EOTA®

EUROPEAN ASSESSMENT DOCUMENT

EAD 330196-01-0604

July 2017

PLASTIC ANCHORS MADE OF VIRGIN OR NON-VIRGIN MATERIAL FOR FIXING OF EXTERNAL THERMAL INSULATION COMPOSITE SYSTEMS WITH RENDERING

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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).

This document supersedes EAD 330196-00-0604

In comparison to the previous version, the following has changed:

- Amendment of tests and assessment of non-virgin materials

Contents

1   SCOPE OF THE EAD

1.1   Description of the construction product

The EAD "Plastic anchors for fixing of external thermal insulation composite systems with rendering" (short form: Plastic anchors for ETICS) sets out the basis for assessing plastic anchors to be used for fixing of external thermal insulation composite systems with rendering [1] and the fixing of VETURE Kits – Prefabricated Units for External Wall Insulation [2] in the base material (substrates) made out of concrete and masonry.

The EAD covers plastic anchors only be used as multiple fixings, which means that, in the case of excessive slip or failure of a fixing point, the load of the component can be transmitted to neighbouring fixing points. The load transfer in case of excessive slip or failure of one fixing point to neighbouring fixing points does not need to be taken into account in the design of the fastenings for the ETICS or VETURE Kits.

The EAD covers plastic anchors only be used for tension loads resulting from wind loads only. The dead load of the ETICS is transmitted by the adhesion of the ETICS.

The EAD covers plastic anchors with a maximum characteristic resistance N_{Rk} of 1,5 kN.

Types and operating principles:
Plastic anchors for ETICS consist of an expansion element and a plastic expansion sleeve with a plate for fixing the ETICS (Figure 1.1 and Figure 1.2) or a plastic expansion sleeve with a collar for fixing profiles for the ETICS (Figure 1.3) or VETURE Kits.

The plastic sleeve and expansion element form a unit.

The plastic sleeve is expanded by hammering or screwing in the expansion element which presses the sleeve against the wall of the drilled hole.

Plastic anchors with a screw as an expansion element are so called "screwed in anchors". Plastic anchors with a nail as an expansion element are so called "nailed in anchors".

Materials:
Plastic anchors for ETICS consist of the following materials:
−   Expansion element: Metal (steel) or plastic
−   Expansion sleeve and plate: plastic
−   Plastics: virgin or non-virgin material made of polyamide PA 6 and PA 6.6; polyethylene PE or polypropylene PP or other polymeric materials
−   virgin material: material which has not been moulded before; in the moulding process only reworked material (e.g. sprue) is added received as waste material from the same moulding process; this regenerated material is of the same feedstock and identical with the rest of the material
−   non-virgin material: other than virgin material

Dimensions:
This EAD applies to plastic anchors with an external diameter of plastic sleeve of at least 5 mm. The effective anchorage depth h_{ef} shall be at least 25 mm.

Depending on the specific design of the anchor, the overall plastic anchor embedment depth in the base material h_{nom} is equal to or larger than h_{ef}.

The edge distance shall be $c_{min} \geq 100$ mm and the spacing $s_{min} \geq 100$ mm.

