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EAD **330196-01-0604-v01**

May 2018

European Assessment Document for

Screwed-in plastic anchors for fixing of external thermal insulation composite systems with renderings or insulation products on bottom side of ceilings

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

This EAD is a variant to EAD 330196-01-0604[1] due to its added use of screwed-in plastic anchor for fixing external thermal insulation composite systems with renderings (hereinafter ETICS) or insulation products on the bottom side of ceilings. For this reason, products on substrates made of concrete and regarding the tension loads resulting from the dead load of the ETICS or insulation products are assessed according to this EAD.

EAD 330196-01-0604 clause 1.1 for screwed-in plastic anchor (herein after anchor) applies.

Because the assessment of characteristic pull-through resistance depends on the insulation material, it shall be available on the market and described in the ETA as part of the intended use of the anchor (see clause 1.2.1). Therefore, the insulation material is part of the product assembly and shall be necessarily used within the product assessment process. It shall be stated/described in ETA.

Minimum data for describing the insulation products (also the one in ETICS) to be used are the type of material, dimension, density or weight per square meter, tensile strength perpendicular to the faces and compression strength. Exceptionally, when justified to avoid ambiguities, these data may be accompanied by adding the trade name of the insulation product.

In addition to the information given in clause 1.2.1 of EAD 330196-01-0604 regarding the UV-protection for anchors used with ETICS, the anchors used with insulation products shall include UV-protection cover made of stainless steel or carbon steel with coating which is resistant in corrosion conditions class at least C3 according to EN ISO 9223 and EN ISO 12944-2 Table 1. This cover may be replaced if in maintenance tasks damages in cover coating, corrosion or mechanical damages are present.

Intended use of the anchor covered by this EAD is shown on Figures 1.1.1 and 1.1.2.

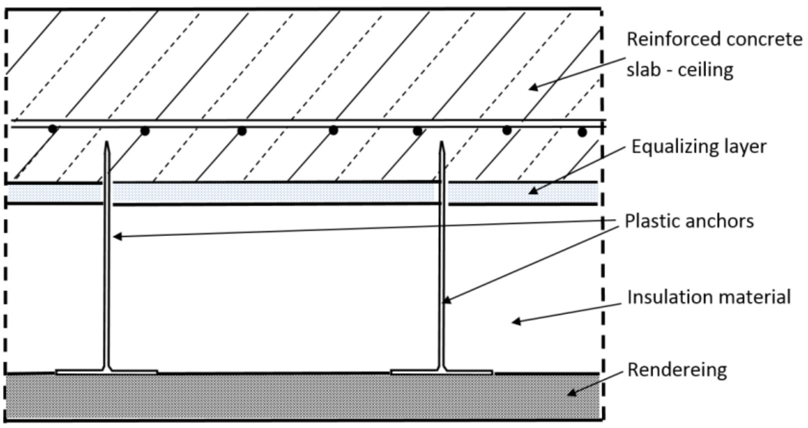


Figure 1.1.1. Installed anchors with insulation material and rendering – overall view.

1 All undated references to standards in this EAD are to be understood as references to the dated versions listed in chapter 4.

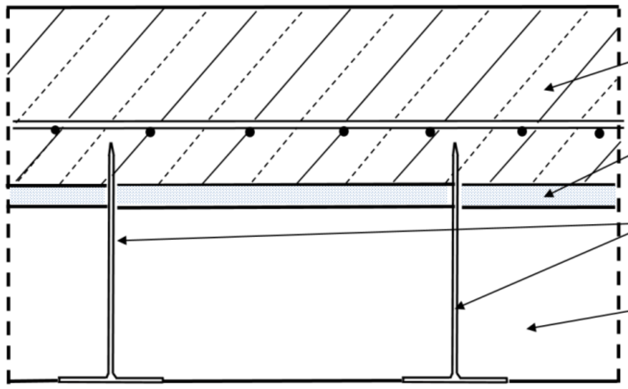


Figure 1.1.2. Installed anchors with insulation material and without rendering – overall view.

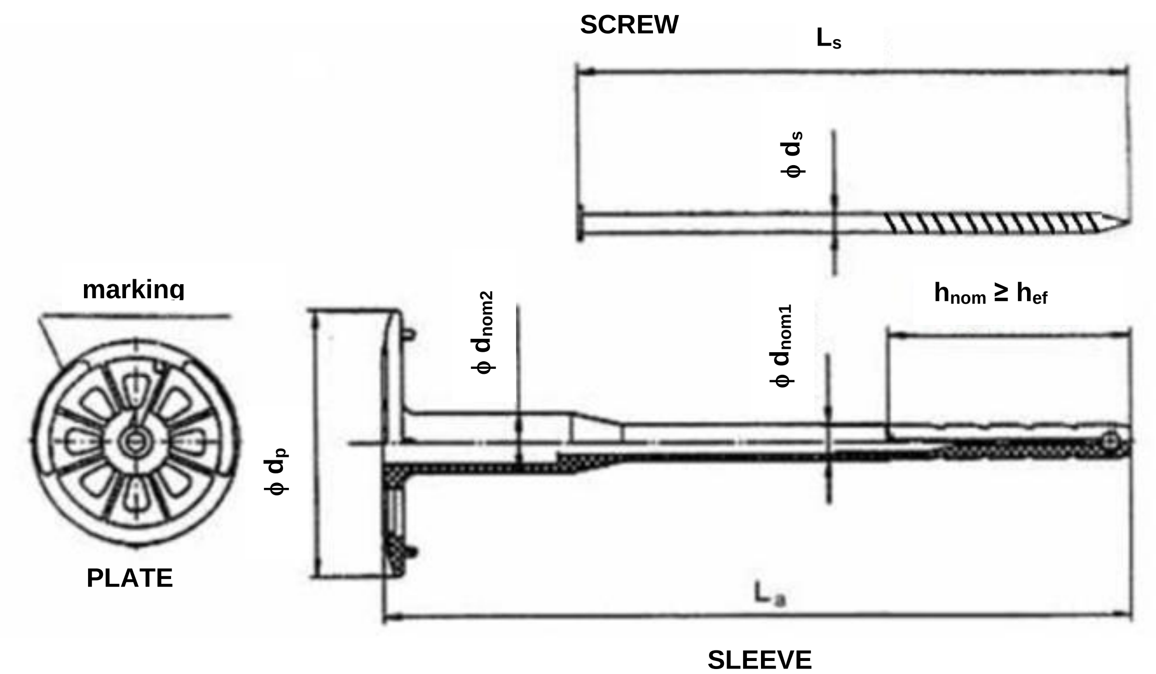
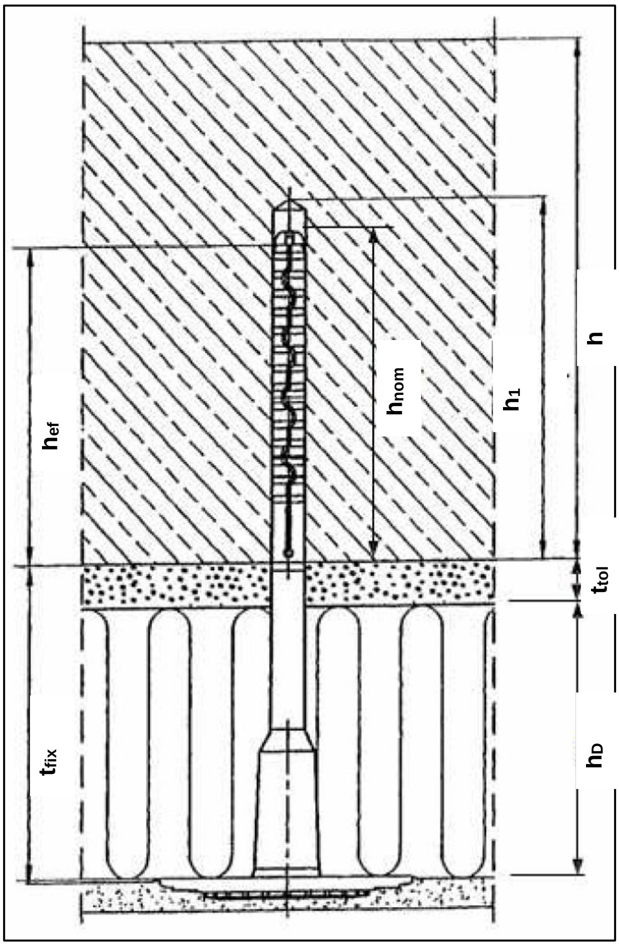


Figure 1.1.3. Components of anchor.



Legend:
h ....thickness of member (ceiling)
h_{ef} ....effective anchorage depth
h_1 ....depth of drilled hole to deepest point
h_{nom}......overall anchor embedment depth on the base material ($h_{nom} \geq h_{ef}$)
h_D.........thickness of insulation material
t_{fix} ....thickness of fixture
t_{tol} ....thickness of equalizing layer for compensation o tolerances of non-load bearing coating

Figure 1.1.2. Installed anchor.

