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance are laid down in Table 6.

Table 6 Control plan for the notified body; cornerstones

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control *(for systems 2+)*					
1	The notified body shall verify ability of the manufacturer for a continuous and orderly manufacturing of the product. In particular, the following items shall be appropriately considered - personnel and equipment - the suitability of the factory production control established by the manufacturer - full implementation of the prescribed test plan	Control of devices and equipment and the documentation of the FPC	As defined in the control plan	As defined in the control plan	When starting the production process or when starting a new production line
Continuous surveillance, assessment and evaluation of factory production control *(for systems 2+)*					
2	The notify body shall verify - the manufacturing process - the system of factory production control - the implementation of the prescribed test plan are mantained	Control of the documentation of the FPC	As defined in the control plan	As defined in the control plan	Once a year

4. REFERENCE DOCUMENTS

[1] EAD 330196-01-0604: Plastic Anchors made of virgin or non-virgin material for fixing of External Thermal Insulation Composite Systems with Rendering, July 2017

[2] ETAG 029 Guideline for the European Technical Approval of Metal Injection Anchors for use in Masonry, April 2013

[3] EOTA TR 034: General BWR3 Checklist for EADs/ETAs Dangerous Substances, October 2015

[4] ISO 6946:2007 Building components and building elements - Thermal resistance and thermal transmittance - Calculation method

[5] ISO 10456:2007 Building materials and products - Hygrothermal properties - Tabulated design values and procedures for determining declared and design thermal values

[6] EN ISO 8990:1996-09 Thermal insulation - Determination of steady-state thermal transmission properties - Calibrated and guarded hot box

[7] ISO 3506-1:2009 Mechanical properties of corrosion-resistant stainless steel fasteners – Part 1: Bolts, screws and studs

[8] ISO 3506-2:2009 Mechanical properties of corrosion-resistant stainless steel fasteners – Part 2: Nuts

[9] EN 771-1:2011 +A1:2015 Specification for masonry units. Part 1: Clay masonry units

[10] EN 771-2:2011 +A1:2015 Specification for masonry units. Part 2: Calcium silicate masonry units

[11] EN 771-3:2011 +A1:2015 Specification for masonry units. Part 3: Aggregate concrete masonry units (Dense and lightweight aggregates)

[12] EN 771-4:2011 +A1:2015 Specification for masonry units. Part 4: Autoclaved aerated concrete masonry units

[13] EN 771-5:2011 +A1:2015 Specification for masonry units. Part 5: Manufactured stone masonry units

[14] EN 771-6:2011 +A1:2015 Specification for masonry units. Part 6: Natural stone masonry units

[15] EN 300:2006 Oriented Strand Boards (OSB) – Definitions, classification and specification

[16] EN 634-2:2007 Cement-bonded particleboards – Specifications – Part 2: Requirements for OPC bonded particleboards for use in dry, humid and external conditions

[17] EN 15283-2:2008 +A1:2009 Gypsum boards with fibrous reinforcement. Definitions, requirements and test methods. Gypsum fibre boards

[18] EN 312:2010 Particleboards. Specifications

[19] EN 520:2004 +A1:2009 Gypsum plasterboards. Definitions, requirements and test methods

[20] EN 636:2012 +A1:2015 Plywood. Specifications

[21] EN 206:2013 +A1:2016 Concrete – Specifications, performance, production and conformity

[22] EN 1520:2011 – Prefabricated reinforced components of lightweight aggregate concrete with open structure with structural or non-structural reinforcement

[23] EN 12602:2016 Prefabricated reinforced components of autoclaved aerated concrete

[24] EN 13501-1:2007 +A1:2009 Fire classification of construction products and building elements. Classification using test data from reaction to fire tests

[25] EN 12667:2001 Thermal performance of building materials and products. Determination of thermal resistance by means of guarded hot plate and heat flow meter methods. Products of high and medium thermal resistance

[26] EN 10088-5:2009 Stainless steels. Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes

[27] EN ISO 6988:1994 Metallic and other non-organic coatings – Sulphur dioxide test with general condensation of moisture

[28] EN 1990:2002/A1:2005 Eurocode - Basis of structural design

[29] EN 16383:2016 Thermal insulation products for building applications - Determination of the hygrothermal behaviour of external thermal insulation composite systems with renders (ETICS).

