EUROPEAN ASSESSMENT DOCUMENT

EAD 330965-01-0601

February 2020

POWDER-ACTUATED FASTENER FOR THE FIXING OF ETICS IN CONCRETE

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 No (EU) 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

The powder-actuated fastener for the fixing of ETICS in concrete (in the following referred to as fastener) consists of a plastic part made of high-density polyethylene (PE-HD) or polyamide (PA6 or PA6.6) and a suitable nail which is driven into the concrete perpendicular to the surface without previous drilling using a powder-actuated fastening tool according to EN 15895 [1][1] with a cartridge as propelling charge.

Type A: The nail is made of zinc coated tempered carbon steel with non-electrolytically applied zinc flake coating according to EN ISO 10683 [2] or stainless steel in accordance with EN 10088-3 [3] which in addition can be zinc plated.

The minimum anchorage depth in uncoated concrete is at least 25 mm. The minimum anchorage depth h_v in coated concrete is at least 18 mm.

Type B: The nail is made of electroplated and tempered carbon steel. The minimum anchorage depth h_v in concrete is at least 18 mm.

The assessment methods and criteria of this EAD are valid for a shaft diameter of the nail of 3 mm to 5 mm.

Type A: The fastener is pre-assembled. The plastic part consists of a shaft and a plate for holding the thermal insulation. The length of this plastic part depends on the thickness of the thermal insulation, e.g., 60, 70, 80 mm. The plastic part can in addition be combined with a larger plate made of plastic which can be slipped-on.

The cylindrical shaft of the plastic part serves to transmit wind suction loads and also serves as guiding device for the setting tool. The central opening serves as guidance for the nail.

Figure 1.1.1, Figure 1.1.2 and Figure 1.1.3 show examples of the product for type A.

Type B: Figure 1.1.4 shows an example of the plastic plate, which consists of an inner ring and an outer ring. Both rings are connected by means of several plastic ribs. The perforations between the inner and the outer ring allow the connection with the adhesive.

The centre area of the plastic plate is equipped with a connection part in order to allow centric positioning of the plate onto the fastener guide of the powder-actuated fastening tool. This connection part needs to further ensure that the plastic plate remains stuck on the fastener guide during tool handling and fastener installation. The plastic part has a centre hole with a diameter d_{pl} which is at least 0.4 mm greater than the diameter d of the nail.

Figure 1.1.4 and Figure 1.1.5 show examples of the product for type B.

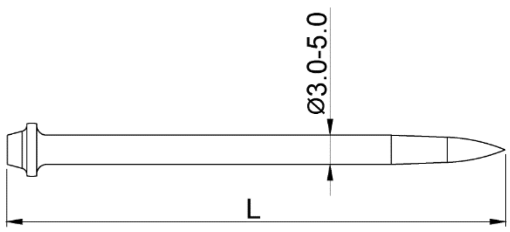
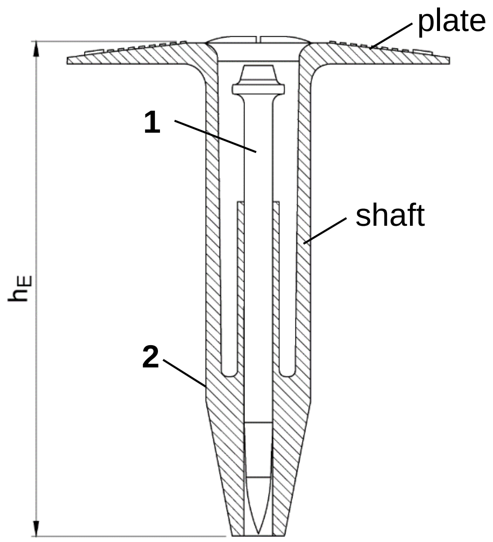
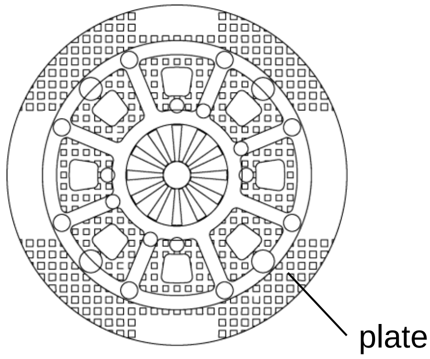


Figure 1.1.1 Example of nail for type A

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





marking:
- manufacturer
- item designation

1 …. steel nail
2 …. plastic part

Figure 1.1.2 Example of a plastic part for type A (cross-section and top view)

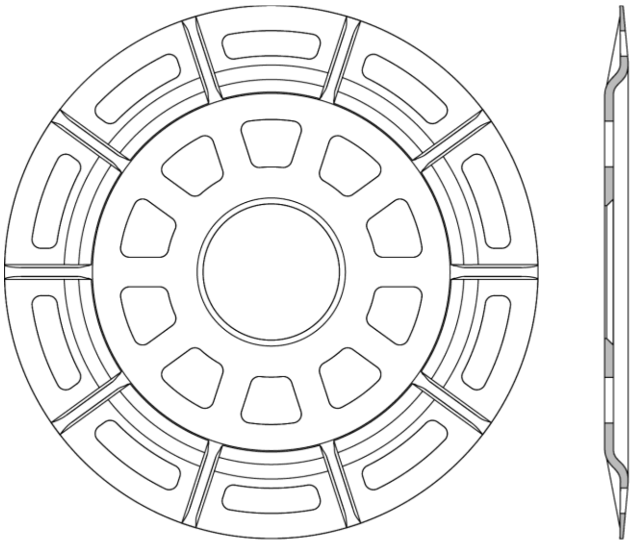


Figure 1.1.3 Example of an additional larger plate - type A

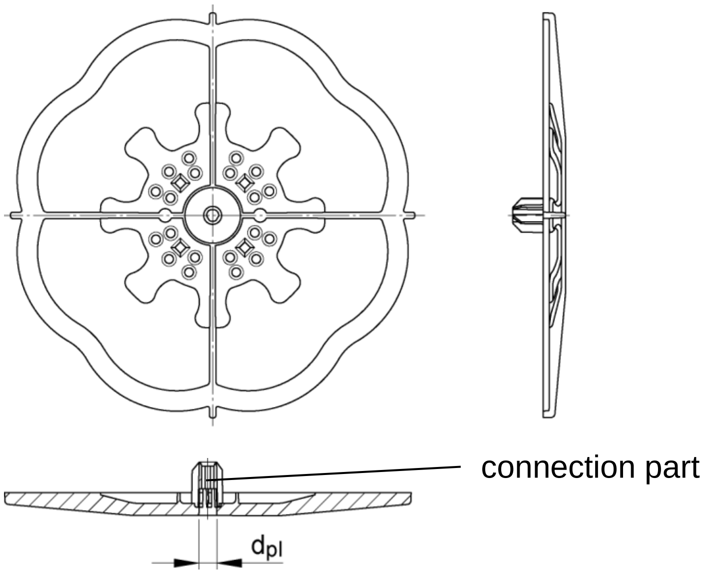


Figure 1.1.4 Example of plastic plate - type B

Figure 1.1.5 shows examples of the nails. Either single nails assembled with a plastic washer or collated nails assembled in a plastic magazine strip can be used.

Single nail with plastic guidance washer

Collated nails in plastic magazine strip

Figure 1.1.5 Example of nails for type B

The product is not fully covered by EAD 330965-00-0601. Compared to the previous version of the EAD, the following changes are introduced:

- Product type B and relevant assessment methods are added (product described in 330965-00-0601 is designated as type A).

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 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.

1.2 Information on the intended use of the construction product

1.2.1 Intended use

The fastener (plastic part fixed with nails) is intended for multiple use only for the anchorage of external thermal insulation composite systems (ETICS) according to EAD 040083-00-0404 [4]. As insulation material expanded polystyrene according to EN 13163 [5] or mineral wool according to EN 13162 [6] are used for the ETICS.

For multiple use it is assumed that in the case of excessive slip or failure of one fastener the load can be transmitted to neighbouring fasteners without noticeably affecting the probability of failure of the thermal insulation composite system.

A powder-actuated fastening tool according to EN 15895 [1] is used in order to install the fastener.

For the installation of the product the necessary tools foreseen by the manufacturer are to be used and the relevant manufacturer's instructions shall be followed to the detail. The performance of the fastener is assessed under the assumption that both these preconditions are met.

Type A: The plastic part fixes the ETICS mechanically to the concrete.

The system is intended to be used either in coated or in uncoated concrete (use conditions are given in Table 1.2.1.1) under the responsibility of an engineer experienced in anchorages for ETICS or VETURE kits.

The product is intended to be used by installation by a powder-actuated fastening tool, that allows the detection of setting defects. The geometry of the plastic part and the fastener guide is such that due to their special shape there will be a higher clamping force between the shaft of the plastic part and the guiding device than between the plastic part and the insulation material. So, when removing the powder-actuated fastening tool after installation, the fastener is exposed to a check loading.

Type B: Each plastic plate of the fastener is completely filled with an adhesive to which the insulation of the ETICS is glued.

The system is intended to be used in uncoated concrete of new construction under the responsibility of an engineer experienced in anchorages for ETICS or VETURE kits.

The bond resistance is assessed in the ETA of the respective EAD for ETICS (see EAD 040083-00-0404 [4]).

The fastener is to be used only for anchorages subject to static or quasi-static loading.

Within the ETICS the fastener is only used for transmission of tension loads due to wind actions. The fastener is not being used for the transmission of dead loads of the external thermal insulation composite system or other loads.

In relation to its conditions of use the following materials for the nails are used:

(1) use in structures subject to dry, internal conditions:

Nails made of carbon steel with zinc coating with a minimum thickness of 5 microns

(2) 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[2] exist:

Type A: Nails made of tempered carbon steel with non-electrolytically applied zinc flake coating according to EN ISO 10683 [2] with 960 h salt spray testing without red rust

Type B: Nails made of carbon steel with zinc coating with a minimum thickness of 5 microns which are covered by at least 50 mm insulation material

(3) use according EN 1993-1-4, Annex A [7]:

[2] Particular aggressive conditions are, e.g., permanent, alternating immersion in seawater or the splash zone of seawater, chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g., in desulphurization plants or road tunnels where de-icing materials are used).

Nails made of stainless steel according EN 1993-1-4, Annex A, Tables A.3 and A.4 [7], dependent on the Corrosion Resistance Class (CRC).

The fasteners are intended to be used in reinforced or unreinforced normal weight compacted concrete without fibres as the base material with a strength class of at least C12/15 and at maximum C35/45 for type A and with a strength class of at least C20/25 and at maximum C50/60 for type B according to EN 206 [8]. An anchorage of the fastener in weather-beaten concrete and exposed aggregate concrete is not covered by this EAD.

Type A: The maximum thickness of adhesive or equalizing layer amounts to 20 mm in case of uncoated concrete. With regards to the maximum thickness of the adhesive or equalizing layer in case of coated concrete see Table 1.2.1.1.

Figure 1.2.1.1 and Figure 1.2.1.2 show the installed product for type A.