1.2 Information on the intended use of the construction product

1.2.1 Intended use

EAD 330196-01-0604 clause 1.2.1. applies. However, in addition, this EAD variant covers:

- Anchors made of only virgin material to be used on the bottom side of ceilings for fixing ETICS or insulation products that are purely mechanically fixed or mechanically fixed with supplementary adhesive, as it is defined in clause 1.1 of EAD 040083-00-0404.
- The ceilings intended to be used are made of non-cracked normal weight concrete (defined as base material group A according to Table 1.1 of EAD 330196-00-0604) and cracked normal weight concrete.

Figure 1.3 of EAD 330196-01-0604 is applicable although rotated 90º in the clockwise direction.

1.2.2 Working life/durability

EAD 330196-01-0604, clause 1.2.3. applies.

1.3 Specific terms used in this EAD

1.3.1 General

EAD 330196-01-0604, clause 1.3.1 applies.

Additional term:

product assembly = anchor and insulation material.

1.3.2 Anchors

EAD 330196-01-0604, clause 1.3.2 applies.

Additional terms for screw:

d_s	=	diameter of the anchor.
L_s	=	length of the anchor.

1.3.3 Materials

EAD 330196-01-0604, clause 1.3.3 applies for the base material (substrate).

Additional specific terms for insulation product (also the one in ETICS):

TR	=	nominal tensile strength perpendicular to insulation surface defined by the manufacturer of insulation product.
$T_{R,test}$	=	actual (tested) tensile strength perpendicular to insulation panel surface determined according to EN 1607.

1.3.4 Assessment of tests

EAD 330196-01-0604, clause 1.3.4 applies.

Additional specific terms for assessment:

α_{vPT}	=	reduction factor of variation in pull-through tests with insulation plates.
α_{vFOAM}	=	reduction factor of variation in static foam block tests with insulation plates.
δ_{sh-h}	=	short-term displacement (movement) of the anchor at the surface of the horizontal base material relative to the surface of the base material in direction of the load (tension) outside the failure area. The displacement includes the steel and base material deformations and a possible anchor slip.
δ_{lg-h}		long-term displacement (movement) of the anchor at the surface of the horizontal base material relative to the surface of the base material in direction of the load (tension) outside the failure area. The displacement includes the steel and base material deformations and a possible anchor slip.
X-value	=	point thermal transmittance of a screwed-in plastic anchor [W/K].
X (h_{min})	=	point thermal transmittance of an anchor for the minimum insulating layer thickness according to to the manufacturers specification [W/K].
X (150 mm)	=	point thermal transmittance of an anchor for insulating layer thickness of 150 mm [W/K].
X (h_{max})	=	point thermal transmittance of an anchor for the maximum insulating layer thickness according to the manufacturers specification [W/K].

X (h ≤ 150)	=	nominal value of the point thermal transmittance of an anchor in the range of minimum insulating layer thickness up to and including 150 mm [W/K].
X (h > 150)	=	nominal value of the point thermal transmittance of an anchor in the range of 150 mm up to the maximum insulating layer thickness [W/K].
X (h_{min} – h_{max})	=	value of the point thermal transmittance of an anchor in the entire range of the insulating layer thickness [W/K].
θ_{se}	=	external temperature [°C].
θ_{si}	=	internal temperature [°C].
A	=	cross-cut end of the relevant test cuboid, vertical to the heat flow [m²].
A_{panel}	=	surface of insulation panel in static foam block test [m²].
h	=	insulating layer thickness of the thermal insulation product [mm].
h_{min}	=	minimum insulating layer thickness according to the manufacturer instruction [mm]
h_{max}	=	maximum insulating layer thickness according to the manufacturer instruction [mm].
L^{3D}	=	thermal coupling coefficient for 3-dimensional calculation [W/K].
n	=	number of anchors per m² [1/m²].
n_{panel}	=	number of anchors per insulation [m²].
$N_{Rk,sh}$	=	short-term characteristic resistance for single anchor under tension load.
$N_{Rk,lg}$	=	long-term characteristic resistance for single anchor under tension load.
$N_{Rk,lg-a}$	=	long-term characteristic resistance for single anchor under tension load assumed by the manufacturer [kN].
$N_{Rk,non-cracked}$	=	characteristic tensile resistance in non-cracked concrete – determined according to EAD 330196-01-0604 [kN].
$N_{Rk,panel,sh}$	=	characteristic resistance for an insulation product under short-term tension load to be indicated in ETA [kN/m²].
$N_{Rk,panel,lg}$	=	characteristic resistance for an insulation product under long-term tension load to be indicated in ETA [kN/m²].
R	=	pull-through force [N].
R_u	=	failure load in a pull-through test [N].
$R_{u,m}$	=	mean failure load of a test series of pull-through test [N].
$R_{u,m,foam}$	=	mean failure load of a test series of static foam block test [N].
$R_{5\%}$	=	5 %-fractile of failure loads in a test series of pull-through test [N].
$R_{5\%,foam}$	=	5 %-fractile of failure loads in a test series of static foam block test [N].
R_{se}	=	thermal resistance of external surface [(m²·K)/W].
R_{sh}	=	short-term characteristic pull-through resistance defined for one anchor [N].
R_{lg}	=	long-term characteristic pull-through resistance defined for one anchor [N].
$R_{insul-panel,sh}$	=	short-term characteristic pull-through resistance for an insulation product [kN/m²].
$R_{insul-panel,lg}$	=	long-term characteristic pull-through resistance for an insulation product [kN/m²].
R_{si}	=	thermal resistance of internal surface [(m²·K)/W].
R_P	=	equivalent thermal resistance of the test specimen [(m²·K)/W].
ΔT	=	temperature difference between internal and external temperature [K].
U_c	=	modified thermal transmittance of the wall (with thermal insulation product and anchor) [W/(m²·K)].
U	=	thermal transmittance of the wall with thermal insulation product, without thermal bridges [W/(m²·K)].

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of the anchors for fixing of ETICS or insulation products on bottom side of ceilings is assessed in relation to the essential characteristics.

Table 2.1.1 Essential characteristic of the product and assessment methods and criteria for 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	Not assessed in this EAD [2]		
Basic Works Requirement 4: Safety in use			
1	Characteristic load bearing capacity	EAD 330196-01-0604, clause 2.2.1	Level: - N_{Rk} [kN] - c_{min} [mm] - s_{min} [mm]
2	Characteristic load bearing capacity on horizontal substrate - Characteristic resistance for an insulation product under short-term tension load - Characteristic resistance for an insulation panel under long-term tension load	2.2.1	Level: - $N_{Rk,panel,sh}$ [kN/m²] - $N_{Rk,panel,lg}$ [kN/m²]
3	Displacement	EAD 330196-01-0604, clause 2.2.3	Level - N [kN] - $\Delta\delta_N$ [mm] -

2 The anchorages are used to fix a cladding or component which is not class A1 and the plastic parts of the anchor are located in the drilled hole of the base material (concrete or masonry) and fixture. Where the plastic parts of the anchor are embedded in concrete or masonry it may be assumed that these plastic parts do not make any contribution to fire growth or to the fully developed fire and they have no influence to the smoke hazard. In the context of this end use application the plastic parts embeded in concrete can be considered to satisfy any reaction to fire requirements. Where the plastic parts of the anchor are embedded in the cladding component, which is not class A1 the plastic parts can be considered not to influence the reaction to the class of the cladding component.

No	Essential characteristic	Assessment method	Type of expression of product performance
	Basic Works Requirement 2: Safety in case of fire		
4	Displacement on horizontal substrate - Tension load - Short-term displacement - Long-term displacement	2.2.2	Level - N_h [kN] - $\delta_{sh,h}$ [mm] - $\delta_{lg,h}$ [mm]
5	Plate stiffness - Diameter of the anchor plate - Load resistance of the anchor plate - Plate stiffness	EAD 040083-00-0404, Annex G[3]	Level - Diameter of an anchor plate [mm] - Load resistance of the anchor plate [kN] Plate stiffness [kN/mm]
6	Characteristic pull-through resistance: - Short-term characteristic pull-through resistance - Long-term pull-through resistance	2.2.3	Level - $R_{insul\text{-}panel,sh}$ [kN/m^2] - $R_{insul\text{-}panel,lg}$ [kN/m^2]
	Basic Works Requirement 6: Energy economy and heat retention		
7	Thermal transmittance - Point thermal transmittance of an anchor - Insulation layer thickness of the ETICS	Annex A[4]	Level - χ-value [W/K] - h_D [mm]

3 This reference leads to exactly same assessment method as the reference to row 4 in Table 2.1 in the EAD 330196-01-0604

4 This reference leads to exactily same assessment method as the reference to row 5 in Table 2.1 in the EAD 330196-01-0604

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

EAD 330196-01-0604, clause 2.2, introductive part for anchor applies.

2.2.1 Characteristic load bearing capacity on horizontal substrate

This characteristic is only applicable to anchors intended to be used on the bottom side of ceilings.

The whole test program for the base material A (according to Table 2.2 in EAD 330196-0604) (normal weight concrete) according to lines 1, 3 to 8 of Table 2.3 in EAD 330196-01-0604 applies with the following additional aspects:

- Characteristic resistance for an insulation product under short term tension load ($N_{Rk,panel,sh}$) for normal-weight cracked and non-cracked concrete. See clause 2.2.1.5.5.
- Characteristic resistance for an insulation product under long-term tension load ($N_{Rk,panel,lg}$) only for normal-weight non-cracked concrete. See clause 2.2.1.5.6.