[30] EN 10244-2:2009 Steel wire and wire products - Non-ferrous metallic coatings on steel wire - Part 2: Zinc or zinc alloy coatings

[31] EN 990:2003 Test methods for verification of corrosion protection of reinforcement in autoclaved aerated concrete and lightweight aggregate concrete with open structure

[32] ETAG 004: Guideline for European Technical Approval of External Thermal Insulation Composite Systems with Rendering, February 2013

[33] EN 12524:2000 Building materials and products - Hygrothermal properties - Tabulated design values

[34] EN 1946 Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties

Part 1: Common criteria:1999

Part 2: Measurements by the guarded hot plate method:1999

Part 3: Measurements by the guarded heat flow meter method: 1999

Part 4: Measurements by hot box methods:2000

[35] EN 1934:1998 Thermal performance of buildings - Determination of thermal resistance by hot box method using heat flow meter – Masonry

[36] EN 10204:2004 Metallic products. Types of inspection documents

[37] EN 12090 :2013 Thermal insulating products for building applications. Determination of shear behaviour

ANNEX A - METHODS OF THE INJECTED ANCHOR TESTING

The pull-out tests shall be performed based on appropriate application of the principles of the EAD 330196-01-0604 [6], Annex A.

A.1. TENSILE TESTS

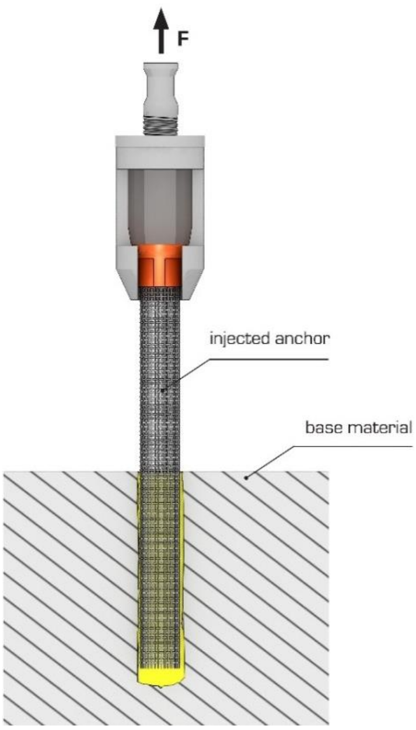


Figure A.1:
Tests for determination of resistance in base material under tensile load

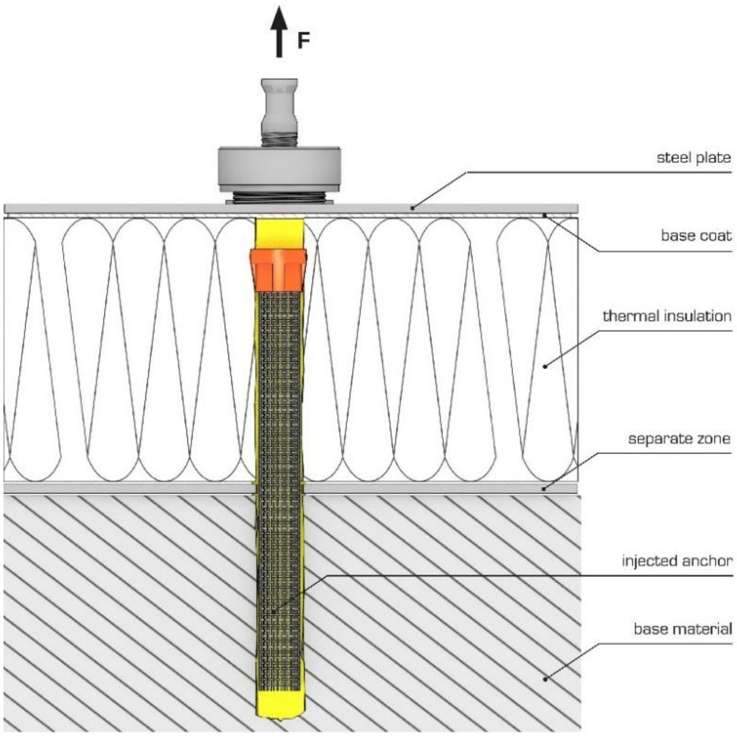


Figure A.2:
Tests for determination of resistance under tensile load without the effect of expansion zone