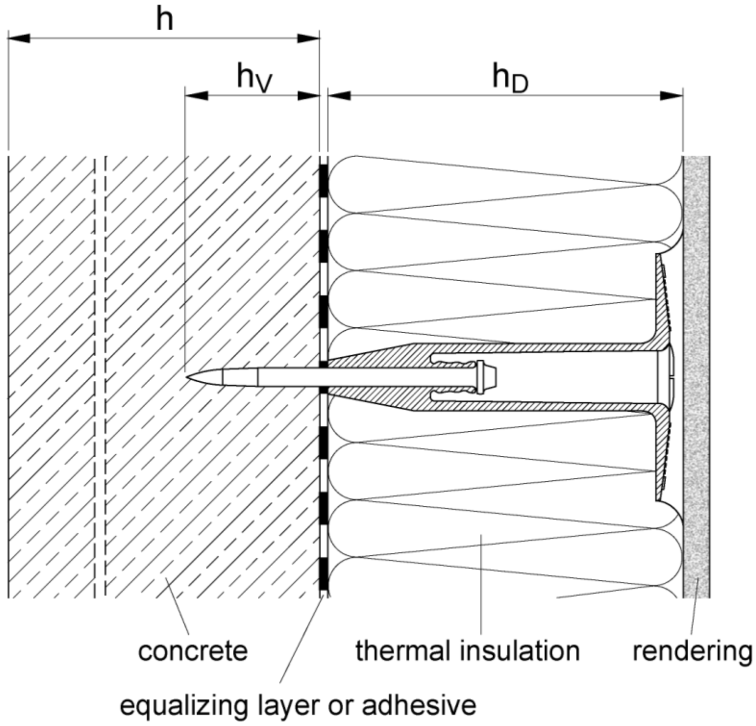


Figure 1.2.1.1 Installed condition of the fastener in case of uncoated concrete - type A

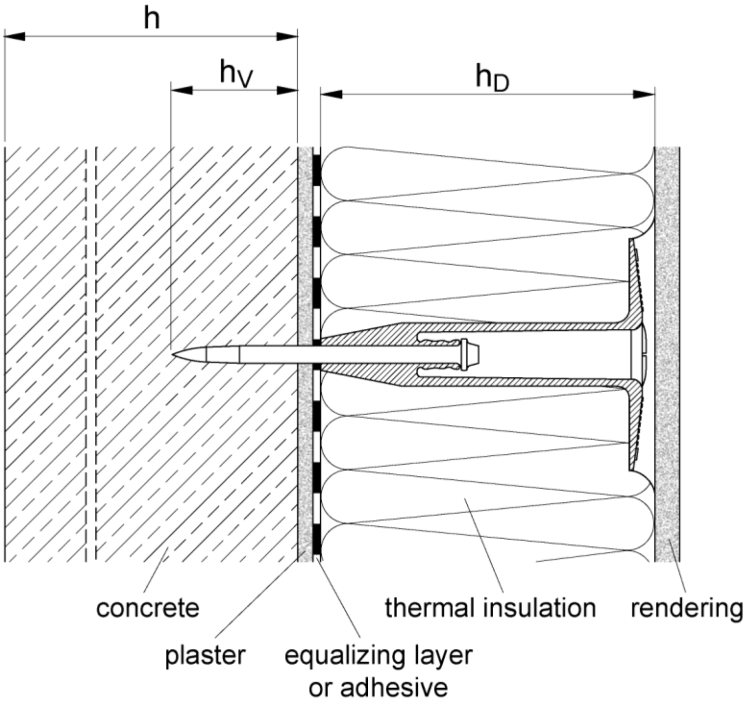


Figure 1.2.1.2 Installed condition of the fastener in case of coated concrete - type A

Figure 1.2.1.3 shows the installed product for type B.

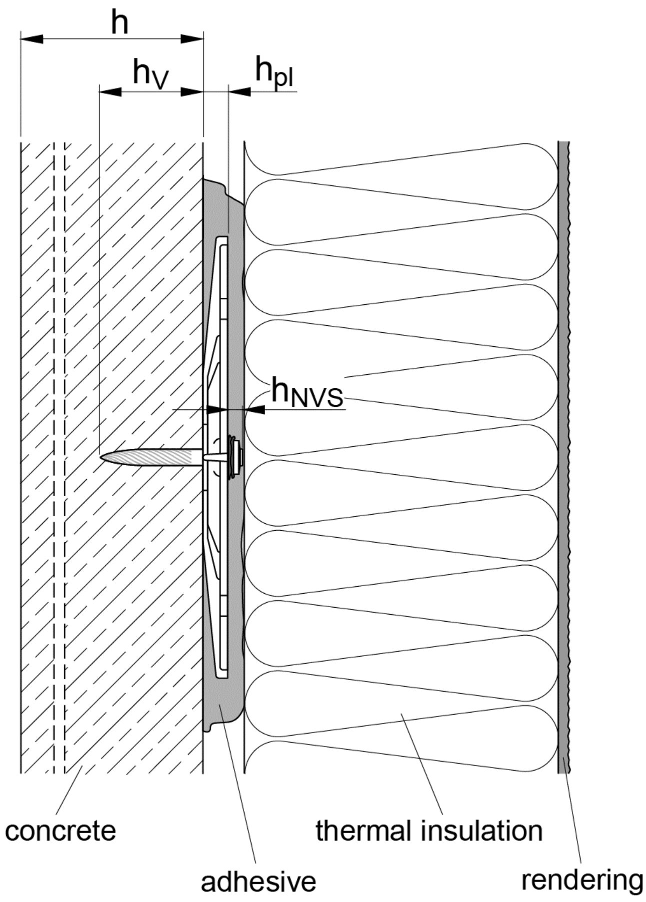
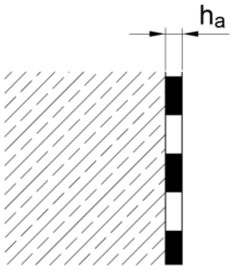
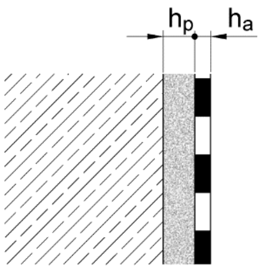


Figure 1.2.1.3 Installed condition of the fastener - type B

Table 1.2.1.1 summarizes the application conditions for type A. Painted concrete without plaster is equivalent with uncoated concrete.

Table 1.2.1.1 Intended use conditions for type A

Application condition	Thickness of coatings, equalizing layer and adhesive
Uncoated concrete with equalizing layer and adhesive  h_a … thickness of equalizing layer or adhesive	$h_a \leq 20$ mm
Concrete coated with plaster and equalizing layer or adhesive  h_p … thickness of plaster h_a … thickness of equalizing layer or adhesive	$h_p \leq 15$ mm and $(h_p + h_a) \leq 25$ mm

This EAD covers plastic anchors which are not exposed to UV-radiation for more than 6 weeks, during the use as they are protected by the rendering after installation.

This EAD applies to applications where the minimum thickness of concrete members in which the fasteners are installed is at least h = 100 mm.

Type A: The fastener can be used in the temperature range -20 °C to + 60 °C. The minimum setting temperature of the fastener is +5 °C.

Type B: The fastener is intended to be used in the temperature range 0 °C to +40 °C. The minimum setting temperature of the fastener is 0 °C.

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 fastener for the intended use of 25 years when installed in the works (provided that the fastener 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.

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[3].

[3] 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.

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given 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 Designation

Powder-actuated fastener/ Fastener	=	assembled component consisting of a plastic part and a steel nail achieving anchorage between the base material (concrete) and the fixture (insulation of ETICS)
Plastic part	=	Type A: consisting of a shaft and a plate for holding the thermal insulation, made of high-density polyethylene Type B: plastic plate made of high-density polyethylene (PE-HD) or polyamide (PA6, PA6.6)
Fixture	=	component to be fixed to the concrete member (here ETICS, respectively insulation of ETICS)
Anchorage	=	an assembly comprising base material (concrete), fastener and fixture

1.3.2 Symbols

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

Fasteners

h	=	thickness of concrete member
h_D	=	thickness of insulation material
h_a	=	thickness of adhesive and equalizing layer
h_p	=	thickness of plaster of coated concrete
h_{pl}	=	total height of plastic part, see Figure 1.2.1.3
h_{NVS}	=	nail head stand-off, see Figure 1.2.1.3
h_V	=	mean anchorage depth in the concrete
d	=	shaft diameter of the nail
L	=	overall length of the nail
L_S	=	shank length of the nail
c	=	edge distance
c_{min}	=	minimum allowable edge distance
s	=	spacing of the fastener
s_{min}	=	minimum allowable spacing

Tests / Assessment

F_A	=	pull-out force in a test in installation safety test F1(A) for type A
F_R	=	frictional force in a test in installation safety test F1(A) for type A
$N^t_{5\%}$	=	5%-fractile of the ultimate load (normal distribution) in a test series
$N^r_{5\%}$	=	5%-fractile of the ultimate load (normal distribution), reference test
$N^t_{ln5\%}$	=	5%-fractile of the ultimate load (logarithmic distribution) in a test series

$N^{r}_{ln5\%}$	=	5%-fractile of the ultimate load (logarithmic distribution), reference test
$N^{t}_{Ru,m}$	=	mean value of ultimate loads in a test series
$N^{r}_{Ru,m}$	=	mean value of ultimate loads in a test series, reference test
α	=	ratio of test value / reference value
n	=	number of tests in a test series
k_s	=	statistical factor
$s_{ln(x)}$	=	standard deviation calculated by the logarithmic test values
v	=	coefficient of variation
δ_0	=	displacement of the fastener (nail and plastic part) under short term tension loading
N_{Rk}	=	characteristic resistance under tension loads stated in ETA
γ_M	=	partial safety factor for the material
f_c	=	concrete compressive strength measured on cylinders
f_{cube}	=	concrete compressive strength measured on cubes with a side length of 150 mm
$f_{cube100}$	=	concrete compressive strength measured on cubes with a side length of 100 mm
$f_{cube200}$	=	concrete compressive strength measured on cubes with a side length of 200 mm
f_{cm}	=	mean concrete compressive strength

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 powder-actuated fastener for the fixing of ETICS in concrete is assessed in relation to the essential characteristics.

Table 2.1.1 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 4: Safety and accessibility in use			
1	Resistance to pull-out failure of the nail	2.2.1	Level: $N_{Rk,p}$ [kN]
2	Resistance to failure of the plastic part	2.2.2	Level: $N_{Rk,Pl}$ [kN]
3	Minimum edge distance Minimum spacing	2.2.3	Level: c_{min} [mm] Level: s_{min} [mm]
4	Displacement	2.2.4	Level: δ_0 [mm]
5	Plate stiffness - type A	2.2.5	Level: c [kN/mm]
Basic Works Requirement 6: Energy economy and heat retention			
6	Point thermal transmittance – type A	2.2.6	Level: χ [W/K]

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.

An overview of the test program for the assessment of the various essential characteristics of the product is given in Annex A.

Provisions valid for all tests, description of the tests as well as general aspects of the assessment (determination of 5% fractile values, determination of reduction factors, etc.) are also given in Annex A.

The tests shall be performed according to Annex A, Table A.1.2.1, Table A.1.2, Table A.1.3.1 and Table A.1.3.2. Details of tests are given in section A2.

2.2.1 Resistance to pull-out failure of the nail under tension load

The characteristic tension resistance $N_{Rk,p}$ with regards to pull-out behaviour of the nail is determined as follows:

For uncoated concrete - type A and type B:

$$N_{Rk,p} = N_{Rk,0} \cdot \min \alpha_u \qquad (2.2.1.1)$$

For coated concrete - type A:

$$N_{Rk,p} = N_{Rk,0} \cdot \min \alpha_u \cdot \alpha_{u,4} \qquad (2.2.1.2)$$

$N_{Rk,p}$ shall be reduced by the factor max N (applied) / max N, if the applied load (see equation (A.2.5.10.1) and (A.2.5.10.2)) of the test series F5 is smaller than the required load.

with:

$N_{Rk,0}$ = characteristic reference resistance (basic value) = min $N_{ln5\%}$ according to equation (A.3.1.1) of test A1 and A2 according to Table A.1.2.1 and Table A.1.2.

min α_u = minimum α_u of the functioning tests F2, F3, F5, F6 and F11 according to Table A.1.3.1 and Table A.1.3.2; ($\leq$ 1,0)

$\alpha_{u,4}$ = α_u of the functioning test F4 (only type A) according to Table A.1.3.1; ($\leq$ 1,0)

α_u = α / req. α (2.2.1.2)

with:

α = α-factor according to equation (A.3.3.1) of the functioning tests
- F2, F3, F5, F6 for type A
- F5, F6, F11 for type B

req. α = required α according to Table A.1.3.1 (type A) and Table A.1.3.2 (type B)

2.2.2 Resistance to failure of the plastic part under tension load

2.2.2.1 Resistance to failure of the plastic part (A3, A4, A5)

The characteristic tension resistance $N_{Rk,Pl}$ of the plastic part is determined as follows.

$$N_{Rk,Pl} = N_{Rk,0,Pl} \cdot \alpha / \text{req. } \alpha \qquad (2.2.2.1.1)$$

with: $N_{Rk,Pl}$ = characteristic resistance of the plastic part (resistance of the shaft or the resistance of the plate)

$N_{Rk,0,Pl}$ = characteristic reference resistance (basic value) = $N_{5\%}$ according to equation (A.3.1.2) of test
- A3 (shaft) and A4 (plate) according to Table A.1.2.1 for type A
- A5 (plate) according to Table A.1.2 for type B

α = α-factor according to equation (A.3.3.2) of the functioning tests
- F7 (shaft), F8 (plate) and F9 according to Table A.1.3.1 for type A
- F1(B), F9, F10 according to Table A.1.3.2 for type B

req. α = required α according to Table A.1.3.1 (type A) and Table A.1.3.2 (type B)

2.2.2.2 Installation safety - plastic part type A (F1(A))

Due to the positive locking or friction-tight contact between fastener guide and the fastener a check load shall be applied when pulling out the fastener guide from the plastic part.
The frictional force between plastic part and insulation material and the pull-out force between fastener guide and plastic part shall be determined.