Anchors usually have only one anchorage depth. If the anchor has more than one possible anchorage depth, then tests shall be done at each specified depth. Alternatively, for reducing the number of tests, the most unfavourable depth (minimum depth as defined in the MPII) shall be tested, in this case the result shall also apply to more favourable depths.

Minimum edge distance (c_{min}) and minimum spacing (s_{min}) shall be defined either as the values already defined in clause 1.1 of EAD 330196-01-0604 or other greater values defined in the Manufacturer's product Installation Instructions (MPII). Defined minimum edge distance (c_{min}) and minimum spacing (s_{min}) shall be considered in the tests.

The details of tests are given in EAD 330196-01-0604, Annex A clause A.5 for tests in non-cracked concrete, EAD 330284-00-0604, Annex A clause A2.5.2 for tests in cracked concrete and in EAD 330287-00-0604 clause A2.5.5 for sustained load tests in non-cracked concrete.

Short term characteristic resistance ($N_{Rk,panel,sh}$) [in kN/m^2], long term characteristic resistance ($N_{Rk,panel,lg}$) [in kN/m^2], minimum edge distance (c_{min}) [in mm] and minimum spacing (s_{min}) shall be given in ETA.

2.2.1.1 Tests

The tests according to EAD 330196-01-0604, Table 2.3, shall be carried out in normal-weight non-cracked concrete.

Additional reference and functional tests shall be performed in cracked and non-cracked concrete according to the following Table 2.2.1.1.1.

Table 2.2.1.1.1 Additional tests for characteristic load bearing capacity of anchors in bottom side of ceilings

	Purpose of test	Base material	Crack width	Drill bit	Minimum number of tests per anchor size	Criteria for ultimate load required α[1)]	Remarks to the test procedure described in clause
1	Characteristic resistance in cracked concrete	C20/25	0,2	$d_{cut,m}$	5	-	2.2.1.2
2	Functioning under sustained load	C20/25	0	$d_{cut,m}$	5	≥ 1,0	2.2.1.3
3	Functioning in cracked concrete	C20/25	0,35	$d_{cut,max}$	5	≥ 0,75	2.2.1.4

Note:

1) Calculated according to equations 2.2.1.5.3.1 and 2.2.1.3.2 respectively.

All tests described in Table 2.2.1.1.1 shall be performed under normal ambient temperature (+21 ± 3) °C and with standard conditioning of plastic sleeve (defined in clause 2.2.2.5 in EAD 330196-01-0604).

2.2.1.2 Reference tension tests in cracked concrete

Reference tension tests are used for assessment of characteristic resistance for an insulation product under short term tension load (equation 2.2.1.5.5.1).

For determination of characteristic resistance of the anchor to action (tension) in cracked concrete, tests specifications according to Table 2.2.1.1.1, line 1, shall be used.

The tension tests shall be performed according to EAD 330284-00-0604, Annex A, clause A.2.

2.2.1.3 Functioning under sustained load

Tests shall be performed in non-cracked concrete. The anchor shall be subjected to a load in accordance to Equation (2.2.1.3.1), which is kept constant (variation ± 5%).

$$N_p = N_{Rk,non\text{-}cracked} / 3 \qquad (2.2.1.3.1)$$

where

$N_{Rk,non\text{-}cracked}$ = characteristic tensile resistance in non-cracked concrete, determined according to EAD 330196-01-0604, Equation (2.14)

The tests shall be carried out over at least 5000 hours for polymeric sleeves of PE (polyethylene), PP (polypropylene) or other polymeric material. They may be stopped after 3000 hours if increments of displacements between 2000 hours and 3000 hours are very low. A very low increment is less than 0,1 mm in average of all 5 tests if all single increments are lower than 0,2 mm.

Tests with at least 3000 hours are sufficient for polymeric sleeves of polyamide PA 6 or PA 6.6 based on current experience with this material.

After completion of the sustained load test, the anchor shall be unloaded. After unloading residual tension test according to EAD 330196-01-0604, Annex A clause A.5 shall be performed.

As a result:

- extrapolated displacement according to equation 2.2.1.5.4.1 and

- α-value from residual tension test which is used in equation 2.2.1.5.5.2, shall be derived according to equations 2.2.1.5.3.1 or 2.2.1.5.3.2, depending on variation of test results

shall be calculated for each test specimen.

Mean extrapolated displacement got from assessment of functioning under sustained load is sub-result for calculation of long-term displacement $\delta l_{g\text{-}h}$ in mm (in paragraph 2.2.2) stated in ETA.

2.2.1.4 Functioning in cracked concrete

Pull-out tests in cracks width 0,35 mm shall be performed with maximum drill bit diameter $d_{cut\ max}$ in low strength concrete (C20/25).

The tension test shall be carried out in accordance with EAD 330284-00-0604, Annex A, clause A2.5.2.

2.2.1.5 Assessment of characteristic load bearing capacity of an anchor

2.2.1.5.1 5 %-fractile of the ultimate loads

EAD 330196-01-0604, clause 2.2.2.13, applies.

2.2.1.5.2 Conversion of ultimate loads to take account of concrete and steel strength

EAD 330196-01-0604, clause 2.2.2.13, applies.

2.2.1.5.3 Criteria valid for tension tests

In all tension tests the following criteria shall be considered:

a) EAD 330196-01-0604, clause 2.2.2.13, “Criteria for all tests” a).

b) In the tests according to Table 2.2.1.1.1, lines 2 and 3, the factor α shall be larger than the value given in the same Table:

$$\alpha = \text{lower value of} \quad \frac{N^t_{Ru,m}}{N^r_{Ru,m}} \qquad (2.2.1.5.3.1)$$

$$\text{and} \quad \frac{N^t_{u,5\%}}{N^r_{u,5\%}} \qquad (2.2.1.5.3.2)$$

where

$N^t_{Ru,m}$; $N^t_{u,5\%}$ = mean (converted if necessary) value or 5 %-fractile, respectively, of the ultimate loads in a test series according to Table 2.2.1.1.1, lines 2 and 3

$N^r_{Ru,m}$; $N^r_{u,5\%}$ = mean (converted if necessary) value or 5 %-fractile, respectively, of failure load in the test for series according to Table 2.2.1.1.1, line 1 for cracked concrete and according to Table 2.3, line 1 in EAD 330196-01-0604 for non-cracked concrete

Equation (2.2.1.5.3.2) is based on test series with a comparable number of test results in both series. If the number of tests in the two series is very different, then Equation (2.2.1.5.3.2) may be omitted when the coefficient of variation of the test series is smaller than or equal to the coefficient of variation of the reference test series. The reference test for test series from Table 2.2.1.1.1, line 3 is test from test series in Table 2.2.1.1.1, line 1. The reference test for test series from Table 2.2.1.1.1, line 2 is the reference tension test in EAD 330196-01-0604, Table 2.3, line 1. Equation (2.2.1.5.3.2) can also be omitted if the coefficient of variation is $v \leq 15$ % in the tests (functional and reference).

If the criteria for the required α (see Table 2.2.1.1.1) are not met in a test series, then the factor α_1 shall be calculated according to rules given in EAD 330196-01-0604, clause 2.2.2.13, equation (2.11).

2.2.1.5.4 Criteria valid for sustained load tests

The displacements measured in the tests shall be extrapolated according to Equation (2.2.1.5.4.1) (Findley approach) to 25 years. The curve fitting shall be based on data sets covering the time frame between 2000 hours and 3000 hours at least.

$$s(t) = s_0 + a \cdot t^b \qquad (2.2.1.5.4.1)$$

where

s_0 = initial displacement under the sustained load at t = 0 (measured directly after applying sustained load)

a, b = constants (tuning factors), evaluated by a regression analysis of displacements measured during sustained load tests, where “a” is the slope of function and “b” is variable in exponential function

The extrapolated displacements shall be less than the mean value of displacements at the load of overcoming the friction resistance in the reference tests in accordance with EAD-330196-01-0604, clause 2.2.2.2, in non-cracked concrete. The load at overcoming the friction resistance shall be evaluated as described in EAD 330499-01-0601, clause A.2.4.1, for the load at loss of adhesion.

If this condition is not fulfilled, the tests shall be repeated at a lower load $N_{p,reduced}$ until requirement is fulfilled.