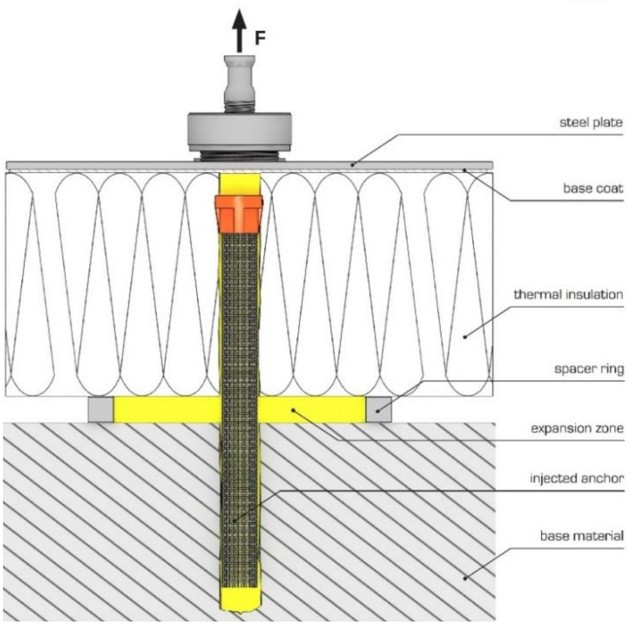


Figure A.3: Tests for determination of resistance under tensile load with the effect of expansion zone

Notes:

The dimensions of the thermal insulation testing block must be defined in such a way, as not to delaminate the thermal insulation.)

The spacer ring shall be used to determine the effective test area. The thickness and inside diameter of the spacer ring shall be stated based on:

- *variability of tests result ≤ 15%.*
- *resistance of the anchor without expansion zone with influence of strength of expanding filling material shall correspond to resistance of the anchor with expansion zone tested with spacer ring*

When the filling material is manufactured from polyurethane foam, the recommended thickness of the spacer ring is 8 mm and the recommended inside diameter of the spacer ring is 80 - 100 mm.

A.2. DYNAMIC WIND UPLIFT TEST

The anchors shall be positioned in such a way, that each anchor transfers the load applied to an area of the same size.

Due to the compressibility of the thermal insulation layer, the anchors count below the edge of the chamber can be increased.