Following condition has to be fulfilled (detection of setting defects, see intended use for fastener Type A):

$$F_{A,5\%} \text{ (0/20/40°C)} \geq 1,3 \cdot F_{R,95\%} \qquad (2.2.2.2.1)$$

and:

$$F_{A,5\%} = F_{Au,m} - k_s \cdot s \qquad (2.2.2.2.2)$$

$$F_{R,95\%} = F_{Ru,m} + k_s \cdot s \qquad (2.2.2.2.3)$$

with: $F_{A,5\%}$ = 5%-fractile of the ultimate load of pull-out force F_A
$F_{R,95\%}$ = 95%-fractile of the ultimate load of frictional force F_R
$F_{Au,m}$ = mean value of ultimate load of pull-out force F_A in a test series
$F_{Ru,m}$ = mean value of ultimate load of frictional force F_R in a test series
k_s = statistical factor
s = standard deviation

2.2.2.3 Durability of the plastic parts against alkaline solutions

The durability of the plastic part shall be tested against high alkalinity (pH = 13,2). The assessment methods are valid, if the requirements according to Table 2.2.2.3.1 in comparison with the test results in section A2.5.17 are fulfilled.

Table 2.2.2.3.1 Limits for susceptibility to environmental stress cracking

Test-method	Criteria	limit for susceptibility to environmental exposure[2)]
Visual analysis	Cracking	in all specimens no cracks visible with naked eye
tension test EN ISO 527-1[1)]	tension strength	≤ 5 % reduction of tension strength
tension test EN ISO 527-1[1)]	strain ε_m at maximum load	≤ 20 % reduction of strain ε_m
tension test EN ISO 527-1[1)]	strain ε_1 at 50 % of the maximum load	≤ 20 % reduction of strain ε_1

[1)] EN ISO 527-1 [9]

[2)] according to EAD 330196-01-0604 [10]

2.2.3 Minimum edge distance and spacing

Test series A2 is carried out with spacing and edge distances given by the manufacturer. In this case c_{min} and s_{min} result from the distances of the fasteners in test series A2.
In the absence of manufacturer's instructions, the minimum edge distance is $c_{min} \geq 100$ mm and the minimum spacing is $s_{min} \geq 200$ mm.

2.2.4 Displacements

The displacements under short-term tension loading shall be given in the ETA for a load N (N is recommended as $N = N_{Rk} / [\gamma_M \cdot \gamma_F]$ with γ_M and $\gamma_{M,Pl}$ according to section 2.2.1, 2.2.2.1 and $\gamma_F = 1.5$).

These displacements δ_0 are evaluated from tests

- test series A1(A), A3 and A4 for type A
- test series A1(B) and A5 for type B

They shall correspond to the sum of the mean value of these test series (A1: pull-out of nail from concrete, A3: elongation in the shaft, A4 and A5: displacements of the plate).

Alternatively, for type B the total deformations may be evaluated from 5 tension tests with the test setup of test procedure F1(B), shown in Figure A.2.4.7.1.

The displacements (in mm) shall be rounded up to zero or five on the first place after the decimal point.

2.2.5 Plate stiffness - type A

The plate stiffness c [kN/mm] of the anchor plate is assessed according to Annex B.

2.2.6 Point thermal transmittance - type A

The point thermal transmittance χ [W/K] is assessed according to Annex C.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Commission Decision 97/463/EC.

The system is 2+.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the powder-actuated fastener for the fixing of ETICS in concrete in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1, Table 3.2.2 and Table 3.2.3.

Table 3.2.1 Control plan for the manufacturer - nail; cornerstones

No	Subject/type of control	Test or control method	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	Dimensions: - nail head: check of shape, height, diameter, concentricity - diameter of shaft - geometry and length of tip	Measuring or optical checks according to control plan	Laid down in control plan	10	Every manufacturing batch
2	Raw material specification and properties (tensile and yield strength, fracture elongation, chemical composition)	Inspection certificate 3.1 according to EN 10204 [11] [10]	Specification	1	Every manufacturing batch
3	Core hardness	Rockwell hardness tests according to EN ISO 6508-1 [12]	Laid down in control plan	10	Every manufacturing batch
4	Metallurgical properties	Metallurgical investigations (micro-sections) according to control plan	Laid down in control plan	10	Every manufacturing batch
5	Deformation capacity, ductility	Bending deformation tests according to control plan	Laid down in control plan	20	Every manufacturing batch
6	Zinc plating	X-ray measurement, microscopical method or magnetic method	Laid down in control plan	10	Every manufacturing batch

Table 3.1.2 Control plan for the manufacturer – plastic part; cornerstones

No	Subject/type of control	Test or control method	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	Melt volume-flow rate (MVR) or melt flow rate (MFI) of raw material	EN ISO 1133-1 [13]	Laid down in control plan Tolerance: for MFI ≤ 10: ± 1 for MFI > 10: ± 10%	1	Every raw material batch
2	DSC-curve of raw material	EN ISO 11357-1 [14]	Laid down in control plan Tolerance: ± 5 K	-	Every manufacturing batch or twice / year
3	Density of raw material	EN ISO 1183 [15]	Laid down in control plan	1	Every raw material batch
4	Geometry of the injection moulded: - check of shape and marking - length of product - thickness of shaft sleeve	Measuring or optical	Laid down in control plan	1	Working shift

Table 3.2.3 Control plan for the manufacturer – assembled product (only type A); cornerstones

No	Subject/type of control	Test or control method	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	Identity check of the individual parts	Visual check	Laid down in control plan	10	Working shift
2	Distance fastener head - plate	Visual check or sliding calliper	Laid down in control plan	10	Working shift

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body of the powder-actuated fastener for the fixing of ETICS in the procedure of assessment and verification of constancy of performance are laid down in Table 3.3.1.

Table 3.3.1 Control plan for the notified body; cornerstones

Nr	Subject/type of control	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					
1	Ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the fastener	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	Laid down in control plan	-	1
Continuous surveillance, assessment and evaluation of factory production control					
2	Verifying that the system of factory production control and the specified automated manufacturing process are maintained taking account of the control plan.	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.2.1 to 3.2.3	Laid down in control plan	-	1/year

4 REFERENCE DOCUMENTS

[1] EN 15895:2011+A1:2018: Cartridge-operated hand-held tools – safety requirements – Part 1: Fixing and hard marking tools.

[2] EN ISO 10683:2018: Fasteners – Non-electrolytically applied zinc flake coatings

[3] EN 10088–3:2014: Stainless steel: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes

[4] EAD 040083-00-0404 External thermal insulation composite systems (ETICS) with renderings, January 2019

[5] EN 13163:2012+A2:2016: Thermal insulation products for buildings - Factory made expanded polystyrene (EPS) products - Specification

[6] EN 13162:2012, amended 2015: Thermal insulation products for buildings - Factory made mineral wool (MW) products – Specification

[7] EN 1993-1-4:2006+A1:2015: Eurocode 3: Design of steel structures − Part 1-4: General rules - Supplementary rules for stainless steels

[8] EN 206:2013+A1:2016: Concrete - Specification, performance, production and conformity

[9] EN ISO 527-1:2019: Plastics; determination of tensile properties; part 1: general principles

[10] 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

[11] EN 10204:2004: Metallic products – types of inspection documents

[12] EN ISO 6508-1:2015: Metallic materials – Rockwell hardness test

[13] EN ISO 1133-1:2011: Plastics - Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics - Part 1: Standard method

[14] EN ISO 11357-1:2016: Plastics - Differential scanning calorimetry (DSC) - Part 1: General principles

[15] EN ISO 1183: Plastics - Methods for determining the density of non-cellular plastics (Part 1, 2019: Immersion method, liquid pyknometer method and titration method; Part 2, 2019: Density gradient column method, Part 3, 1999: Gas pyknometer method)

[16] EN ISO 1110:2019: Plastics – Polyamides – Accelerated conditioning of test specimens

[17] EN 197-1:2011: Cement Part 1: Composition, specifications and conformity criteria for common cements

[18] R. Lewandowski: Beurteilung von Bauwerksfestigkeiten an Hand von Betongütewürfeln und –bohrproben, Schriftenreihe der Institute für Konstruktiven Ingenieurbau der Technischen Universität Braunschweig, Heft 3, Werner Verlag, Düsseldorf, 1971

[19] EN 998-1:2016: Specification for mortar for masonry – Part 1: Rendering and plastering mortar.

[20] EAD 330083-02-0601: Power-actuated fastener for multiple use in concrete for non-structural applications, March 2018

[21] EN ISO 3167:2014: Plastics; multipurpose test specimens

[22] EN ISO 10211:2017: Thermal bridges in building construction - Heat flows and surface temperatures - Detailed calculations

[23] EN ISO 6946:2017: Building components and building elements - Thermal resistance and thermal transmittance - Calculation method

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

[25] EN ISO 10456:2007+AC:2009: Building materials and products - Hygrothermal properties - Tabulated design values and procedures for determining declared and design thermal values

[26] 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

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

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

A ANNEX A TEST PROGRAM AND GENERAL ASPECTS OF ASSESSMENT

A1 Test program

A1.1 Overview test program

The test program for the assessment consists of:

- Basic tension tests to assess basic values of characteristic resistance
- Any other tests to assess the characteristic resistance regarding various effects for the relevant application range according to the intended use (functioning tests).

Details of tests are given in section A2.

A1.2 Basic tension tests

The reference tests A1 have to be performed with all different types of powder-actuating fastening tools to be assessed. The reference tests A1 have further be performed with all different types of fastener guides − guide for single nails and magazine for collated nails − per powder-actuated fastening tool.

Table A.1.2.1 Test program of Basic tension tests – type A

No	Purpose of test	Concrete strength	Minimum number of tests	Temperature [°C]
A1(A)	Reference test Resistance to pull-out failure of the nail	a) C12/15	20	21 ± 3
		b) C20/25	50	
		c) C35/45	20	
A2(A)	Characteristic spacing and edge distances	C12/15 ≤ C35/45	10	21 ± 3
A3	Resistance to failure of the plastic part: shaft	-	10	21 ± 3
A4	Resistance to failure of the plastic part: plate	-	10	21 ± 3

Table A.1.2.2 Test program of Basic tension tests – type B

No	Purpose of test	Concrete strength	Minimum number of tests	Temperature [°C]
A1(B)	Reference test Resistance to pull-out failure of the nail	a) C20/25	50	21 ± 3
		b) C50/60 or max strength class (1)	50	
A2(B)	Characteristic spacing and edge distances	C20/25 ≤ C50/60	10	21 ± 3
A5	Resistance to failure of the plastic plate (2)	-	10	21 ± 3

(1) if there is an application for anchorage in concrete strength class less than C50/60 only; tests are required in concrete with a compressive strength $f_{ck,test} \geq f_{ck,used}$ + 20 MPa (in case of C20/25) and $f_{ck,test} \geq f_{ck,used}$ + 10 MPa (in case of C40/50), $f_{ck,test} \geq f_{ck,used}$ + 5 MPa (in case of C50/60), interim values can be interpolated linear.

(2) plastic parts conditioned to norm climate 23/50 [16] (only for polyamide)

A1.3 Functioning tests

The tests shall be performed as single fastener tests in concrete members without any influence by edge and spacing effects under tension loading. In all functioning tests displacements can be measured externally (e.g., by displacement transducers) or internally (e.g., measurement of piston stroke).