It is allowed that repeated tests with lower load are not performed for the whole time needed for sustained load test. Minimum needed time for additional tests at reduced load is the time until stabilization of displacement on the straight line but at least 500 h. In this case the displacement after 25 years shall be calculated according to Equation (2.2.1.5.4.2):

$$s(t)_{reduced} = s(t) \times s(N_{p,reduced}) / s(N_{p,required}) \qquad (2.2.1.5.4.2)$$

where

$s(t)$ = extrapolated displacement under the required load, calculated according to Equation (2.2.1.5.4.1)

$s(N_{p,reduced})$ = displacement under reduced sustained load at the time when test is finished (Figure 2.2.1.5.4.1)

$s(N_{p,required})$ displacement under required sustained load at the time when test at reduced sustained load is finished (Figure 2.2.1.5.4.1) p,required

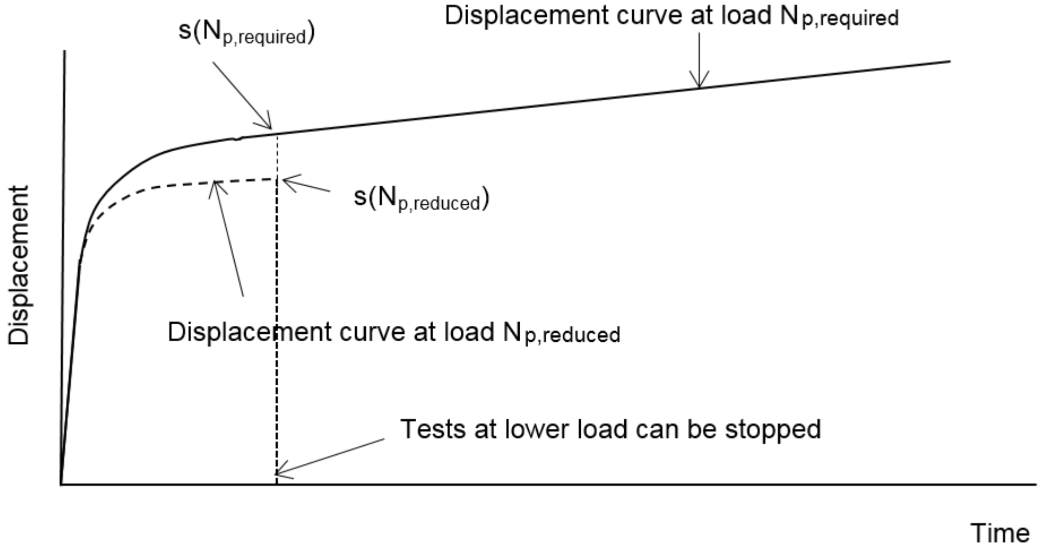


Figure 2.2.1.5.4.1: Criteria for performing tests at lower sustained load $N_{p,reduced}$

2.2.1.5.5 Short-term characteristic resistance for a panel (pull-out of the anchor)

Short-term characteristic resistance for a panel is derived with multiplication of short-term characteristic resistance of a single anchor $N_{Rk,sh}$ and number of anchors per m²:

$$N_{Rk,panel,sh} = N_{Rk,sh} \times n_{panel} \qquad (2.2.1.5.5.1)$$

with

$N_{Rk,sh}$ = short-term characteristic resistance for single anchor under tension load calculated according to Equation (2.2.1.5.5.2)

n_{panel} = number of anchors per m² as indicated in ETA

Short-term characteristic resistance $N_{Rk,sh}$ for single anchor under tension load shall be calculated as follows:

$$N_{Rk,sh} = N_{Rk,0} \cdot \min\alpha_{1\text{-}1} \cdot \min\alpha_{1\text{-}2} \cdot \alpha_v \qquad (2.2.1.5.5.2)$$

where

$N_{Rk,sh}$ = characteristic short-time resistance. These values shall be rounded down to the numbers given in EAD 330196-01-0604, equation (2.14)

$N_{Rk,0}$ = minimum characteristic resistance of reference tension tests according to Table 2.2.1.1.1, line 1 for normal-weight cracked concrete and EAD 330196-01-0604, Table 2.3, line 1 for normal-weight non-cracked concrete.

min $\alpha_{1\text{-}1}$ = minimum value α_1 according to EAD 330196-01-0604, Equation (2.11) with the tests under conditioning and temperature defined in EAD 330196-01-0604, Table 2.3, lines 4 and 5 ($\alpha_{1\text{-}1} \leq 1{,}0$).

min α_{1-2} = minimum value α_1 according to Equations (2.2.1.5.3.1) and (2.2.1.5.3.2) respective with tests under sustained load and functioning in cracked concrete (Table 2.2.1.1.1, lines 2 and 3) and according to EAD 330196-01-0604, Equation (2.11), with tests for functioning depending on the diameter of the drill bit, functioning under repeated loads and functioning under relaxation defined in EAD 330196-01-0604, Table 2.3, lines 3, 6 and 7 ($\alpha_{1-2} \leq 1{,}0$).

α_v = value αv to represent a coefficient of variation of the ultimate loads in the tests larger than 20% (see EAD 330196-01-0604, Equation (2.8); $\alpha v \leq 1{,}0$).

Short-term characteristic resistance for a panel ($N_{Rk,panel-sh}$) in kN/m² shall be given in ETA.

2.2.1.5.6 Long-term characteristic resistance for a panel (pull-out of the anchors)

Long-term characteristic resistance for a panel is derived with multiplication of long-term characteristic resistance of a single anchor $N_{Rk,lg}$ with number of anchors per m²:

$$N_{Rk,panel,lg,} = N_{Rk,lg} \times n_{panel} \quad (2.2.1.5.6.1)$$

where

$N_{Rk,lg}$ = long-term characteristic resistance for single anchor under tension load calculated according to Equation (2.2.1.5.6.2)

n_{panel} = number of anchors per m² as indicated in ETA

Long-term characteristic resistance $N_{Rk,lg}$ for single anchor under tension load is calculated from applied sustained load in sustained load tests for which criteria according to clause 2.2.1.5.4 were met:

$$N_{Rk,lg} = N_{p,applied} \quad (2.2.1.5.6.2)$$

$N_{p,applied}$ = applied load in sustained load test $N_{p,applied} = N_p$ (according to Equation (2.2.1.3.1)) if criteria described in 2nd paragraph of clause 2.2.1.5.4 were met (no reduction of sustained load is necessary). If for meeting of criteria reduction of sustained load was needed, then $N_{p,applied} = N_{p,reduced}$

Long-term characteristic resistance for a panel ($N_{Rk,panel-lg}$) in kN/m² shall be given in ETA.

2.2.2 Displacement on horizontal substrate

Displacement under short-term tension loading on horizontal substrate (δ_{sh-h}) shall be evaluated as minimum of average value of displacements of the reference tension tests in cracked concrete according to Table 2.2.1.1.1, line 1, and average value of displacements in non-cracked concrete in the test series of EAD 330196-01-0604, Table 2.3, line 1, according to rules given in EAD 330196-01-0604.

Displacement under long-term tension loading (δ_{lg-h}) shall be calculated from results of sustained load tests (Table 2.2.1.1.1, line 2) according to Equation (2.2.2.1):

$$\delta_{lg-h} = \frac{\delta_{m2}}{1{,}35} \quad (2.2.2.1)$$

where:

δ_{m2} = mean extrapolated displacement in the sustained load tests. It is evaluated as s(t) according to Equation (2.2.1.5.4.1) if no reduction of sustained load was necessary. Otherwise, it is evaluated according to Equation (2.2.1.5.4.2).

In ETA short term (δ_{sh-h}) and long term (δ_{lg-h}) displacement in mm shall be given.

2.2.3 Characteristic pull-through resistance

The test program for the assessment consists of:

- short-term pull-through tests (clause 2.2.3.1),
- static foam block tests (clause 2.2.3.2),
- long-term foam block tests (clause 2.2.3.3).

Tests shall be performed:

- with type of insulation product manufacturer has applied for,
- using decisive insulation product with minimum tensile strength perpendicular to faces,
- using minimum thickness of decisive insulation product.

Information which shall be given for insulation product in ETA are:

- material type,
- fibre orientation (where relevant),
- density,
- tensile strength perpendicular to insulation panel surface,
- compressive strength, and
- bending strength.

All of these properties shall be provided by producer of insulation product. If any of these properties are missing it shall be derived on the basis of tests according to:

- EN ISO 29470 for defining of density,
- EN 1607 for defining of tensile strength perpendicular to insulation panel surface,
- EN ISO 29469 for definition of compressive strength and
- EN 12089 for definition of bending strength.

The purpose of the short-term pull-through tests is to determine the basic technical data required to predict the short-term ($R_{insul\text{-}panel,sh}$) and long-term ($R_{panel,lg}$) pull-through resistance of one anchor in thermal insulation products as described in clause 2.2.3.4.5 (short-term pull-through resistance) and 2.2.3.4.6 (long-term pull-through resistance).

The purpose of the static foam block tests is to determine the basic technical data required to predict the pull-through resistance of an anchor group (or unit of an anchor scheme) if in short-term pull-through tests tensile failure mode of insulation material occur or if anchor pattern forces low spacing between the anchors.

The purpose of long-term foam block tests is to define long-term load level (dead load) at which anchor can resist for estimated lifetime.

All test results are applicable to all higher strengths and thicknesses of insulation products.

Short-term pull-through and static foam block tests shall be performed in dry conditions (at (23 ± 2)°C and (50 ± 5) % RH). If the tensile strength perpendicular to faces of the insulation product in wet conditions tested according to EAD 040083-00-0404, clause 2.2.14.2 is less than 80% of that tested in dry condition, the pull-through and static foam block tests shall be carried out also in wet conditions. Wet conditions shall meet with exposure of insulation plates to heat-moisture actions at (70 ± 2) °C and (95 ± 5) % RH in climatic chamber for at least 28 days, followed by drying period at (23 ± 2) °C and (50 ± 5) % RH until constant mass is achieved. Constant mass is achieved when there is less than 0,1% change in weight in 2 consecutive 24h interval weighings.