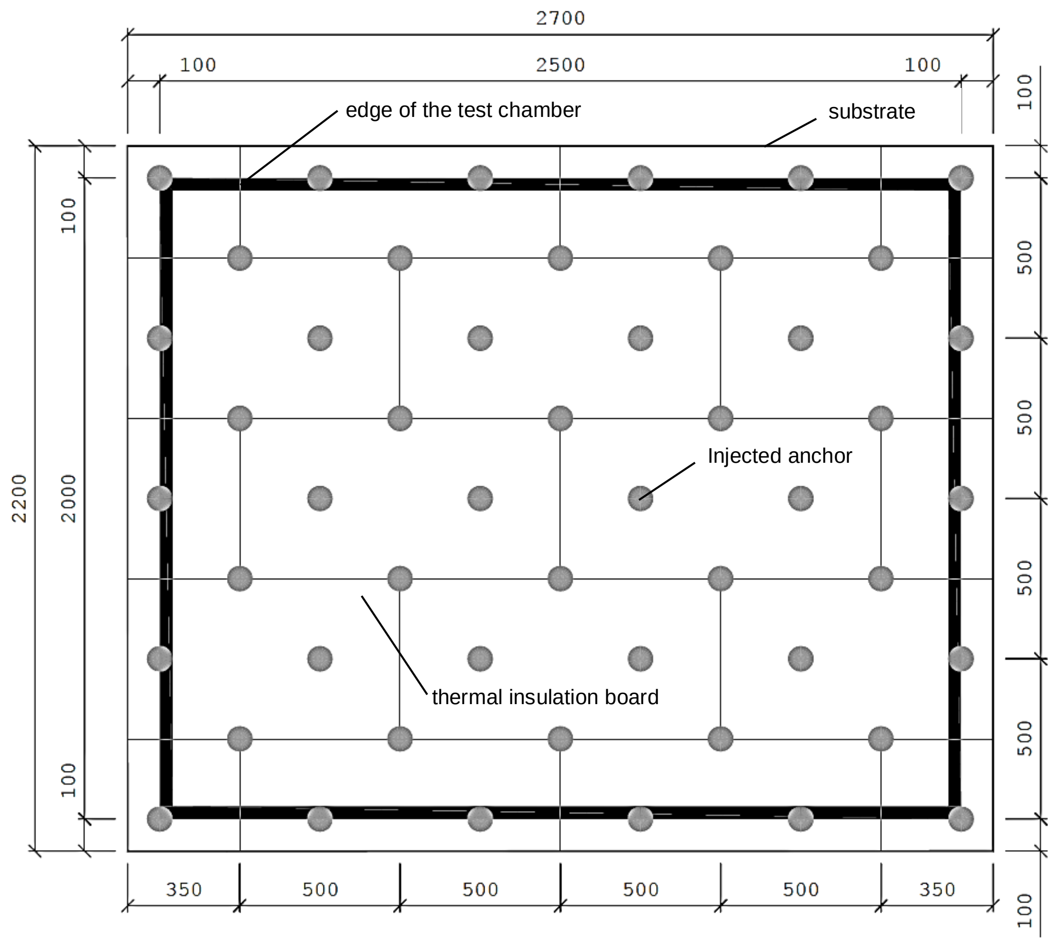
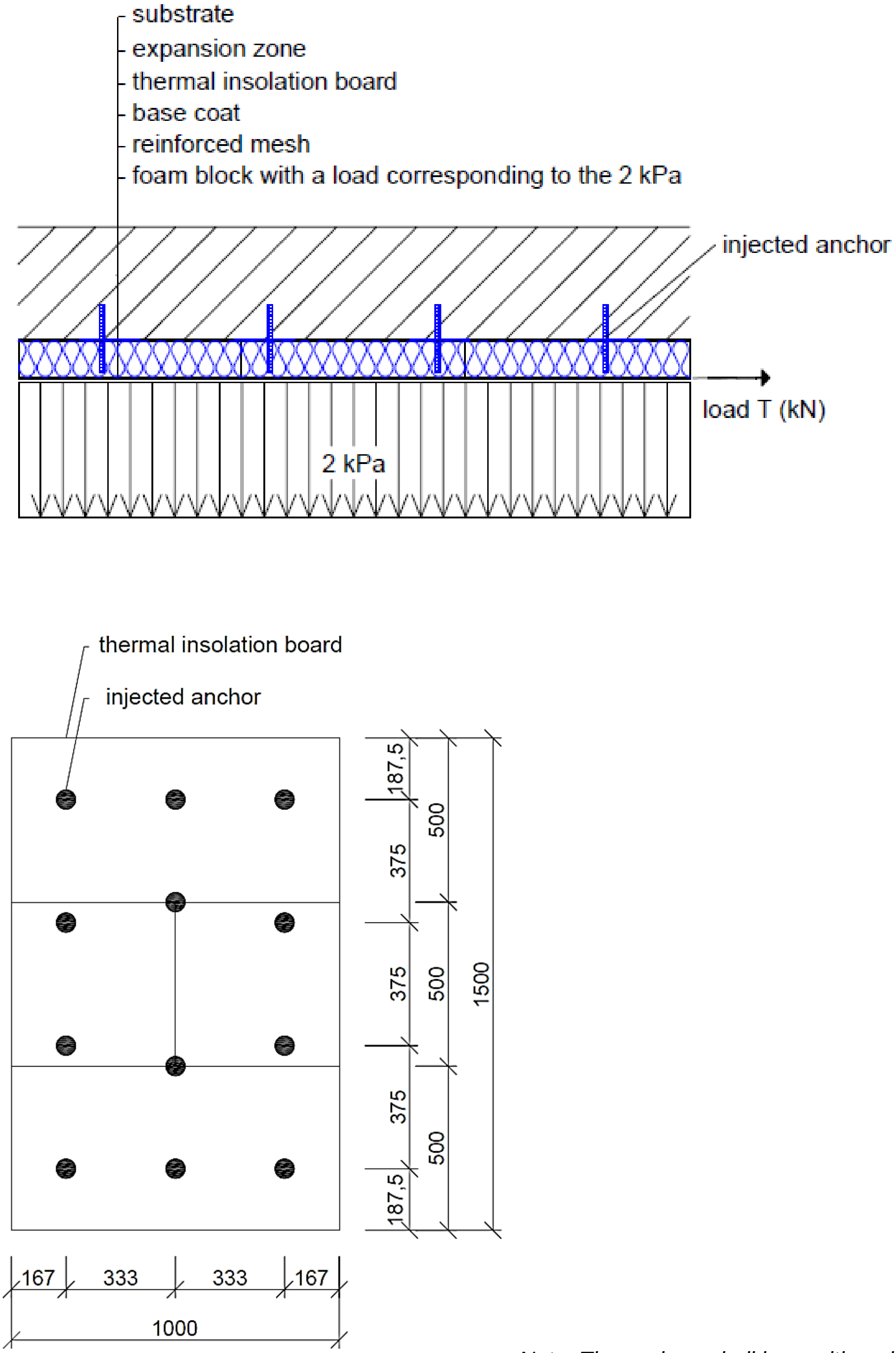


Figure A.4: Dynamic wind uplift test - example of setting of the insulation boards and anchors

A.3. SHEAR TEST



Note: The anchors shall be positioned in such a way, that each anchor transfers the load applied to an area of the same size.