Table A.1.3.1 Test program of Functioning tests - type A

No	Purpose of test		Concrete strength	Minimum number of tests	Tem-perature [°C]	Criteria req. α (1)	Reference test
F1(A)	Installation safety – plastic part	a) friction force F_R between plastic part and insulation material	-	5	21 ± 3	-	-
		b) pull-out force F_A between fastener guide and plastic part	-	5 each	0 20 40	-	-
F2	Load resistance in carbonated concrete		C 12/15 ≤ C 35/45	20	21 ± 3	0.75	A1(A)
F3	Load resistance in concrete with an equalizing layer (2)		C 12/15 ≤ C 35/45	20	21 ± 3	0.75	A1(A)
F4	Load resistance in coated concrete	a) uncoated	C 20/25	20	21 ± 3	-	-
		b) coated (3)		20	21 ± 3	1.0	F4a
F5	Functioning under repeated loads	a) after setting	C 12/15	10	21 ± 3	-	-
		b) after load cycles		10	21 ± 3	1.0	F5a
F6	Load resistance after relaxation	a) after setting	C 20/25	20	21 ± 3	-	-
		b) after 1 month		20	21 ± 3	1.0	F6a
		c) after 3 months		20	21 ± 3	1.0	F6a
F7	Load resistance of the plastic part: Shaft		-	5	60	1.0	A3
F8	Load resistance of the plastic part: Plate		-	5	- 20	1.0	A4
				5	60	1.0	
F9	Influence of pigmentation on the plastic part		-	5	21 ± 3	0.95	A3, A4

(1) α value according to clause A3.3
(2) coated with equalizing layer h_a = 20 mm, see Table 1.2.1.1
(3) coated with h_p = 15 mm and (h_p + h_a) = 25 mm, see Table 1.2.1.1

Table A.1.3.2 Test program of Functioning tests - type B

No	Purpose of test		Concrete strength	Minimum number of tests	Tem-perature [°C]	Criteria req. α (1)	Reference test
F1(B)	Installation safety – plastic part (2)	a) plastic part dry (3)	C20/25	10	21 ± 3	1.0	A5
		b) plastic part cold (4)		10	0 ± 3	1.0	A5
F5	Functioning under repeated loads	a) after setting	C20/25	10	21 ± 3	-	-
		b) after load cycles		10	21 ± 3	1.0	F5a
F6	Relaxation	a) after setting	C20/25	20	21 ± 3	-	-
		b) after 1 month		20	21 ± 3	1.0	F6a
		c) after 3 months		20	21 ± 3	1.0	F6a
F9	Influence of pigmentation on the plastic part		-	5	21 ± 3	0.95	A5
F10	Effect of temperature – plastic part (5)		-	5	0 ± 3	1.0	A5
				5	40 ± 3	1.0	
F11	Hydrogen embrittlement		C20/25	5	21 ± 3	0.9 (6)	A1(B) (7)

(1) α value according to clause A3.3.

(2) to be performed with all fastening tools to be assessed (both single fastener guide and fastener magazine)

(3) plastic parts conditioned dry (only for polyamide): storage at 70 °C till no more weight reduction occurs

(4) plastic parts conditioned to norm climate 23/50 [16] (only for polyamide) and minimum 24 hours exposed to minimum installation temperature

(5) plastic parts conditioned to norm climate 23/50 [16] (only for polyamide) and minimum 24 hours exposed to test temperature

(6) for calculation of α only comparison of mean value is required

(7) In case of different setting conditions between F11 and A1(B) (e.g., concrete batches or anchorage depth because of isolation) additional reference tests with setting conditions of test F11 are possible. For these tests longer fasteners of the same type of fastener may be used and be driven into pre-drilled holes to allow application of high pre-stressing forces in the steel to avoid premature pull-out failure.

A2 Details of tests

A2.1 Test samples

Samples shall be chosen to be representative of normal production as supplied by the manufacturer, including steel nail and plastic part.

A conditioning of the plastic part made of polyamide (PA6 or PA6.6) is required per Table A.1.2.2 and Table A.1.3.2. Conditioning to norm climate 23/50 is to be done according to EN ISO 1110 [16].

A conditioning of the plastic part made of high-density polyethylene (PE-HD) is not necessary because polyethylene does not absorb any humidity.

A2.2 Test members

A2.2.1 General

The fasteners are tested in concrete members using compacted normal weight concrete without fibres with strength classes in the range of C20/25 - C50/60 in accordance with EN 206 [8]. The fastener performance is only valid for the range of tested concrete.

The test members shall comply with the following:

A2.2.2 Aggregates

The tests are to be carried out under laboratory conditions on test specimens of maximum 16 mm of grain (aggregate) size. For concrete strength class C 20/25 or C 30/37, in addition, tests shall be carried out on specimens of maximum 32 mm of grain size (within test A1).

Aggregates shall be of natural occurrence (i.e., non-artificial) and with a grading curve falling within the boundaries given in Figure A.2.2.2.1. The aggregate density shall be between 2.0 and 3.0 t/m³ (see EN 206 [8]).

The boundaries reported in Figure A.2.2.2.1 are valid for aggregate with a maximum size of 16 mm. For different values of maximum aggregate sizes, different boundaries may be adopted, if previously agreed with the responsible TAB.

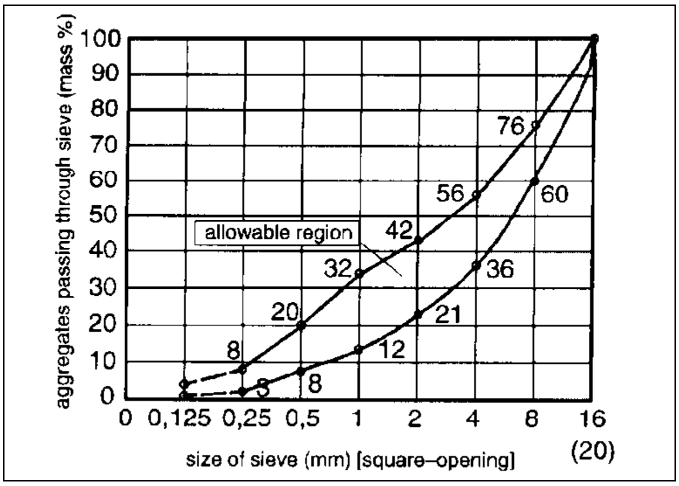


Figure A.2.2.2.1 Admissible region for the grading curve

A2.2.3 Cement

The concrete shall be produced using Portland cement Type CEM I or Portland-Composite cement Type CEM II/A-LL, CEM II/B-LL (see EN 197-1 [17])

A2.2.4 Water/cement ratio and cement content

The water/cement ratio shall not exceed 0,75 and the cement content shall be at least 240 kg/m³.

No additives likely to change the concrete properties (e.g., fly ash, or silica fume or other powders) shall be included in the mixture.

A2.2.5 Concrete strength

For the tests carried out in low strength concrete (strength class C20/25) and high-strength concrete (strength class C50/60) the following mean compressive strengths at the time of testing fasteners shall be obtained for the two classes:

C20/25	f_c	=	20-30 MPa (cylinder: diameter 150 mm, height 300 mm)
	f_{cube}	=	25-35 MPa (cube:150 x 150 x 150 mm)
C50/60	f_c	=	50-60 MPa (cylinder: diameter 150 mm, height 300 mm)
	f_{cube}	=	60-70 MPa (cube:150 x 150 x 150 mm)

It is recommended to measure the concrete compressive strength either on cylinders with a diameter of 150 mm and height of 300 mm, or on cubes of 150 mm.

The following conversion factors for concrete compressive strength from cube to cylinder may be used:

C20/25 $$f_c = \frac{1}{1{,}25} f_{cube} \qquad \text{(A.2.2.5.1)}$$

C50/60 $$f_c = \frac{1}{1{,}20} f_{cube} \tag{A.2.2.5.2}$$

For other dimensions, the concrete compressive strength may be converted as follows:

$$f_{cube100} = \frac{1}{0{,}95} f_{cube} \tag{A.2.2.5.3}$$

$$f_{cube} = \frac{1}{0{,}95} f_{cube200} \tag{A.2.2.5.4}$$

$f_{cube} = f_{core100}$ (acc. to EN 197-1 [17], section 7.1) (A.2.2.5.5)

Note: Additional literature for conversion is given by R. Lewandowski,[18]

For every concreting operation, specimens (cylinder, cube) shall be prepared having the dimensions conventionally employed in the member country. The specimens shall be made, cured and conditioned in the same way as the test members.

Generally, the concrete control specimens shall be tested on the same day as the fasteners to which they relate. If a test series takes a number of days, the specimens shall be tested at a time giving the best representation of the concrete strength at the time of the fastener tests, e.g., at the beginning and at the end of the tests. In this case the concrete strength at the time of testing can be determined by interpolation.

The concrete strength at a certain age shall be measured on at least 3 specimens. The mean value of the measurements governs.

If, when evaluating the test results, there should be doubts whether the strength of the control specimens represents the concrete strength of the test members, at least three cores of 100 mm diameter shall be taken from the test members outside the zones where the concrete has been damaged in the tests, and tested in compression. The cores shall be cut to a height equal to their diameter, and the surfaces to which the compression loads are applied shall be ground or capped. The compressive strength measured on these cores may be converted into the strength of cubes by equation (A.2.2.5.5).

A2.2.6 Reinforcement

Tests are to be performed in non-cracked concrete only. In cases where the test member contains reinforcement to allow handling or for the distribution of loads transmitted by the test equipment, the reinforcement shall be positioned such as to ensure that the loading capacity of the tested fasteners is not affected. This requirement will be met if the reinforcement is located outside the zone of concrete cones having a vertex angle of 120°.

A2.2.7 Casting and curing of test members

The test members shall be cast horizontally. They may also be cast vertically if the maximum height is 1,5 m and complete compaction is ensured.

Test members and concrete specimens (cylinders, cubes) shall be cured and stored indoors for seven days. Thereafter they may be stored outside provided they are protected such that frost, rain and direct sun does not cause a deterioration of the concrete compression and tension strength. When testing the fasteners, the concrete shall be at least 21 days old.

Test members and concrete specimen shall be stored in the same way.

A2.3 Installation of fasteners

The fasteners shall be installed in accordance with the installation instruction supplied by the manufacturer unless otherwise required in a specific test series.

The fasteners shall be installed in a concrete surface that has been cast against a form of the test member.

Type A: For all tests with concrete base material the fastener has to be driven into the concrete together with insulation material made of expanded polystyrene with the following characteristics:

- compressive strength at 10 % deformation ≥ 65 kPa
- density: about 15 kg/m³

- thickness of the insulation material ≥ 60 mm

The energy to drive the nail is to be selected such that the mean anchorage depth h_v amounts to the required anchorage depth. The mean anchorage depth in uncoated concrete is at least 30 mm (tested without equalizing layer and adhesive). The mean anchorage depth h_v in coated concrete is at least 20 mm (tested without equalizing layer and adhesive).

Type B: The energy to drive the nail is to be selected such that the stand-off tolerance range h_{NVS} (Figure 1.2.1.3) is observed. The mean anchorage depth h_v in concrete shall be at least 20 mm.

A2.4 Test equipment

Tests shall be carried out using measuring equipment having a documented calibration according to international standards. The load application equipment shall be designed to avoid sudden increase in load especially at the beginning of the test. The measurement bias of the measuring chain of the load shall not exceed 2% of the measured quantity value.

When required, displacements shall be recorded continuously (e.g., by means of electrical displacement transducers) with a measuring bias not greater than 0,020 mm or 2,0 % for displacements > 1 mm.

The test rig shall allow the formation of an unrestricted rupture cone. For this reason, the distance between the support reaction and the fastener shall be at least 2 h_V as shown in Figure A.2.4.1.1 and Figure A.2.4.2.1.

A2.4.1 Test equipment for pull-out resistance of the nail – type A

For tests A1(A), A2(A), F2, F3, F4, F5 and F6 with type A the nail is installed in accordance with A2.3. An example for the test setup is shown in Figure A.2.4.1.1.