The decision of which kind of short-term test is performed is made on the basis of:

- failure mode in pull-through tests

- minimum distance between neighbouring anchors

For this reason, 2 procedures are distinguished (procedure A and B) and are described in paragraph 2.2.3.4.6 and Table 2.2.3.1.

Short term characteristic pull-through resistance ($R_{insul,panel-sh}$) [in kN/m^2], long term characteristic pull-through resistance ($R_{insul,panel-lg}$) [in kN/m^2] shall be given in ETA.

Table 2.2.3.1: Procedures for short-term characteristic pull-through resistance for a panel

<table>
<tr><th>Type of failure in short-term pull-through tests / Spacing between anchors</th><th>Cone failure mode</th><th>Tensile failure mode</th></tr>
<tr><td>≥ [2 × radius of failure cone] and
≥ [2 × (thickness of tested insulation panel + plate radius of tested anchor plate)]</td><td>Procedure A</td><td rowspan="4">Procedure B*</td></tr>
<tr><td>≥ [2 × radius of failure cone] and
< [2 × (thickness of tested insulation panel + plate radius of tested anchor plate)]</td><td rowspan="3">Procedure B*</td></tr>
<tr><td>< [2 × radius of failure cone] and
≥ [2 × (thickness of tested insulation panel + plate radius of tested anchor plate)]</td></tr>
<tr><td>< [2 × radius of failure cone] and
< [2 × (thickness of tested insulation panel + plate radius of tested anchor plate)]</td></tr>
</table>

* If procedure B is needed, it can be omitted, and procedure A is applicable in case if normalized tensile stresses perpendicular to faces calculated per m^2 of insulation product in pull-through tests (in dry conditions) are less than 85% of actual tensile resistance of insulation plate and therefore no tensile failure mode occurs.

The tests shall be performed on test specimens which consist of insulation material and anchors.

Short term ($R_{insul-panel,sh}$) and long term ($R_{insul-panel,lg}$) characteristic resistance in kN/m^2 shall be given in ETA and is valid for anchor pattern given in ETA.

2.2.3.1 Short-term pull-through tests

For determination of characteristic pull-through resistance ($R_{insul-panel,sh}$) of anchor tests according to EN 16382 for middle area position shall be performed in insulation material with minimum tensile strength perpendicular to faces and minimum thickness.

For each test series mean failure load ($R_{Ru,m}$), 5% fractile ($R_{5\%}$) and coefficient of variation (α_{vPT}) according to clauses 2.2.3.4.1, 2.2.3.4.2 and 2.2.3.4.3 shall be calculated.

2.2.3.2 Static foam block tests

Static foam block tests shall be performed in accordance with EN 13495 – method A, in dependence of conditions described in Table 2.2.3.1.

Insulation panels for static foam block tests shall have dimensions that the position in foam block tests represents at least the smallest repetitive unit of the anchor scheme.

For each test series mean failure load ($R_{Ru,m,foam}$), 5% fractile ($R_{5\%,foam}$) and coefficient of variation (α_{vFOAM}) according to clauses 2.2.3.4.1, 2.2.3.4.2 and 2.2.3.4.4 shall be calculated.

2.2.3.3 Long-term foam block tests

Long-term foam block tests shall be performed with test setup as described in EN 13495 – method A, with modification as follows:

Tests are performed until failure, but not for more than 2000 hours. Failure represents pull-through of individual anchor or tensile failure of insulation product. If failure occur sooner than in 100 hours, test results shall be discarded, and additional test shall be performed.

For verification of long-term pull-through resistance, tests at minimum 5 different loads with a difference of at least 50 N/m² shall be performed. Steps for load levels are defined in such manner that it is possible to define fitting curve as defined in clause 2.2.3.4.4. If for example at first chosen load level there isn't any failure until 2000 h, at least 50 N/m² higher load shall be chosen for next test. And opposite if at chosen load level failure occurred sooner than in 100 hours, at least 50 N/m² lower load level shall be chosen for next test. Failure occurs when the value of sustained load starts to decrease. Failure represents pull-through of individual anchor or tensile failure of an insulation material. At least 1 test at every load level shall be performed.

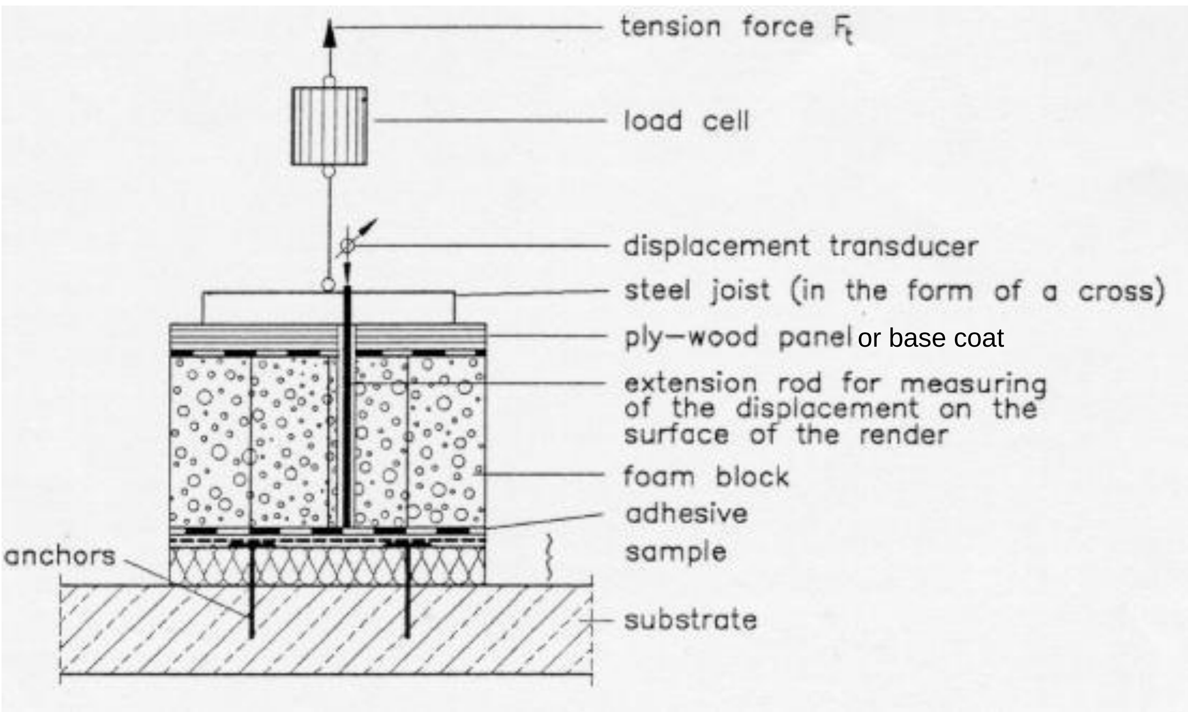


Figure 2.2.3.3.1: Test setup for long-term pull-through tests for determination of time to failure

Anchors shall be fixed to substrate using decisive insulation panel with minimum number of anchors / m² and if needed (according to description in clause 2.2.3.4.5) also with maximum number of anchors / m². Insulation panels shall have dimensions that the position in foam block tests represents at least the smallest unit of the anchor scheme. They shall not be glued to the substrate. Insulation panel shall be covered with ply-wood panel with base coat or base coat only. Adhesion of the base coat shall be higher than tensile resistance of insulation product. Long-term load shall be introduced to the ply-wood or base coat by foam blocks.

During tests load shall be kept constant (variation within ±5 %) and time of failure shall be recorded.

For each test series data point with intersection of load level and time to failure shall be defined.

2.2.3.4 Assessment of pull-through capacity

2.2.3.4.1 5 %-fractile of the ultimate loads

The 5 %-fractile of the ultimate loads measured in a test series shall be calculated according to statistical procedures for a confidence level of 75 %. If a precise verification does not take place, in general, a normal distribution and an unknown standard deviation of the population shall be assumed.

For pull-through tests according to clause 2.2.3.1:

$$R_{5\%} = R_{Ru,m} (1 - k_s \times v) \qquad (2.2.3.4.1.1)$$

For static foam block test: according to clause 2.2.3.2:

$$R_{5\%,foam} = R_{Ru,m,foam} (1 - k_s \times v) \qquad (2.2.3.4.1.2)$$

e.g.,

n = 5 tests: k_s = 2,463

n = 10 tests: k_s = 2,103

2.2.3.4.2 Conversion of ultimate loads to take account of thermal insulation product tensile strength perpendicular to faces

Influence of the panel strength shall be taken into account according to equations (2.2.3.4.2.1 and 2.2.3.4.2.2).