Figure A.5: Shear resistance test - Example of setting of the insulation boards and anchors

ANNEX B - POINT THERMAL TRANSMITTANCE OF ANCHORS

The correct assessment of the thermal performance of an ETICS assumes that the effect of anchors used to fix the ETICS to the substrate is known. It generally applies that each anchor in the ETICS acts as thermal bridge and an increased heat loss occurs in the sphere of influence of the anchor. The extent of the heat loss depends on the construction of the wall and the thermal properties of the anchor: The higher the thermal resistance of the undisturbed wall, the higher the influence of the anchors related to the heat transfer coefficients of the wall.

The characteristic value of the thermal properties of an anchor is the point thermal transmittance χ of the anchor. This value is not a product constant but a value depending on the thermal conductivities and thicknesses of the substrate and the insulating layer. To simplify the procedure the χ-value can be determined in the most unfavourable substrate, where the anchor may be used according to the European Technical Assessment. Alternatively the χ-value can be determined and declared for each base material group separately. The point thermal transmittance χ can increase or decrease with increasing thickness of the insulating material depending on the type of anchor.

The point thermal transmittances χ should be listed for thicknesses of the insulating of 100 mm.

B.1 Specific terms

χ	=	point thermal transmittance of an anchor [W/K]
$\chi_{(100\text{ mm})}$	=	point thermal transmittance of an anchor for insulating layer thickness of 100 mm [W/K]
h	=	insulating layer thickness [mm]
U_c	=	modified heat transfer coefficient of the wall (with insulating layer and anchor) [W/(m^2.K)]
U	=	heat transfer coefficient of the wall with ETICS, without thermal bridges [W/(m^2.K)]
n	=	number of anchors per m^2 [1/m^2]
R_{se}	=	external heat transfer resistance [W/(m^2.K)]
R_{si}	=	internal heat transfer resistance [W/(m^2.K)]
R_P	=	equivalent thermal resistance of the test specimen [W/(m^2.K)]
A	=	cross cut end of the relevant test cuboid, vertical to the heat flow [m^2]
ΔT	=	temperature difference between internal and external temperature [K]
θ_{se}	=	external temperature [°C]
θ_{si}	=	internal temperature [°C]
L^{3D}	=	thermal coupling coefficient for 3-dimensional calculation [W/K]

B.2 ASSESSING OF POINT THERMAL TRANSMITTANCES

B.2.1 Determination of point thermal transmittances

The point thermal transmittance χ results from:

$$\chi = \frac{Uc - U}{n}$$

The calculated value will be rounded to four decimal places.

B.2.2 Determination of the nominal value

The nominal value of the point thermal transmittance χ will be determined as $\chi_{(h_{fix})}$ [W/K] for the insulating layer thickness according to the manufacturers specification or as $\chi_{(100\text{ mm})}$ [W/K]. The nominal value of the point thermal transmittances has to be rounded upwards and shown in the following steps in W/K: 0 / 0,001 / 0,002 / 0,003 / 0,004 / 0,006 / 0,008. The step "0 W/K" may be taken, if the peak value of the point thermal transmittance χ in the considered range is smaller than 0,0005 W/K. In the ETA for the anchor the following note shall be recorded for the step "0 W/K": "The thermal bridge effect of the anchor is smaller than 0,0005 W/K and can therefore be neglected in the calculation".

B.2.3 Description of the nominal value

The nominal value of the point thermal transmittance χ has to be given for the most unfavourable base material group. The nominal values includes all base material groups, with which the anchor might be used. The area of insulating layer thickness for which the nominal value is valid is stated in brackets behind the "χ". Indexing of the base material groups is optional when the nominal value is determined from base material group a.