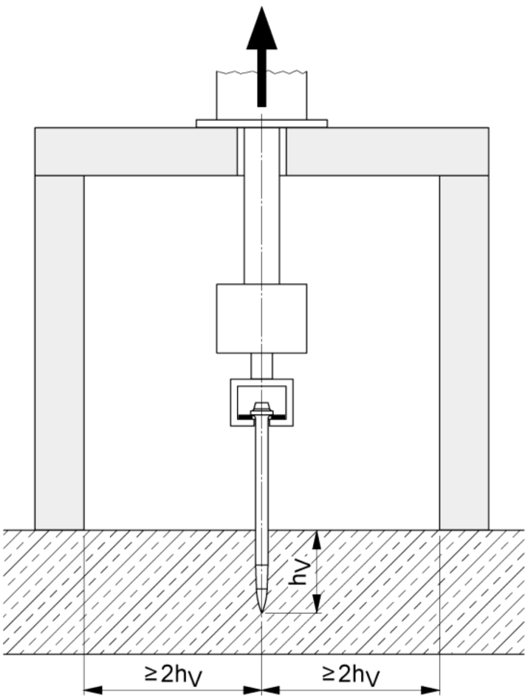


Figure A.2.4.1.1 Test setup for determination of pull-out resistance of the nail – type A

A2.4.2 Test equipment for pull-out resistance of the nail – type B

For tests A1(B), A2(B), F5 and F6 with type B the nail is installed in accordance with A2.3. An example for this test setup is shown in Figure A.2.4.2.1.

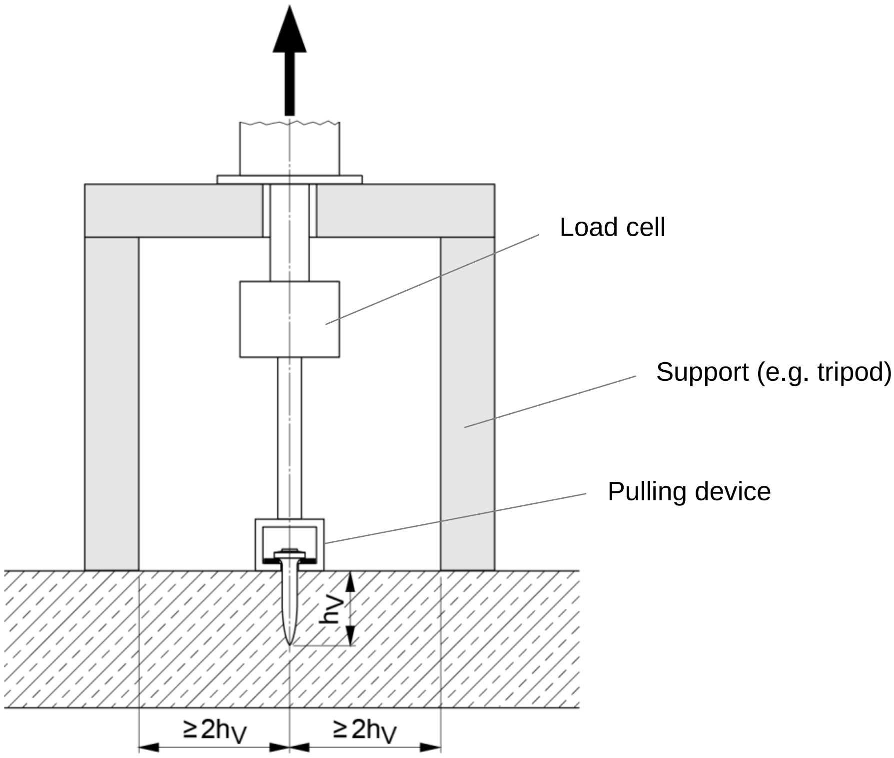


Figure A.2.4.2.1 Test setup for determination of pull-out resistance of the nail – type B

A2.4.3 Test equipment for resistance of the plastic part: shaft - type A

An example for the test setup for tests A3 and F7 with type A is shown in Figure A.2.4.3.1.

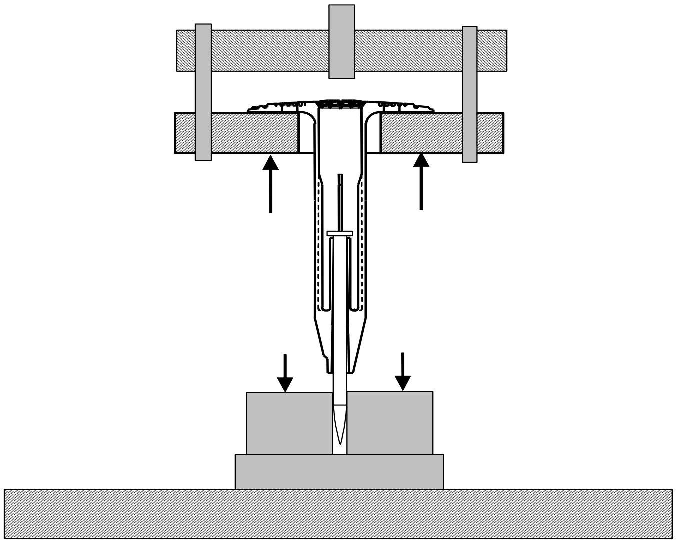


Figure A.2.4.3.1 Determination of tension resistance of the shaft - type A

A2.4.4 Test equipment for resistance of the plastic part: plate - type A

The tests A4 and F8 with type A shall be carried out according to Annex B.

A2.4.5 Test equipment for resistance of the plate - type B

Figure A.2.4.5.1 shows the test setup for the A5 and F10- tests (load resistance of the plastic part, type B). The load shall be applied via a solid supporting steel plate with an inner diameter of 30 mm.

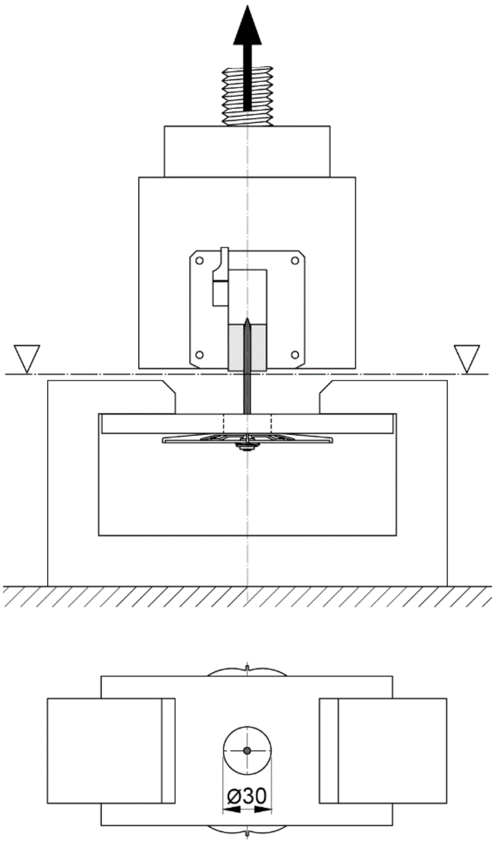


Figure A.2.4.5.1 Test setup for determination of pull-through resistance of plate - type B

A2.4.6 Test equipment for installation safety test F1(A)

Examples for the test setup for the installation safety tests F1(A) for type A are shown in Figure 2.4.6.1 and Figure A.2.4.6.2.

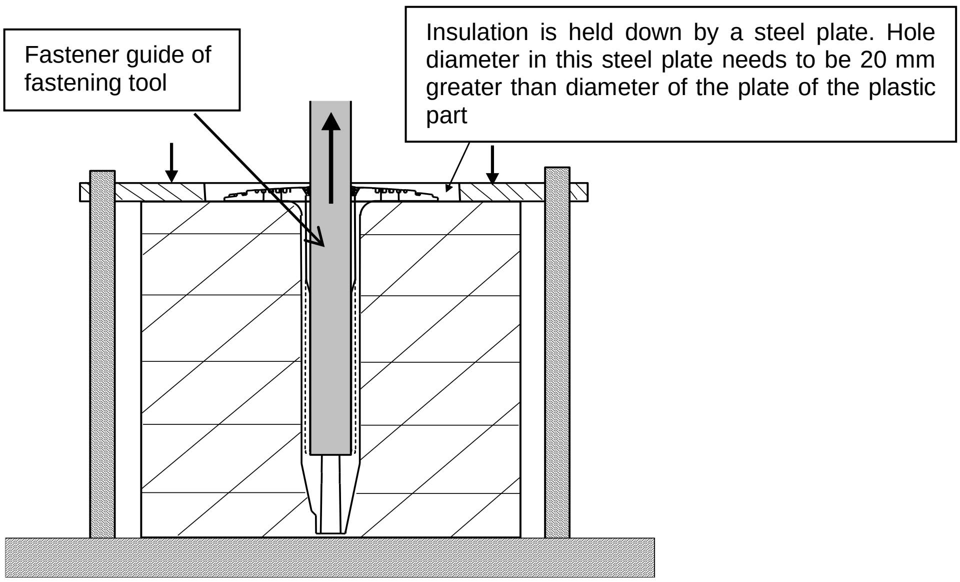


Figure A.2.4.6.1 Determination of frictional forces F_R - type A

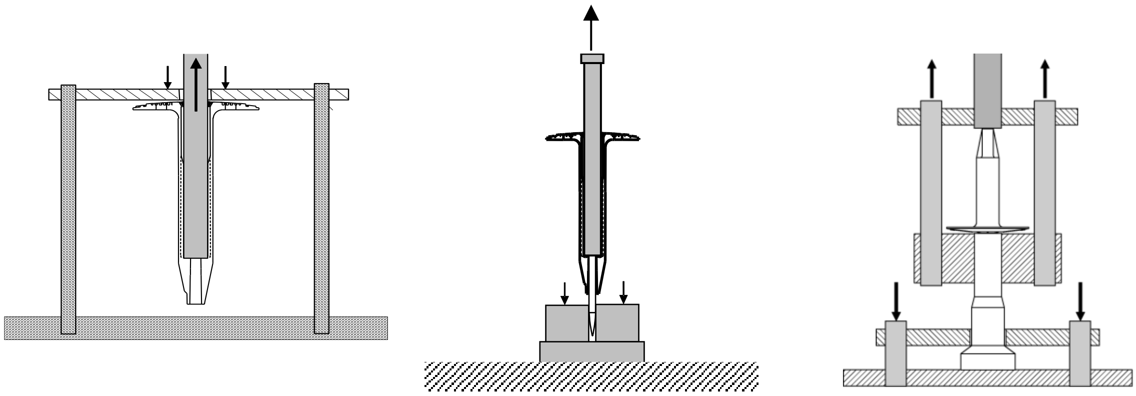


Figure A.2.4.6.2 Determination of pull-out force F_A of fastener guide from plastic part - type A

A2.4.7 Test equipment for installation safety test F1(B)

Figure A.2.4.7.1 shows the test setup for the installation safety tests F1(B) for type B, which allows the force introduction into the installed plastic plate.

Figure A.2.4.7.1 also shows the positioning of the displacement gauge for displacement measurement. The gauge is positioned to the top surface of the plastic part close to the fastener head.