For pull-through tests according to clause 2.2.3.1:

$$R_{Ru,m} (TR) = R^{t}_{u,m} \times c_1 \qquad (2.2.3.4.2.1)$$

For static foam block tests according to clause 2.2.3.2:

$$R_{Ru,m,foam} (TR) = R_{tu,m,foam} \times c_1 \qquad (2.2.3.4.2.2)$$

where

$R_{Ru,m}$ (TR) = mean failure load of a pull-through normalized to nominal tensile strength perpendicular to the insulation panel surface

$R^{t}_{u,m}$ = mean failure load of a pull-through tests

c_1 = $\left(\frac{T_{Rk}}{T_{R,test}}\right)^n \leq 1{,}0$

TR = nominal (defined in the Declaration of performance) tensile strength perpendicular to insulation panel surface declared by the manufacturer of insulation product

$T_{R,test}$ = actual average tensile strength perpendicular to insulation panel surface, tested according to EN 1607

n = coefficient evaluated from pull-through/static foam block test results in panel with two different panel tensile strengths.

without tests: n = 1

with pull-through tests: $$n = \frac{\log\left(\frac{R_{u,m}(T_{R,max})}{R_{u,m}(T_{R,min})}\right)}{\log\left(\frac{T_{R,test}(T_{R,max})}{T_{R,test}(T_{R,min})}\right)}$$

with static foam block tests: $$n = \frac{\log\left(\frac{R_{u,m,foam}(T_{R,max})}{R_{u,m,foam}(T_{R,min})}\right)}{\log\left(\frac{T_{R,test}(T_{R,max})}{T_{R,test}(T_{R,min})}\right)}$$

$R_{u,m}$ ($T_{R,max}$) = mean failure load of a pull-through tests performed in panels with maximum actual tensile strength perpendicular to surface

$R_{u,m,foam}$ ($T_{R,max}$) = mean failure load of a static foam block tests performed in panels with maximum actual tensile strength perpendicular to surface

$R_{u,m}$ ($T_{R,min}$) = mean failure load of a pull-through tests performed in panels with minimum actual tensile strength perpendicular to surface

$R_{u,m}$ ($T_{R,min}$) = mean failure load of a static foam block tests performed in panels with minimum actual tensile strength perpendicular to surface

$T_{R,test}$ ($T_{R,max}$) = actual tensile strength perpendicular to insulation panel with higher (maximum) tensile strength perpendicular to surface determined according to EN 1607

$T_{R,test}$ ($T_{R,min}$) = actual tensile strength perpendicular to insulation panel with lower (minimum) tensile strength perpendicular to surface determined according to EN 1607

2.2.3.4.3 Criteria valid for short-term pull-through tests

If a coefficient of variation of the ultimate loads in one test series is larger than 20 % an additional factor α_{vPT} shall be considered in the determination of the characteristic loads.

$$\alpha_{vPT} = \frac{1}{1 + (v(\%) - 20) \cdot 0{,}03} \qquad (2.2.3.4.3.1)$$

where

v(%) = maximum value of coefficient of variation (≥ 20 %) of the ultimate loads of all test series.

2.2.3.4.4 Criteria valid for static foam block tests

If a coefficient of variation of the ultimate loads in one test series is larger than 20 % an additional factor $\alpha_{v,FOAM}$ shall be considered in the determination of the characteristic loads.

$$\alpha_{vFOAM} = \frac{1}{1 + (v(\%) - 20) \cdot 0{,}03} \qquad (2.2.3.4.4.1)$$

where

v(%) = maximum value of coefficient of variation (≥ 20 %) of the ultimate loads of all test series.

2.2.3.4.5 Criteria valid for the long-term foam block tests

The $\log_{10}$ of the data sets of the tests according to clause 2.2.3.3 shall be plotted, see Figure 2.2.3.4.4.1, fitted by a regression analysis and extrapolated to 25 years gaining R (t = 25 years) in accordance to Equation (2.2.3.4.4.1). One data set represents intersection of load in long-term foam block tests and time to failure at that load.

The fit shall be based on at least 5 data sets with failure time greater than 100 hours whereby at least 3 data sets shall have failure time greater than 1000 hours. Tests that haven't failed at a certain time (e.g., more than 2000 hours, can be stopped and considered to have failed at the time they were stopped. If the load of this samples is greater than any load of a specimen that has failed at shorter time, the load assigned to this data set shall be equal to the lowest load of specimens that have failed at shorter time. The slope "m" shall be negative, else extrapolation is not accepted and additional tests for gaining more data sets are necessary. For gaining a negative slope it is accepted that the result of an adequate foam block tests in accordance to clause 2.2.3.2 is considered for fitting the data sets whereby time to failure is set to the time the foam block test took to yield maximum load (typically between 1 and 3 min).

$$\log_{10}(R(t)) = m \times \log_{10}(t) + n \qquad (2.2.3.4.4.1)$$

with

R(t) = load level and belonging failure time t

t = time

m,n = constants (tuning factors), evaluated by a regression analysis of loads at which failure occur, "m" is the slope in a double $\log_{10}$ chart and "n" the intersection with y axis

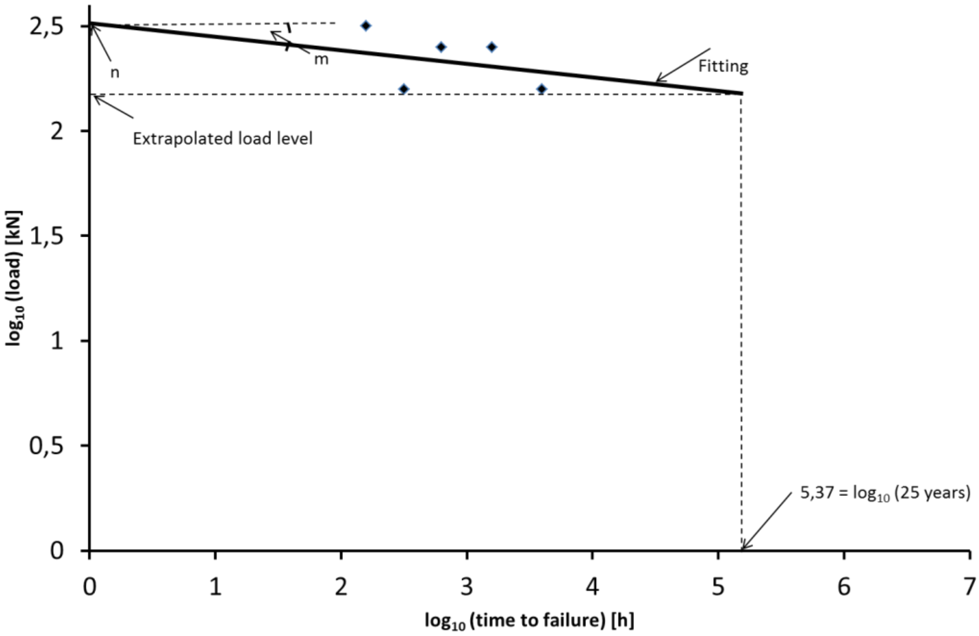


Figure 2.2.3.4.4.1: Fitting of curve at long-term foam block tests for determination of time to failure

Alternatively, assessment can be done in semi-logarithmic scale ($\log_{10}$ (t)).

2.2.3.4.6 Short-term characteristic pull-through resistance for a panel

The short-term characteristic pull-through resistance of a panel is defined based on short-term pull-through tests or static foam block tests in dependence of conditions described in clause 2.2.3 according to 2 procedures described in Table 2.2.3.1.

A) The short-term characteristic pull-through resistance of a panel is derived by multiplication of short-term characteristic pull-through resistance as defined for single anchor R_{sh} with number of anchors per m^2:

$$R_{insul\text{-}panel\text{-}sh} = \min (R_{sh} \times n_{panel} ; TR) \quad (2.2.3.4.5.1)$$

where

R_{sh} = short-term characteristic resistance of pull-through tests for single anchor according to Equation (2.2.3.4.5.2) defined for one anchor.

TR see description in clause 2.2.3.4.2.

n_{panel} = number of anchors per m^2 indicated in MPII.

The short-term characteristic pull-through resistance for single anchor shall be calculated according to Equation (2.2.3.4.5.2):

$$R_{sh} = R_{5\%} \cdot \alpha_{vPT} \quad (2.2.3.4.5.2)$$

where

$R_{5\%}$ = characteristic resistance of pull-through tests for single anchor according to Equation (2.2.3.4.5.2) defined for one anchor.

α_{vPT} = coefficient of variation calculated according to Equation (2.2.3.4.3.1).

B) The short-term characteristic pull-through resistance of a panel shall be derived according to test results on foam block tests performed with defined anchor patters, which shall be given in ETA.

B1) If type of failure in both cases is tensile failure of insulation panel, short-term characteristic pull-through resistance of a panel is derived on the basis of test results with minimum and maximum number of anchors / m² according to Equation (2.2.3.4.5.3):

$$Ri_{nsul\text{-}panel\text{-}sh} = R_{sh\text{-}foam} / A_{foam} \qquad (2.2.3.4.5.3)$$

where

$R_{sh\text{-}foam}$ = short-term characteristic resistance of static foam block tests according to Equation (2.2.3.4.5.4) defined for anchor pattern per m².

TR = see description in clause 2.2.3.4.2.

A_{panel} = surface (in m²) of insulation panel in static foam block test.

The short-term characteristic pull-through resistance of a panel shall be calculated according to Equation (2.2.3.4.5.4):

$$R_{sh\text{-}foam} = R_{u,foam,5\%} \cdot \alpha_{vFOAM} \qquad (2.2.3.4.5.4)$$

where

$R_{u,foam\ 5\%}$ = Characteristic resistance of static foam-block tests according to Equation (2.2.3.4.1.2) defined for anchor patters per m².