B.3 DETAILS OF METHOD AND CRITERIA FOR ASSESSMENT

B.3.1 General

The determination of the point thermal transmittance (χ-value) can be realized by measurement carried out for the reference construction described in follow. The point thermal transmittance χ results from calculation according to section B.2.1 with the heat transfer coefficient Uc of the disturbed construction of wall determined by means of measurement.

B.3.2 Test sample

B.3.2.1 Reference construction

For determination of the point thermal transmittance χ the following reference construction is used as basis:

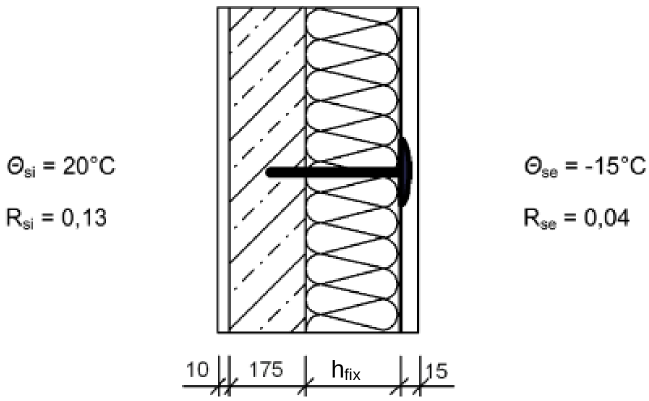


Figure 3.1: Drawing of the reference construction (not full-scale)

The anchor has to be arranged according to the installation situation indicated by the manufacturer. The determinations concerning the building component layers remain untouched. For the building component layers the characteristic values of the material according to EN 12524 [33] are to be used:

Table B.3.1 Characteristic design values of the materials of the reference construction

Building component layer	Design value of thermal conductivity [W/(m·K)]	Thickness of the layer [mm]
(1) interior plaster: gypsum plaster without aggregate	0,57	10
(2) substrate	see Table B.3.2	175
(3) insulating layer	0,035	h_{fix} or 100 mm
(4) external rendering: lime-cement plaster	1,0	15

The point thermal transmittance x has to be determined for the most unfavourable substrate, with which the anchor may be used according to the European Technical Assessment. Alternatively the x-value can be determined and declared for each base material group separately. Only base material groups, in which the anchor may be used according to the ETA, might be used for calculation. A determined value covers all substrates with a lower thermal conductivity also. When selecting normal weight concrete as the substrate for determination, the determined value may cover all base material groups.

Table B.3.2 Characteristic design values of the base material groups

Base material group	Description	Design value of thermal conductivity [W/(m·K)]
A	Normal weight concrete	2,30
B	Solid masonry	1,20
C	Hollow or perforated masonry	0,56
D	Lightweight aggregate concrete with open structure	0,36
E	Autoclaved aerated concrete	0,16

B.3.2.2 Anchor properties

The thermal conductivities of the anchor materials are to be assessed according to EN 12524 [33] or ISO 10456 [5]. The dimensions are to be determined by means of a test specimen or they are to be taken from the manufacturer's technical documentation.

B.3.2.3 Boundary conditions

The heat transfer resistances result according to ISO 6946 [4] for the horizontal thermal conductivity:
R_{se} = 0,04 (m^2.K)/W
R_{si} = 0,13 (m^2.K)/W
For the measurement applies:
The temperature difference between inside and outside shall be ΔT = 35 K
(e.g.: θ_{se} = -15 °C ; θ_{si} = 20 °C).
The edge surfaces of the test specimen are to be considered as adiabatic.

B.3.3 Measurement

The determination of the thermal transmittance Uc must be determined in accordance with EN 1946, Part 1 to 4 [34]. The measurement can be realised according to EN ISO 8990 [6] or EN 1934 [35]. A reference test specimen is to be used according to section B.3.2. The thermal transmittance U of the undisturbed wall is to be measured according to the same method as for the thermal transmittance U_c.

Note: When placing the anchor, the distance to the edge and between the anchors should not fall below 300 mm.

ANNEX C - TEST METHODS FOR FILLING MATERIAL

This Annex specifies test methods for one component PUR foams used as filling material of injected anchors for thermal insulation boards. Other filling materials are not covered by this Annex. If not determined otherwise, the test procedures shall be performed at (23 ± 2) °C and (50 ± 5) % RH (standard conditions). The bottle/can shall be shaken at least 20 times before application. The first approximately 100 g of foam is discarded by spraying. The technique of application (straw/gun) shall be as given in the manufacturer's application instructions. If not determined otherwise (either in the test procedure description or manufacturer's instructions), the spray speed is from 100 to 200 mm/s. For the purpose of identification the time between production date and testing has to be taken into account.