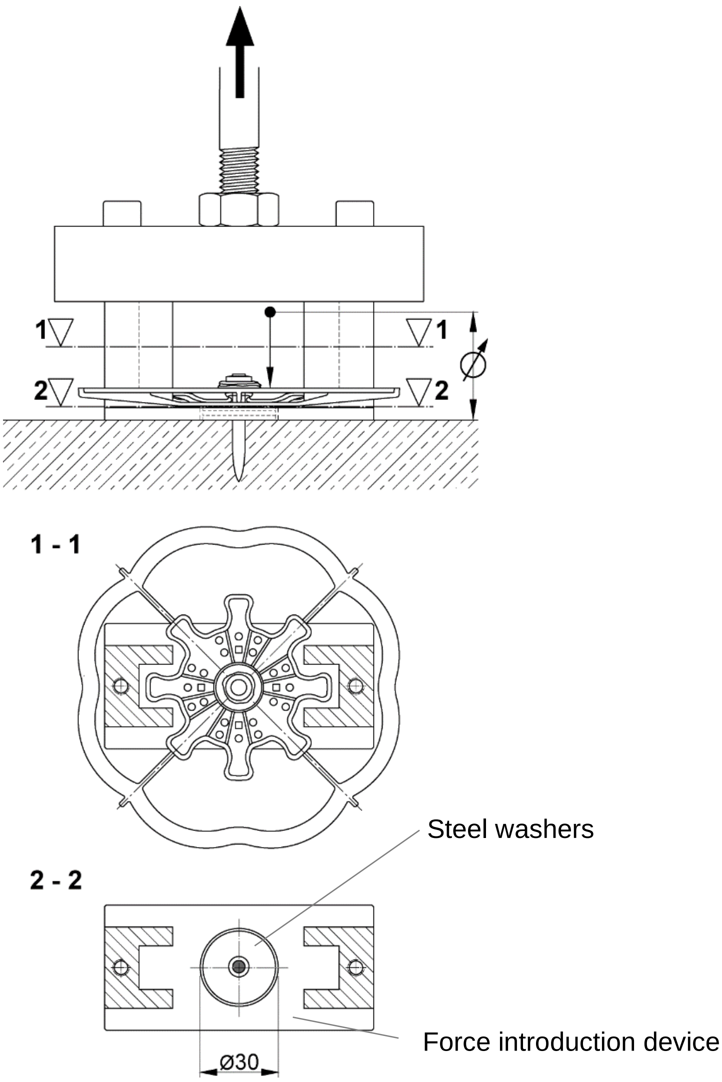


Figure A.2.4.7.1 Test setup for installation safety test - type B

A2.5 Test procedure

After installation, the fastener is connected to the test rig and loaded to failure.

The load shall increase in such a way that the average peak load of a test series is reached after 0.5 to 3.0 minutes. All tests shall be performed later than 10 minutes after setting.

The tests may be carried out with load, displacement or hydraulic control. The data shall be collected with a minimum frequency 5 Hz.

A2.5.1 Resistance to pull-out failure of the nail (A1, A2)

The tests shall be carried out in uncoated concrete without equalizing layer or adhesives until failure.

Before pulling the nail the plastic part and insulation (only for type A) can be removed allowing assembly of a pulling device to the nail head.

For determining characteristic spacing and edge distances the tests shall be carried out with the test setup of Figure A.2.4.1.1 (type A) and Figure A.2.4.2.1 (type B) with spacing and edge distances given by the manufacturer. Spacing, edge distances and spalling of concrete shall be recorded.

A2.5.2 Resistance of the plastic part (shaft) – type A (A3)

The load shall be applied via a solid supporting steel ring of a greater inner clear diameter than the shaft dimension including plate stiffening ribs according to Figure A.2.4.3.1. The inner diameter of the ring is acceptable to be less than 30 mm in order to avoid premature failure of the plastic plate.

The nail can be clamped into a steel element. The tension load is then transferred via the shaft. The rate of loading is in case of displacement-controlled testing about 1 mm/min and is in case of force-controlled testing about 1 kN/min.

A2.5.3 Resistance of the plastic part (plate) – type A (A4)

The tests shall be carried out according to Annex B.

A2.5.4 Resistance to failure of the plastic part (plate) – type B (A5)

The load shall be applied via a solid supporting steel plate with an inner diameter of 30 mm. The test setup is shown in Figure A.2.4.5.1.1.

A2.5.5 Installation safety – plastic part type A (F1(A))

The frictional force between plastic part and insulation material (F_R) and the pull-out force between fastener guide and plastic part (F_A) are determined as follows.

a) Frictional forces between plastic part and insulation material (F_R)

The plastic part of the fastener shall be pressed by means of the test engine into the insulation material element made of polystyrene foam of dimensions of at least 200 x 200 x 60 mm. The fastener guide – connected with the test engine – is used to press the plastic part into the insulation. Then the plastic part is pulled out from the insulation material using the fastener guide, see Figure A.2.4.6.1. The tests shall be carried out at a pull-out rate between 100 mm/min and 500 mm/min.
The thickness of the insulation material shall be chosen as a function of length of the plastic part to be tested.
The frictional force F_R shall be measured.
The load/displacement curves shall be recorded.

b) Pull-out force between fastener guide and plastic part (F_A)

The plastic part together with the fastener guide is pressed into the insulation material under the same test parameters as described above. The insulation material shall then be removed.
The pull-out force F_A shall be determined. The test set-up shall correspond to one of the options shown in Figure A.2.4.6.2.
The load/displacement curves shall be recorded.
For the tests carried out at a temperature of 40 °C the elements to be tested shall be conditioned at 40 °C for at least 24 hours.

A2.5.6 Installation safety – plastic part type B (F1(B))

The test setup for F1(B) is shown in Figure A.2.4.7.1.

Before driving the nail into the concrete, steel washers are positioned in the hole (d = 30 mm) of the force introduction device. The total thickness of these washers corresponds at least with the thickness of bottom plate of the force introduction device. The outer diameter of these washers is 29 mm, and the diameter of the inner hole shall be greater than 6 mm.

For compensation of the thickness of the bottom plate of the force introduction device, longer nails of the same nail type may be used. The stand-off tolerance range h_{NVS} (Figure 1.2.1.3) is observed.

A2.5.7 Load resistance in carbonated concrete (F2)

The tests shall be carried out with the test setup of Figure A.2.4.1.1 in concrete with a depth of carbonation of ≥ 5 mm.

A2.5.8 Load resistance in concrete with an equalizing layer (F3)

The tests shall be carried out with the test setup of Figure A.2.4.1.1 in concrete coated with a 20 mm thick equalizing layer, e.g., bonding mortar. After setting, this layer shall be removed and the fastener shall be loaded.

The thickness of levelling layer shall be recorded.

The driving energy shall be adjusted such that the mean anchorage depth amounts to minimum 30 mm[4] by means of 10 reference installations made to the concrete test member without equalizing layer. That driving energy is to be used for the test F3.

A2.5.9 Load resistance in coated concrete (F4)

The tests shall be carried out with the test setup of Figure A.2.4.1.1 in concrete coated with a 15 mm thick layer of cement plaster coated with a supplemental equalizing layer or adhesive. The cement plaster shall comply with general purpose plastering mortar (GP) of compressive strength category CS III or CS IV according to EN 998-1 [19]

The driving energy shall be selected such that in the reference test F4 a) a mean anchorage depth h_v of 30 mm is achieved. That energy setting is used for the test F4 b) with the objective of a mean anchorage depth $h_v \geq 20$ mm. If required the tool energy shall be increased.

A2.5.10 Functioning under repeated loads (F5)

The test setup shown in Figure A.2.4.1.1 (type A) and Figure A.2.4.2.1 (type B) applies.

The single nail is subjected to 10^5 load cycles with a maximum frequency of approximately 6 Hz. During each cycle the load shall change as a sine curve between max N and min N with:

$$\max N = 0.6\ N_{Rk} \qquad (A.2.5.10.1)$$

$$\min N = 0.25\ N_{Rk} \qquad (A.2.5.10.2)$$

with: N_{Rk} = characteristic tension resistance evaluated from the results of test A1 according to Table A.1.2.1 or Table A.1.2.

The displacements shall be measured during the first loading up to max N and then either continuously or at least after 1, 10, 10^2, 10^3, 10^4 and 10^5 load cycles.

The increase of displacement during cycling shall stabilize in a manner indicating that failure is unlikely to occur after some additional cycles.

If the above condition on the displacement is not fulfilled, the tests have to be repeated with a lower maximum load (max N (applied)) until this condition is fulfilled. Then the characteristic resistance N_{Rk} shall be reduced with the factor max N (applied) / max N.

After completion of the load cycles the fastener shall be unloaded, the displacement measured and a tension test to failure performed.

---

4 With a minimum requirement for individual fasteners of 25 mm.

A2.5.11 Relaxation (F6)

The tests shall be carried out in uncoated concrete with the test setup shown in Figure A.2.4.1.1 (type A) and Figure A.2.4.2.1 (type B). The load resistance shall be determined immediately after setting, after 1 month and after 3 months.

A2.5.12 Load resistance of the plastic part: shaft – type A (F7)

The shaft is conditioned at the maximum short-term temperature given in Table A.1.3.1 for at least 24 hours. The test procedure as for A3- test applies.

A2.5.13 Load resistance of the plastic part: plate – type A (F8)

The plate shall be conditioned at -20 °C and 60 °C for at least 24 hours. The test procedure as for A4- test applies.

A2.5.14 Influence of pigmenting on the plastic parts (F9)

All tests with the plastic parts (A3, A4, A5) shall be performed with coloured components. In case the same plastic part is manufactured in different supplemental colours, it is necessary to determine the influence of the new colour on tensile strength at normal ambient temperatures (21 ± 3 °C).

A2.5.15 Effect of temperature on plastic part - type B (F10)

Tests are performed at the maximum short-term temperature of +40 °C and at the minimum short-term temperature of 0°C.
The test procedure as for A5- test applies.

A2.5.16 Hydrogen embrittlement (F11)

The tests are performed to detect fasteners with a high susceptibility to hydrogen induced brittle fracture caused by the production process or by corrosion during (even short-time) exposure to moisture.

The tests have to be performed in keeping with the Functioning Test F6 according to EAD 330083-02-0601 [20].

This test can be omitted if fasteners are made of stainless steel (exception martensitic steel).

A2.5.17 Test for the determination of high alkalinity from plastic sleeve

Test specimen:

1. Manufactured of tension bars according to EN ISO 3167 [21].
2. Drilling holes (diameter 2,8 mm) with a drill into the centre of the tension bars perpendicularly to the flat side of the specimen followed by rubbing the hole with a reamer (diameter 3,0 ± 0,05 mm).
3. Pressing a round pin (diameter according to Table A.2.5.17.1) quickly into tension bars.
4. Putting the tension bars into the different agents (see Table A.2.5.17.1 for number of necessary tension bars).
   - Water (reference tests)
   - High alkalinity (pH = 13,2)

   High Alkalinity:

   The tension bars with pins are stored under standard climate conditions in a container filled with an alkaline fluid (pH = 13,2). All slices shall be completely covered for 2000 hours (T = +21 ℃ ± 3 ℃). The alkaline fluid is produced by mixing water with $Ca(OH)_2$ (calcium hydroxide) powder or tablets until the pH-value of 13,2 is reached. The alkalinity shall be kept as close as possible to pH 13,2 during the storage and not fall below a value of 13,0. Therefore the pH-value has to be checked and monitored at regular intervals (at least daily).

5. After taking the bars from high-alkaline solution investigate them for cracks. Perform tension tests according to EN ISO 527-1 [9]. It is required that the dimensions of the tension bar according to EN ISO 3167 [21] for ref-tests and alkalinity test are the same.

Table A.2.5.17.1 Necessary number of tests on tension bars with pins

line	Test description	Diameter of pins [mm]	water	High alkalinity
1	reference-test	3,0	5	-
2	high alkalinity test	3,5	-	5

A2.6 Test report

As a minimum requirement, the report shall include at least the following information or allow clear traceability to the nail and plastic parts through the reported lot number of the used fastener.