α_{vFOAM} = coefficient of variation calculated according to Equation (2.2.3.4.3.1).

B2) If type of failure with defined pattern is pull-through of individual anchors, short-term characteristic pull-through resistance is then assessed according to procedure A.

The determined short-term characteristic pull-through resistance $R_{insul\text{-}panel,sh}$ is applicable for:

- the tested anchor plate,
- the insulation product of the same material used in tests with the same or greater nominal tensile strength perpendicular to faces, same or greater nominal density and same or greater thickness, same fibre orientation (where relevant), same or greater compressive strength and same or greater bending strength and,
- tested anchor patterns which shall be stated in ETA.

2.2.3.4.7 Long-term characteristic pull-through resistance for a panel

The long-term characteristic pull-through resistance for a panel is defined according to extrapolation of test results in long-term foam block test (Equation (2.2.3.4.6.1)). It is defined by antilogarithmic-exponential procedure of Equation (2.2.3.4.4.1), where load level for expected lifetime is calculated.

$$R_{insul\text{-}panel,lg} = (10^{(m \times \log10(t) + n)}) \times c_1 \times (1 - k_s \cdot v) \qquad (2.2.3.4.6.1)$$

where

t = 25 years.

m, n = constants (tuning factors), evaluated from tests in clause 2.2.3.4.4.

c_1 = conversion factor (see description by the Equation (2.3.4.2.1).

k_s, v = got from short-term pull-through tests/static foam block with the same insulation product.

The determined long-term characteristic pull-through resistance $R_{insul-panel,lg}$ is applicable for:

- the tested anchor plate,
- the same insulation product used in tests with the same or greater nominal tensile strength perpendicular to faces, same or greater nominal density and same or greater thickness and
- the tested anchor patterns.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

EAD 330196-01-0604, chapter 3, applies.

4 REFERENCE DOCUMENTS

EAD 330196-01-0604	Plastic anchors made of virgin or non-virgin material for fixing of external insulation composite systems with rendering.
EAD 040083-00-0404	External Thermal Insulation Composite Systems (ETICS) with rendering.
EAD 330284-00-0604	Plastic anchors for redundant non-structural systems in concrete and masonry.
EAD 330499-01-0601	Bonded fasteners for use in concrete.
EN 1607:2013	Thermal insulating products for building applications – Determination of tensile strength perpendicular to faces.
EN 12089:2013	Thermal insulating products for building applications – Determination of bending behaviour.
EN 13495:2019	Thermal insulation products for building applications – Determination of the pull-off resistance of external thermal insulation composite systems (ETICS) (foam block test).
EN 16382:2016	Thermal insulation products for building applications – Determination of the pull-through resistance of plate anchors through thermal insulation products.
EN ISO 6946:2017	Building components and building elements – Thermal resistance and thermal transmittance – Calculation methods.
EN ISO 9223:2012	Corrosion of metals an alloys – Corrosivity of atmospheres – Classification, determination and estimation.
EN ISO 10211:2017	Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations.
EN ISO 12944-2:2017	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 2: Classification of environments.
EN ISO 29470:2020	Thermal insulating products for building applications – Determination of apparent density.
EN ISO 29469:2022	Thermal insulating products for building applications – Determination of compression behaviour.

ANNEX A: POINT THERMAL TRANSMITTANCE OF ANCHORS FOR ETICS OR INSULATION PRODUCTS

A.1 General

A.1.1 Purpose

This annex describes the assessment method of the point thermal transmittance of anchors for fixing thermal insulation composite systems with renderings (ETICS) or insulation products. This method is based on the calculation inputs of standards EN ISO 10211 and EN ISO 6946.

The assessment of the thermal performance of an ETICS or insulation product assumes that the effect of anchors used to fix them to the substrate is known. It generally applies that each anchor in the ETICS acts as a 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 insulated wall, the higher the influence of the anchors related to the thermal transmittance of the wall.

The essential characteristic of an anchor is the point thermal transmittance χ. This χ-value for the point thermal transmittance is not a product constant but a value depending on the thermal conductivities and thicknesses of the insulating layer material.

To simplify the procedure the χ-value may be obtained considering the most unfavourable substrate, where the anchor is intended to be used. Otherwise, the χ-value shall be obtained considering each substrate material (from now one "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 behaviour is not linear as it is represented in the example on Figure A.1.1.1 for three different possible types of anchors.

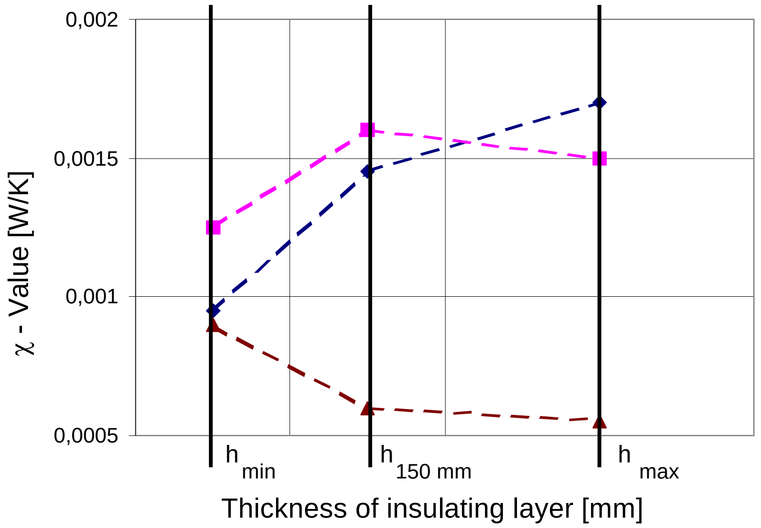


Figure A.1.1.1: Point thermal transmittance χ-value depending on the thickness of the insulating layer.

Insulation products (also those for ETICS) are manufactured in a large range of thicknesses (approximately between 50 mm and 450 mm). At present the average thickness of the insulating layer in Europe is approximately 100 mm with a tendency to rise. As it is shown in Figure A.1.1.1, the X-value can increase with a greater thickness of the insulating layer. The greater thicknesses of the insulating layer, however, only represent a small geographical area of the market.

The point thermal transmittances χ should be listed separately for thicknesses of the insulating layer of the Thermal Insulation Composite System "up to 150 mm" and "greater than 150 mm". This is necessary in order to not require the most unfavourable χ-value for the entire range of the insulating layer thickness as representative dimension.

A.2 Assessment method for point thermal transmittances of anchors

A.2.1 Determination of point thermal transmittances

The point thermal transmittance χ-value results from:

$$\chi = \frac{U_c - U}{n} \quad \text{[W/K]} \qquad \text{(A.2.1.1)}$$

For each insulating layer thickness and for each base material group calculated with the point thermal transmittances shall be determined according to clause A.3.2.2.

The calculated value shall be rounded to four decimal places.

A.2.2 Determination of the nominal value

The nominal values shall be determined from the χ values for each base material group calculated with:

Case 1: Different nominal values for the range of insulating layer thickness application

The nominal value of the point thermal transmittance χ values shall be determined for the significant range as follows:

$\chi(h \leq 150)$ the maximum value of χ (h_{min}) and X(150 mm).

$\chi(h > 150)$ the maximum value of χ (h_{max}) and X(150 mm).

Case 2: No distinction between range of insulating layer thickness application

If only one significant χ-value shall be given as nominal value, it shall be obtained as the maximum value from all tests according to A.3.2.2:

$\chi(h_{min} - h_{max})$ the maximum value for the range from $h = h_{min}$ to $h = h_{max}$

The nominal value of the point thermal transmittances shall be rounded upwards and shown in the following steps in W/K:

0,000 I 0,001 I 0,002 I 0,003 I 0,004 I 0,006 I 0,008

The step "0,000 W/K" may be taken, if the peak value of the point thermal transmittance χ-value in the considered range is smaller than 0,0005 W/K.

In this case, the following note shall be added for the step "0,000 W/K":

“The thermal bridge effect of the anchor is smaller than 0,0005 W/K, therefore, it may be neglected in the calculation”.

A.2.3 Description of the nominal value

The nominal χ-value of the point thermal transmittance shall be given for each base material group, in which the anchor is intended to be used. The form can be chosen free from the following alternatives:

A.2.3.1 Alternative A: Single values (regardless of the base material groups) (see A.4)

Nominal values shall be only determined for the most unfavourable (i.e., with greater thermal conductivity) base material group. The nominal values include all base material groups, with which the anchor is intended to be used, as index. The range of insulating layer thickness for which the nominal value is valid shall be stated in brackets behind the " χ-value".

Indexing of the base material groups is optional when the nominal value is determined from base material group A according to Table A.3.2.1.2.

A.2.3.2 Alternative B: tabulated listing depending on the base material groups (see A.4)

Nominal values shall be determined for different base material groups. These values shall be stated in a table which includes all base material groups, the anchor intended to be used with, line by line and the range of insulation thickness, for which the nominal value shall be given, column by column.

A.2.3.3 Remark

Clause A.4 gives examples for the description.

A.3 Details of method for the assessment

A.3.1 General

The determination of the point thermal transmittance (χ-value) shall be carried out by means of calculation or testing (reference method).