C.1 DENSITY

Required tools:

- PE-foil
- Sharp and clean knife (cutting knife)
- Balance with an accuracy of 0,1 g
- Measuring cylinder with an increment of 10 ml
- Water

Preparation of test specimens:

A full bottle/can shall be used for preparation of test samples. Cylindrically shaped beads with diameter of 20 to 30 mm and about 200 mm length are sprayed on a PE-foil from a distance of approximately 10 mm and left to harden. After 24 hours minimum, the beads shall be cut on both sides to a length of 100 to 150 mm.

Test procedure:

The mass of the samples is measured in grams (**m**) with an accuracy of 0,1 g. A measuring cylinder having an increment of 10 ml is filled with water and a reference volume (**V_0**) is set. By pressing a cutting knife into one end of the bead, the sample is submerged into the measuring cylinder. The increased volume (**V_1**) is read off immediately.

Calculation:

The density of the PUR-Foam is determined by using the following formula:

$$\rho = \frac{m}{\mathrm{V1} - \mathrm{V0}} * 1000$$

The results shall be expressed in kg/m³. The test result shall be calculated as the mean of at least 5 single values.

C.2 TEST METHOD FOR BOND STRENGTH OF FOAM ADHESIVES

Required tools:

- Substrate *(concrete slab according to this EAD, clause 1.2.1, thickness: 40-80 mm)*
- Insulation product *(dimensions*: 50 mm × 50 mm × min. declared thickness)*
- Spacers (any non-sticking material, used to ensure a consistent gap between the specimens of insulation product)
- Weights or clamps, if substrate material is not heavy enough to ensure stability of test sample
- Cutting knife
- Tie anchors to connect the insulation product to a testing machine
  (e.g. made of square metal plates)

- Calliper (accuracy ≤ 0,1 mm) for measuring sample surface area
- tensile testing machine

Preparation of test samples:

The foam is sprayed without interruption from a distance of approximately 10 mm onto the surface of the insulation product which shall be affixed to the substrate. The diameter of the beads shall be from 20 mm to 30 mm without space between them. The foam shall be applied in longitudinal strips or in serpentine pattern (Figure C.2.1). It is very important that, while spraying the next bead(s), the foam is not sprayed into the already applied foam bead(s). The surface shall be fully covered with foam.

If not determined differently (see Test conditions, 'Modification of processing time'), the sample components shall be assembled together after 180±10 seconds from finishing the foam application by firmly pressing the concrete slab onto the foam. If not determined differently (see Test conditions, Modification of foam thickness) the thickness of foam shall be (8 ± 1) mm. The foam has to be able to expand to the lateral sides.

If not determined differently (see Test conditions) the samples are stored for at least 1 day (24 h) at the standard conditions. The required thickness is controlled by clamping the samples or using weights.

After one day curing, tie anchors may be affixed to the insulation product by using a suitable adhesive (see Figure C.2.6), the adhesive may need one day for curing.

Samples shall be cut to the specified dimensions (50 mm x 50 mm) after curing in case larger EPS plates are used.

Figures on the bond strength test - specimen preparation

Figure C.2.1: Spray pattern

Figure C.2.2: Set-up with spacers (ex. 1)

Figure C.2.3: Set-up with spacers (ex. 2)

Figure C.2.4: Set-up with spacers (ex. 3)

Figure C.2.5: Test sample during curing (48hrs)

Figure C.2.6: Tie anchors

Figure C.2.7: Cutting of the surplus

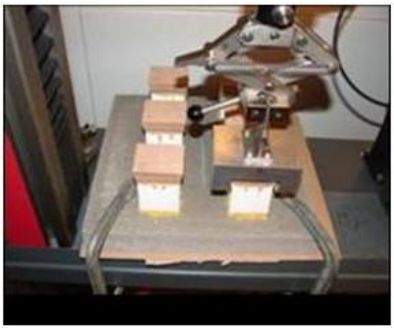


Figure C.2.8: Test set-up in test machine

Test procedure:

The surplus foam shall be carefully cut off (see Figure C.2.7). The tensile test (pull-off test) is performed on at least five test samples at a tension speed of (10 ± 1) mm/min. After testing the sample surface (s) shall be measured in mm², and the test results β_i are calculated by the formula

$$\beta_i = F_i/s_i$$

The test results (individual and mean values) are expressed in N/mm² (MPa) along with description of the failure mode. The way of application (straw/gun, application pattern) shall be given in the test report.