General

- Steel nail:
  - Dimensions: shape, length, diameter, geometry and length of tip, concentricity of nail head
  - Raw material specification and properties (tensile and yield strength, fracture elongation, chemical composition)
  - Core hardness
  - Metallurgical properties
  - Deformation capacity, ductility
  - Zinc plating, type of coating
- Plastic part:
  - Type of plastics
  - DSC- curve, density and melt volume-flow rate (MVR) or melt flow rate MFI of raw material
  - Mechanical properties: tensile strength at yield, tensile stain at yield, tensile strength at break, tensile strain at break, tensile modulus
  - Dimensions of the injection moulded
- Name and address of manufacturer
- Name and address of test laboratory
- Date of tests
- Name of person responsible for test
- Type of test (e.g., tension, short-term or repeated load test)

Test equipment, test setup and execution

Testing equipment: load cells, load cylinder, displacement transducer, software, hardware, data recording

- Test rigs, illustrated by sketches or photographs
- Particulars concerning support of test rig on the test member

Parameters of load application (e.g., rate of increase of load or size of load increase steps)

Concrete test members:

- Composition of concrete. Properties of fresh concrete (consistency, density)
- Date of manufacture
- Dimensions of control specimens, and/or cores (if applicable) measured value of compressive strength at the time of testing (individual results and mean value)
- Dimensions of test member
- Nature and positioning of any reinforcement
- Direction of concrete test member pouring
- Thickness and type of equalizing layer, when applicable
- Thickness and specification of cement mortar, when applicable
- Depth of carbonation, when applicable

Powder-actuated fastener installation conditions

- Fastener: Model designation, total length L of nail
- type A: type and thickness of insulation
- Powder-actuated fastening tool: Tool type, fastener guide, piston, cartridge and tool power setting
- Distances of fasteners from edges of test member and between adjacent fasteners
- Nail head stand-off (distance from top of driven fastener to the surface of the concrete)
- anchorage depth h_v
- type B: check of cracks in the plastic part (test A1(B) and F1(B))

Measured values

- Load-displacement-curve
- Any special observations concerning application of the load
- Failure load
- Failure mode
- Particulars of repeated load tests
  - minimum and maximum load
  - frequency of cycles
  - number of cycles
  - displacements as function of the number of cycles

The above measurements shall be recorded for each test.

A3 General assessment methods

A3.1 Establishing 5%-fractile of the ultimate loads

The 5%-fractile of the ultimate pull-out loads of the nails from the concrete measured in a test series is to be calculated according to statistical procedures for a confidence level of 90 %. In general, a logarithmic distribution with unknown standard deviation shall be assumed.

$$N_{ln5\%} = N_{Ru,m\ ln(x)} - k_s \cdot s_{\ ln(x)} \qquad \text{(A.3.1.1)}$$

e.g., n = 10 tests $k_s = 2.57$
n = 20 tests $k_s = 2.21$
n = 50 tests $k_s = 1.97$

with:
$N_{ln5\%}$ = 5%-logarithmic fractile of the ultimate load, calculated by the logarithmic test values
$N_{Ru,m\ ln(x)}$ = mean value of ultimate load in a test series calculated by the logarithmic test values
k_s = statistical factor
$s_{\ ln(x)}$ = standard deviation calculated by the logarithmic test values

Type B: Setting defects which can visually not be recognized (e.g., failure during installation of the test equipment) shall be considered by N_{Ru} = 0.001 kN.

The 5%-fractile of the ultimate loads of the plastic part measured in a test series is to be calculated according to statistical procedures for a confidence level of 90 %. In general, a normal distribution with unknown standard deviation shall be assumed.

$$N_{5\%} = N_{Ru,m} - k_s \cdot s \qquad \text{(A.3.1.2)}$$

e.g., n = 5 tests $k_s = 3.40$
n = 10 tests $k_s = 2.57$
n = 20 tests $k_s = 2.21$

with: $N_{5\%}$ = 5%-fractile of the ultimate load

$N_{Ru,m}$ = mean value of ultimate load in a test series
k_s = statistical factor
s = standard deviation

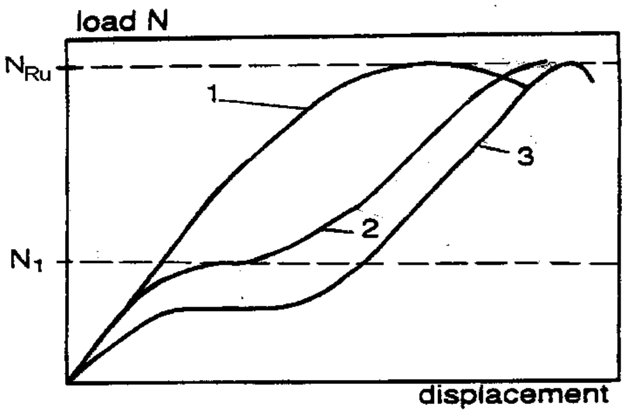
A3.2 Load/displacement behaviour

For the pull-out behaviour of the nail the load/displacement curves shall show a steady increase (see Figure A.3.2.1). However, a reduction in load and/or a horizontal or near-horizontal part in the curve by uncontrolled slip of the fastener is not acceptable up to a load of:

$N_1 = 0.4\ N_{Ru}$ (A.3.2.1)

with:

N_{Ru} = maximum load in the single test.



Curve 1: steady increase of the load displacement curve

Curve 2 and Curve 3: uncontrolled slip at level N_1

Figure A.3.2.1 Requirements for the load/displacement curve

There are no requirements on the scatter of the load/displacement curves.

A3.3 Determination of reduction factor α

The factor α shall be greater than the value given in Table A.1.3.1 (type A) and Table A.1.3.2 (type B).

Pull-out of the nail:

$$\alpha = \min \left\{ \frac{N^t_{Ru,m}}{N^r_{Ru,m}} ; \frac{N^t_{ln5\%}}{N^r_{ln5\%}} \right\} \quad \text{(A.3.3.1)}$$

Plastic part:

$$\alpha = \min \left\{ \frac{N^t_{Ru,m}}{N^r_{Ru,m}} ; \frac{N^t_{5\%}}{N^r_{5\%}} \right\} \quad \text{(A.3.3.2)}$$

with: $N^t_{Ru,m}$; $N^r_{Ru,m}$ = mean value, in a test series or reference test series, respectively

$N^t_{5\%}$; $N^r_{5\%}$ = 5% fractile of the ultimate load (with a normal distribution) of the plastic part in a test series or reference test series, respectively

$N^t_{ln5\%}$; $N^r_{ln5\%}$ = 5% fractile of the ultimate load (with logarithmic distribution) of the test series with pull-out of the fastener or of the reference test series, respectively

If the requirement is not met in a test series, then the reduction factor α_u shall be calculated.

α_u = α / req. α (A.3.3.3)

with:

α = α-factor according to equation (A.3.3.1) of the functioning tests

- F2, F3, F5, F6 for type A
- F5, F6, F11 for type B

and

α-factor according to equation (A.3.3.2) of the functioning tests

- F7, F8, F9 for type A
- F1(B), F9, F10 for type B

req. α = required α according to Table A.1.3.1 (type A) and Table A.1.3.2 (type B)

A3.4 Plate stiffness of the anchor plate - type A

The load resistance and plate stiffness of the anchor plate is assessed according to Annex B.

A3.5 Point thermal transmittance - type A

The point thermal transmittance is assessed according to Annex C.

B ANNEX B PLATE STIFFNESS OF THE PLASTIC PART TYPE A FOR ETICS

B1 Scope

B1.1 General

The assessment for external thermal insulation composite systems with rendering (ETICS) is specified in EAD 040083-00-0404 [4]. The load resistance of the ETICS and the fasteners is determined according to EAD 040083-00-0404 and is particularly linked to the mechanical properties of the plastic part and the insulation material. The minimum requirements to the properties of the plastic part are given in the ETAs according to EAD 040083-00-0404.

These properties are
• the load resistance and
• the plate stiffness.

This Annex covers pull-through tests to evaluate the pull-through resistance and the plate stiffness of plastic parts for fixing of external thermal insulation composite systems with rendering according to EAD 040083-00-0404. The pull-through test shall be carried out according to section B2.

B1.2 Specific terms used in this Annex

c	=	tangent stiffness [kN/mm]
N	=	normal tension force [kN]
s	=	displacement [mm]

B2 Details of method and criteria for assessment

The failure load of the plate shall be determined from at least 5 tests using the product type to be assessed only. During the tests the plate shall rest on a solid support ring with a clear inside diameter of 30 mm. A preload can be applied for determination of the stiffness for curved anchor plates in a way, that the tension load is be transmitted at the inside edge of the support ring. If the anchor plate is stiffened by ribs, recesses, which prevent a contact between the ribs and the supporting ring and the load transmission is not affected by the ribs, shall be designed in the steel ring.
A principle test setup is shown in Figure B.2.1.

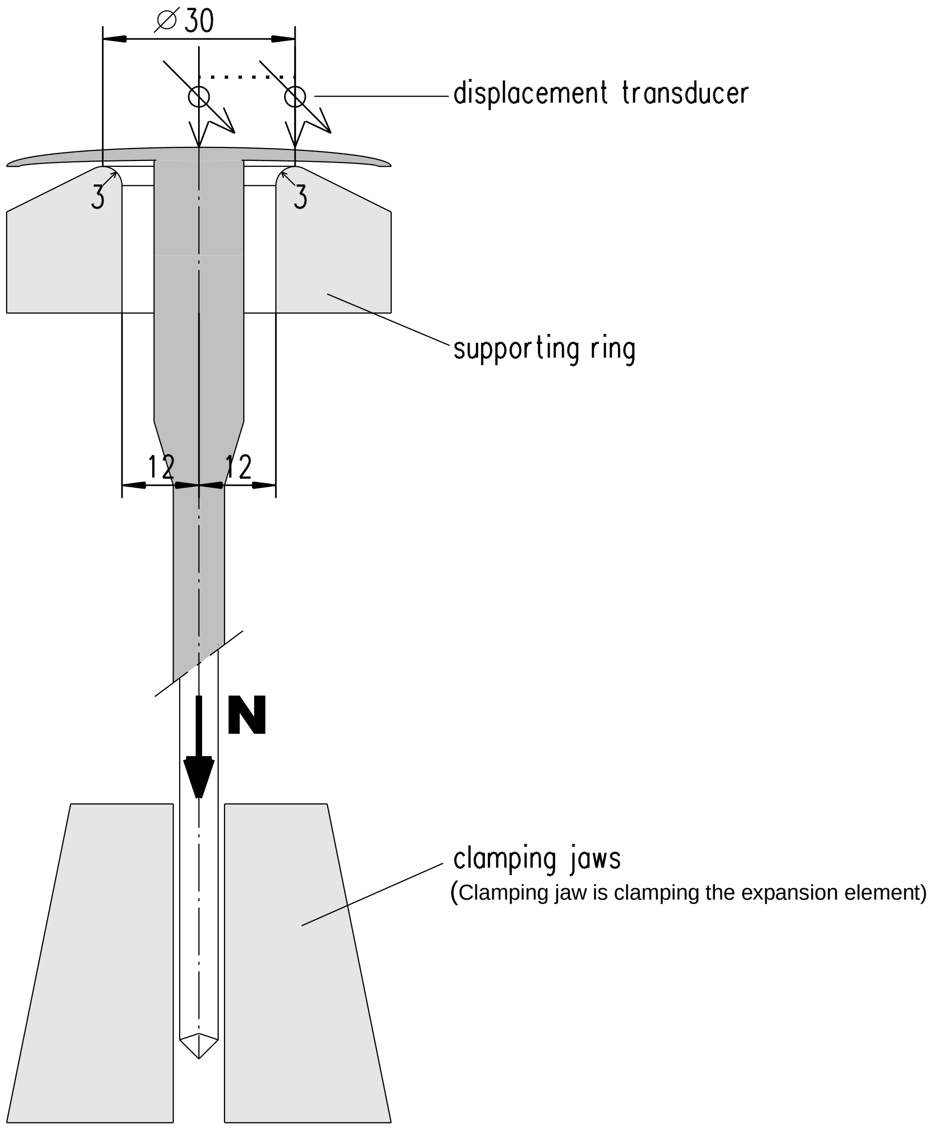


Figure B.2.1 Principle description of the test for determination of the plate stiffness

The tension load is transmitted over the anchor shaft with a loading rate of 1 kN/min ± 20 %.

B3 Assessing of plate stiffness

B3.1 Load resistance

The characteristic resistance has to be determined from the 5%-quantile of the ultimate loads for a confidence level of 90 %. This value has to be stated in the ETA. The reduction of the resistance of the plate caused by increased temperature is included in this value.

B3.2 Plate stiffness

For getting a comparable dimension for the plate stiffness, the tangent stiffness has to be determined for every test. This tangent stiffness states the gradient of an idealised straight line between the points s_u with the appropriate tension force N_u = 0 kN and s_o = 1 mm with the appropriate tension force N_o in the load-displacement-diagram (see Figure B.3.2.1).

The plate stiffness and the diameter of the plate shall be stated in the ETA.