The point thermal transmittance χ-value results from calculation according to clause A.2.1 with the thermal transmittance U_c of the disturbed construction (i.e., including “n” anchors) of wall determined by means of calculation (see clause A.3.3) or by means of testing (see clause A.3.4), reference method.

A.3.2 Test sample

A.3.2.1 Reference construction

For determination of the point thermal transmittance χ-value the following reference construction shall be used:

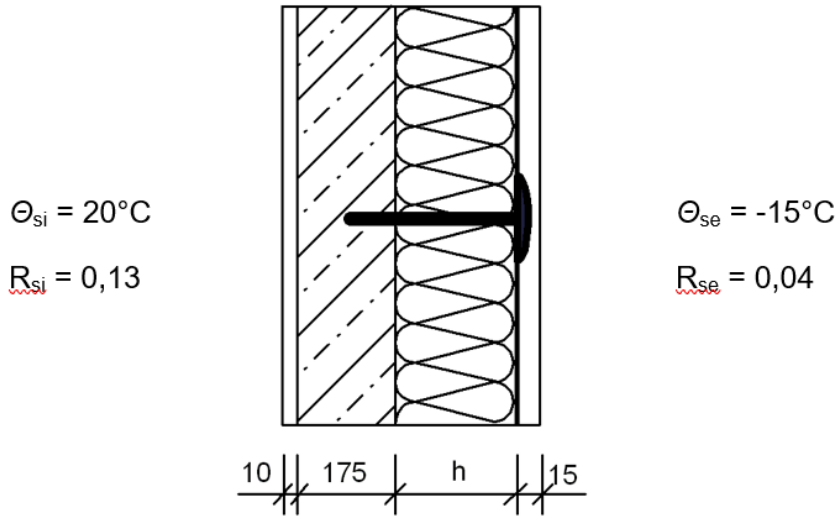


Figure A.3.2.1.1: Drawing of the reference construction (not full-scale).

The thickness of the insulating layer h is described in clause A.3.2.2. The anchors shall be arranged according to the Manufacturer's Product Installation Instructions (MPII). The data concerning the building component layers shall remain untouched.

For the building component layers the characteristic values of the material according to EN ISO 10456shall be used:

Table A.3.2.1.1: 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 A.3.2.1.2	175
(3) insulating layer	0,035	see clause A.3.2.2
(4) external rendering: lime-cement plaster	1,0	15

The point thermal transmittance χ-value shall be determined for the most unfavourable (i.e., with greater thermal conductivity) substrate, with which the anchor is intended to be used. Alternatively, the χ-value may be obtained for each base material group separately. Only base material groups, in which the anchor is intended to be used shall be used for calculation.

A determined χ-value also covers all substrates with a lower thermal conductivity. When selecting normal weight concrete as the substrate for determination, the determined χ-value may cover all base material groups.

Table A.3.2.1.2: 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

A.3.2.2 Thickness of insulating layer

The thickness of the insulating material has a significant influence on the point thermal transmittance χ-value. The nominal value of the point thermal transmittance χ-value shall be determined for the ranges of insulating layer thickness h ≤ 150 mm and h > 150 mm.

The point thermal transmittance χ-value for the three thicknesses of insulating layer shall be determined as follows:

$\chi(h_{min})$ = for the smallest thickness (h_{min}) of the insulating layer range intended to be used.

χ(150 mm) = for the reference thickness of the insulating layer h = 150 mm.

$\chi(h_{max})$ = for the greatest thickness (h_{max}) of the insulating layer range intended to be used.

In case of the result χ(150 mm) is smaller than $\chi(h_{min})$, testing of $\chi(h_{max})$ can be neglected. It is assumed that in any case $\chi(h_{max})$ is smaller than or equal to χ(150 mm).

A.3.2.3 Anchor properties

The thermal conductivities of the anchor materials shall be obtained from EN ISO 10456. The dimensions shall be obtained either by means of the measurement of the anchors or from the MPII.

A.3.2.4 Boundary conditions

The conventional surface resistances shall be obtained according to EN ISO 6946 Table 7, for the horizontal direction of the heat flow 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 shall be considered as adiabatic.

A.3.3 Calculations according to EN ISO 10211

For the determination of the point thermal transmittance χ-value, the thermal transmittance of the wall with anchor U_c shall be determined for each of the constructions considered, by means of numerical analysis according to EN ISO 10211 using a software calibrated according to Annex C of EN ISO 10211.

Specific provisions below shall be considered for defining the calculation model and the expression of the results.

A.3.3.1 Construction of the model for calculation

As significant area for the calculation of the thermal bridge effect a cuboid-shaped area of the wall containing an anchor shall be assumed (see Figure A.3.2.1.1). The anchor shall be placed in the centre of the area considered. In case the anchor is rotationally symmetric in its shape, a partial circular cross-section of the anchor, which shall be placed in an edge of the area considered, may also be used for the calculation or the calculation may be done in polar coordinates.

The dimensions of the area to be considered shall be chosen according to EN ISO 10211 so that the disturbance caused by the anchor shall have no effects on the edges.

The thermal conductivity of potential cavities shall be determined according to EN ISO 6946 Table 8.

A.3.3.2 Subdivision of the model for calculation

The subdivision of the model for calculation by means of the numerical method shall be accomplished in accordance with EN ISO 10211.

Annex A, clause A.2 (d) of this standard determines that the subdivision shall be sufficiently fine, that if n subdivisions are chosen, the sum resulting from the heat flows does not deviate from the subdivisions more than 1 % which would result in the case of second subdivisions.

A.3.3.3 Determination of the thermal transmittance

The thermal transmittance U_c of the wall area with anchor shall be determined according to EN ISO 10211 by the thermal coupling coefficient calculated.

$$U_c = \frac{L^{3D}}{A} \qquad [W/(m^2 \cdot K)] \qquad (A.3.3.3.2)$$

Deviating from EN ISO 10211 the thermal transmittance shall be determined with five decimal places. This is necessary because the point thermal transmittance χ-value to be calculated shall be given rounded to four decimal places.

The thermal transmittance U of the undisturbed wall (without placing the anchors) shall be calculated according to EN ISO 6946.

A.3.4 Testing

The determination of the thermal transmittance U_c be tested in accordance with EN 1946, Parts 1 to 4. The measurement shall be carried out according to EN ISO 8990 or EN 1934 (both methods are considered equivalents). A reference test specimen shall be used according to clause A.3.2.

The thermal transmittance U of the undisturbed wall (without placing the anchors) shall be measured according to the same method and test specimen materials and dimensions as for the thermal transmittance U_c.

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

A.4 Examples for the description of nominal χ-values of the point thermal transmittance

A.4.1 Example 1: Single Values

An anchor might be used in the base material groups a and b for the thicknesses of insulating layer h_{min} = 50 mm to h_{max} = 320 mm. The following nominal values have been determined by means of calculations (see clause A.3.3) or testing (see clause A.3.4):

$\chi_A(h \leq 150 \text{ mm}) = 0{,}002$ W/K and $\chi_A(h > 150 \text{ mm}) = 0{,}003$ W/K

A listing as table is not necessary because the nominal values have been determined for one base material group only. The description is given in single values.

Case 1: Distinction between range of insulation thickness

$\chi(h \leq 150 \text{ mm}) = 0{,}002$ W/K; $\chi(h > 150 \text{ mm}) = 0{,}003$ W/K

Case 2: One χ-value for the whole range of insulation thicknesses

χ(50 – 320 mm) = 0,003 W/K

Indexing is not necessary because the nominal value was calculated with base material group a, which is the worst case (see Table A.3.2.1.2).

A.4.1 Example 2: Table or single values

An anchor might be used in the base material groups B, C and D for the thicknesses of insulating layer h_{min} = 50 mm to h_{max} = 250 mm. The following nominal values have been determined by means of calculations (see clause A.3.3) or testing (see clause A.3.4):

χ_B(h ≤ 150 mm) = 0,002 W/K and χ_B(h > 150 mm) = 0,001 W/K

χ_D(h ≤ 150 mm) = 0,001 W/K and χ_D(h > 150 mm) = 0,001 W/K

Values for χ_C have not been determined. The values from the next higher base material group B also apply for this group C, see Table A.3.2.1.2.

Alternative A: Description as single values

One of the following descriptions shall be stated for the anchor:

Case 1: $\chi_{B,C,D}$(h ≤ 150 mm) = 0,002 W/K; $\chi_{B,C,D}$(h > 150 mm) = 0,001 W/K

Case 2: $\chi_{B,C,D}$(50 – 250 mm) = 0,002 W/K

Alternative B: Description as a table

One of the following descriptions shall be stated for the anchor:

Case 1: Distinction between range of insulation thickness

Base material group	Description	Thickness of insulation layer	
		h ≤ 150 mm	h > 150 mm
B	Solid masonry	0,002	0,001
C	Hollow or perforated masonry	0,002	0,001
D	Lightweight aggregate concrete with open structure	0,001	0,001

Case 2: One χ-value for the whole range of insulation thicknesses

Base material group	Description	Thickness of insulation layer
		Range 50 mm to 250 mm
B	Solid masonry	0,002
C	Hollow or perforated masonry	0,002
D	Lightweight aggregate concrete with open structure	0,001