Test conditions

C.2.1 Standard application conditions

The tensile test is carried out at standard conditions (23 ± 2) °C / (50 ± 5) % RH with standard application conditions:

- Completion of test samples within 180±10 seconds
- Thickness of foam: (8 ± 1) mm

C.2.2 Modification of application conditions

C.2.2.1 Modification of foam thickness

The tensile test is carried out at standard conditions (23 ± 2) °C / (50 ± 5) % RH with a thickness of foam of (15 ± 1) mm by using appropriate spacers.

C.2.2.2 Modification of processing time (open time)

The tensile test is carried out at standard conditions (23 ± 2) °C / (50 ± 5) % RH with the standard thickness of foam of (8 ± 1). The time between spraying the beads and completion of test samples shall be in accordance with the maximum open time declared by the manufacturer.

C.2.2.3 Modification of temperature

Two tensile tests are carried out with the standard thickness of foam of (8 ± 1) mm. For preparation of test samples the following conditioning for substrate, insulation product, application, foam and curing is taken into account:

- Low temperature: (5 ± 2) °C, no RH is required, if not declared differently by the manufacturer
- High temperature: (35 ± 2) °C, (30 ± 5) % RH, if not declared differently by the manufacturer

The duration of storage must ensure the required temperature of all components. After preparation and curing for 24 hours under the defined conditions, the samples are tested without delay at standard conditions (23 ± 2) °C / (50 ± 5) % RH.

C.3 TEST METHOD FOR SHEAR STRENGTH AND SHEAR MODULUS OF FOAM ADHESIVES

Required tools:

- Two chipboard plates, dimensions: 140 mm x 100 mm x min. 10 mm
- two spacers with the dimensions of 20 mm x 100 mm, thickness 8 ± 1 mm, fixed on each end of the test sample on one chipboard
- screw clamps or weights

Preparation of test samples

The foam is sprayed without interruption from a distance of approximately 10 mm onto the surface of the chipboard, onto which the spacers are temporarily fixed. The diameter of the beads shall be 20 to 30 mm without space between them. The foam shall be applied in longitudinal strips or in serpentine pattern. The surface (100 mm x 100 mm) shall be fully covered with foam. The test sample shall be completed within 180±10 seconds by pressing the second chipboard firmly onto the first chipboard until it touches the spacers. During curing of at least 2 days at standard conditions, the required thickness (8 ± 1 mm) is controlled by clamping the samples or using weights. Before testing, the spacers shall be removed and the overlapping foam shall be cut off.

Test procedure:

The test is carried out according to EN 12090 [37] on at least 3 samples at the speed of (3 ± 0,5) mm/min.

The test results (individual and mean values) shall be expressed in kPa according to EN 12090 [37] (chapter 8).

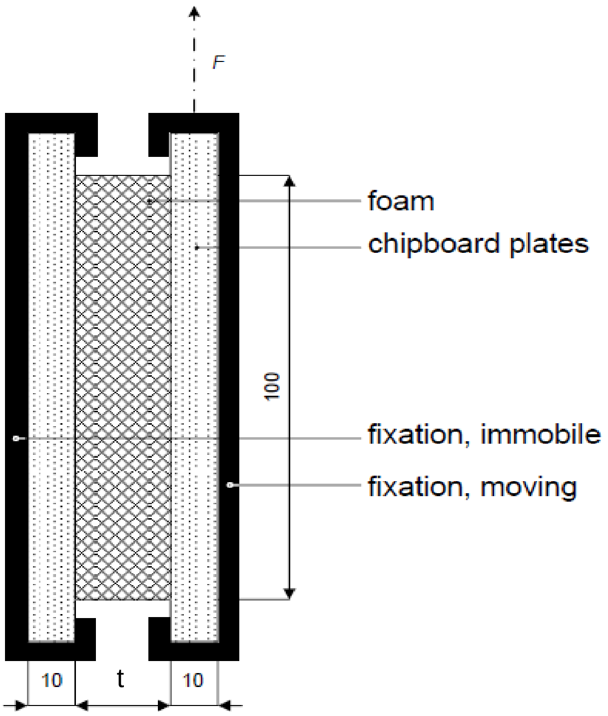


Figure C.3.1: Test sample ready for test