Tangents stiffness:

$$\mathbf{c} = \frac{\mathbf{N_o} - \mathbf{N_u}}{\mathbf{s_o} - \mathbf{s_u}} = \frac{\mathbf{N_o}}{\mathbf{1mm} - \mathbf{s_u}} \qquad \text{(B.3.2.1)}$$

with

with $s_u \leq 0{,}3\ s_o$

The evaluated values shall be rounded upward expediently to 1/10 kN and be stated related to 1 mm deformation (e.g., 0,3 kN/mm / 0,4 kN/mm / 0,5 kN/mm / 0,6 kN/mm / 0,7 kN/mm).

For characterising the plate stiffness the mean value has to be stated. The coefficient of variation shall not exceed 20 %.

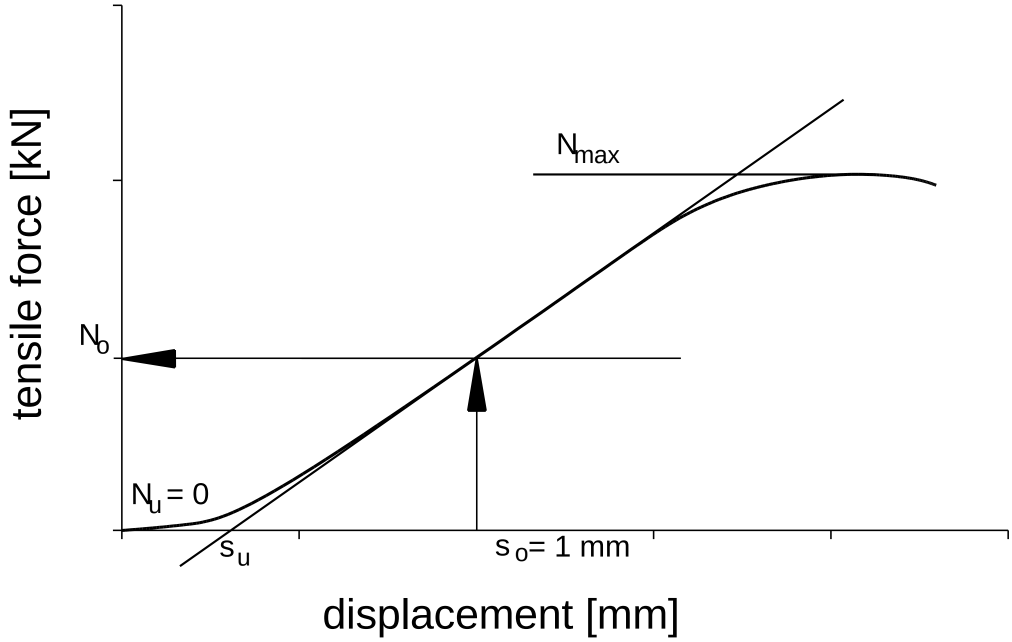


Figure B.3.2.1 Load-displacement-diagram with the idealized straight line

C ANNEX C POINT THERMAL TRANSMITTANCE OF FASTENERS FOR ETICS

C1 Scope

C1.1 General

This Annex serves for evaluating the thermal insulation of fastener for use in Thermal Insulation Composite Systems (ETICS).

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

The characteristic value of the thermal properties of a fastener is the point thermal transmittance χ. This value is not a product constant but a value depending on the thermal conductivities and thicknesses of the substrate and the insulating layer.

The point thermal transmittance χ can increase or decrease with increasing thickness of the insulating material depending on the type of fastener. The behaviour is not linear (cf. Figure C.1.1.1).

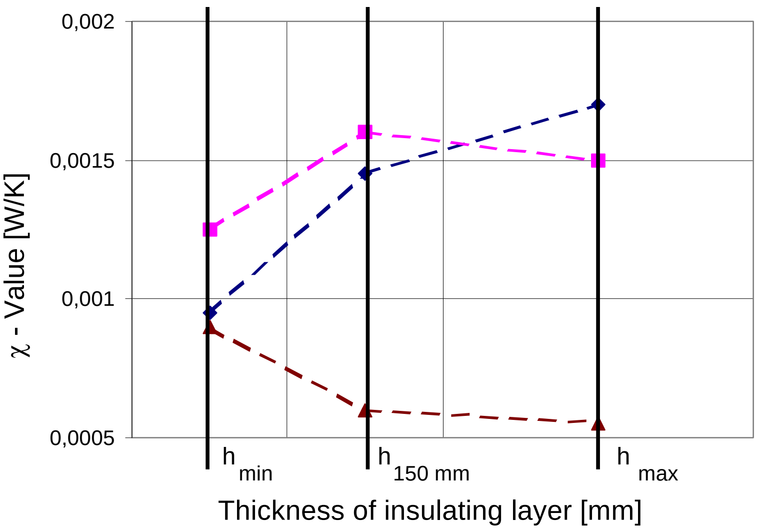


Figure C.1.1.1 Point thermal transmittance χ depending on the thickness of the insulating layer

Thermal Insulation Composite Systems are produced in a large range of thicknesses (approx. between 50 mm and 450 mm). At present the average thickness of the insulating layer in Europe is approx. 100 mm with a tendency to rise. As it is shown in Figure C.1.1.1, the χ-value can increase with a greater thickness of the insulating layer. The great thicknesses of the insulating layer, however, represent a small area of the market only.

The point thermal transmittances χ shall 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 area of the insulating layer thickness as representative dimension.

C1.2 Specific terms

χ	=	point thermal transmittance of a fastener [W/K]
$\chi(h_{min})$	=	point thermal transmittance of a fastener for the minimum insulating layer thickness according to the manufacturer's specification [W/K]
χ(150 mm)	=	point thermal transmittance of a fastener for insulating layer thickness of 150 mm [W/K]
$\chi(h_{max})$	=	point thermal transmittance of a fastener for the maximum insulating layer thickness according to the manufacturer's specification [W/K]
$\chi(h \leq 150)$	=	nominal value of the point thermal transmittance of a fastener in the range of minimum insulating layer thickness up to and including 150 mm [W/K]
$\chi(h > 150)$	=	nominal value of the point thermal transmittance of a fastener in the range of 150 mm up to the maximum insulating layer thickness [W/K]
$\chi(h_{min} – h_{max})$	=	nominal value of the point thermal transmittance of a fastener in the entire range of the insulating layer thickness [W/K]
h	=	insulating layer thickness of the Thermal Insulation Composite System [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]
U_c	=	modified heat transfer coefficient of the wall (with ETICS and fastener) [W/(m²·K)]
U	=	heat transfer coefficient of the wall with ETICS, without thermal bridges [W/(m²·K)]
n	=	number of fasteners per m² [1/m²]
R_{se}	=	external heat transfer resistance [(m²·K)/W]
R_{si}	=	internal heat transfer resistance [(m²·K)/W]
R_P	=	equivalent thermal resistance of the test specimen [(m²·K)/W]
A	=	cross cut end of the relevant test cuboid, vertical to the heat flow [m²]
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]

Indices:

a,b,c,d,e	=	base material groups
min, max	=	minimum / maximum value
si	=	interior surface
se	=	exterior surface
c	=	corrected value

C2 Assessing of point thermal transmittances

C2.1 Determination of point thermal transmittances

The point thermal transmittance χ results from:

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

For each insulating layer thickness and for each base material group calculated with the point thermal transmittances are to be determined according to C3.2.2. U_c is determined according to C3.3.3.

The calculated value will be rounded to four decimal places.

C2.2 Determination of the nominal value

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

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

The nominal value of the point thermal transmittance χ will be determined for the significant areas as follows:

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

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

Case 2: No distinction between areas of insulating layer thickness

If only one significant χ-value shall be given as nominal value, it results as peak value from all tests according to 0:

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

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 fastener the following note shall be recorded for the step "0 W/K":

"The thermal bridge effect of the fastener is smaller than 0,0005 W/K and can therefore be neglected in the calculation".

C3 Details of method and criteria for assessment

C3.1 General

The determination of the point thermal transmittance (χ-value) can be realized by means of calculation or measurement. Both methods are to be carried out for the reference construction described in follow.

The point thermal transmittance χ results from calculation according to section C2.1 with the heat transfer coefficient U_c of the disturbed construction of wall determined by means of calculation (see section C3.3) or by means of measurement (see section C3.4).

C3.2 Test sample

C3.2.1 Reference construction

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

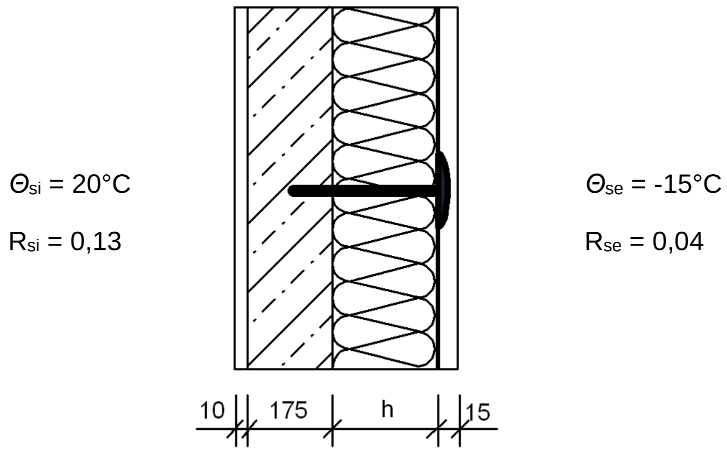


Figure C.3.2.1.1 Drawing of the reference construction (not full-scale)

The thickness of the insulating layer h is described in section C3.2.2. The fastener 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 [24] are to be used:

Table C.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	2,30	175
(3) insulating layer	0,035	see section C3.2.2
(4) external rendering: lime-cement plaster	1,0	15

C3.2.2 Thickness of insulating layer

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

The point thermal transmittance χ for the three thicknesses of insulating layer has to be determined as follows:

$\chi(h_{min})$	=	for the smallest thickness of the insulating layer indicated by the manufacturer h_{min}
χ(150 mm)	=	for the thickness of the insulating layer h = 150 mm
$\chi(h_{max})$	=	for the biggest thickness of the insulating layer indicated by the manufacturer h_{max}

In case the value 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).

C3.2.3 Properties of the fastener

The thermal conductivities of the materials of the fastener are to be assessed according to EN 12524 [24] or EN ISO 10456 [25]. The dimensions are to be determined by means of a test specimen or they are to be taken from the manufacturer's technical documentation.

C3.2.4 Boundary conditions

The heat transfer resistances result according to EN ISO 6946 [23] for the horizontal thermal conductivity:

R_{se} = 0,04 (m²·K)/W

R_{si} = 0,13 (m²·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.

C3.3 Calculations according to EN ISO 10211 [22]

For the determination of the point thermal transmittance, the thermal transmittance of the wall with fastener U_c has to be determined for each of the constructions considered.

C3.3.1 Construction of a finite system

As significant section for the calculation of the thermal bridge effect a cuboid-shaped section of the wall containing a fastener shall be assumed. The fastener is to be placed in the centre of the area considered. In case the fastener is rotationally symmetric in its shape, a partial circular section of the fastener, which is placed in an edge of the area considered, can also be used for the calculation or the calculation can be done in polar coordinates.

The dimensions of the area to be considered has to be chosen according to EN ISO 10211 [22], section 5 so that the disturbance caused by the fastener has no effects on the edges.

The thermal conductivity of potential cavities is to be determined according to EN ISO 6946 [23], Annex D.2.

C3.3.2 Subdivision of the system

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

Annex A, section 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 2n subdivisions.

C3.3.3 Determination of the thermal transmittance

The thermal transmittance U_c of the wall section with fastener will be determined according to EN ISO 10211 by the thermal coupling coefficient calculated.

$$U_c = \frac{L_{3D}}{A} \quad [W/(m^2 \cdot K)] \qquad (C.3.3.3.1)$$

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

The thermal transmittance U of the undisturbed wall is calculated according to EN ISO 6946.

C3.4 Measurement

The determination of the thermal transmittance U_c shall be determined in accordance with EN 1946, Part 1 to 4 [26]. The measurement can be realised according to EN ISO 8990 [27] or EN 1934 [28]. A reference test specimen is to be used according to section C3.2.

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 fastener, the distance to the edge and between the fasteners shall not fall below 300 mm.