Different versions of an anchor with respect to material, strength, type or dimensions are marked such that the relevant product characteristic may be allocated to the corresponding anchor type.
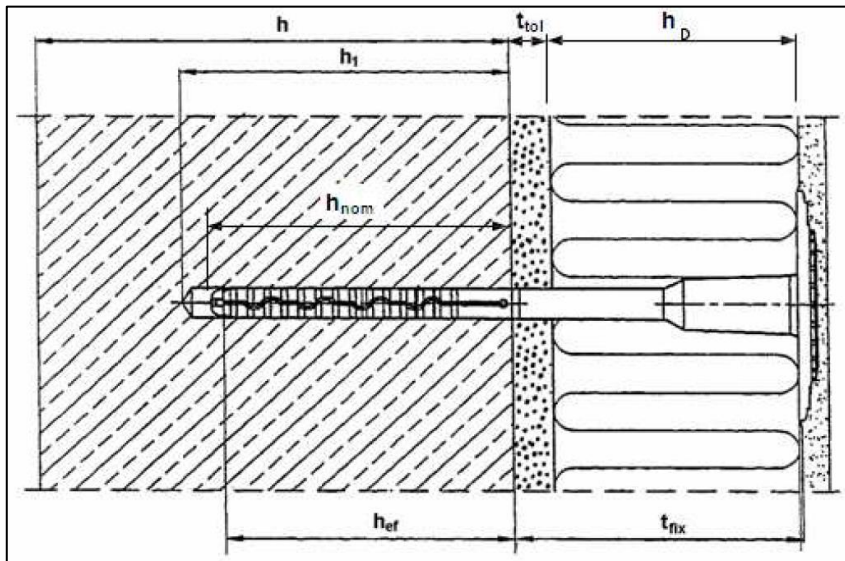
Figure 1.1   Plastic Anchor (nailed-in) for ETICS
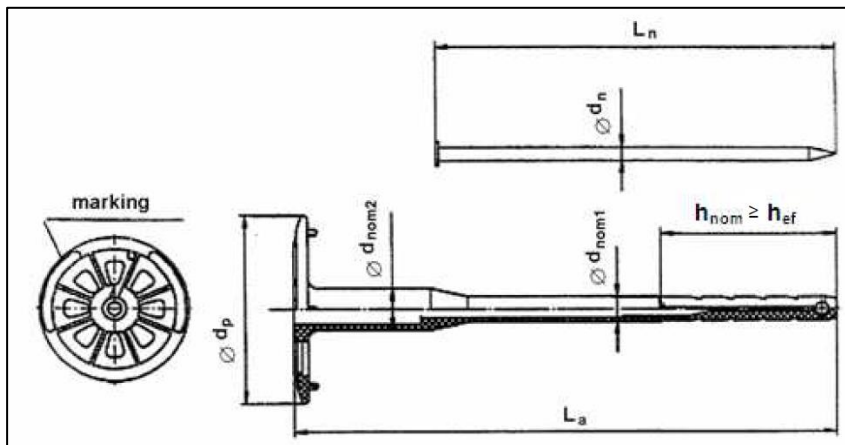
Figure 1.2   Components of plastic anchor
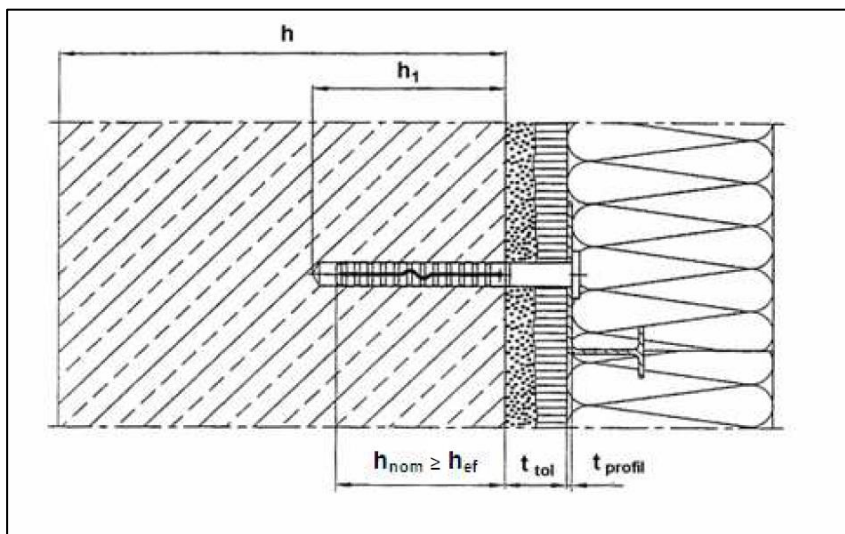
Figure 1.3   Plastic anchors for profiles for ETICS or VETURE Kits

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

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

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

This EAD applies to the use of plastic anchors for fixing ETICS or VETURE kits in concrete and/or masonry. The design and construction of masonry structures in which the plastic anchors are to be anchored is in accordance with Eurocode 6, EN 1996-1-1 [4] and the relevant national regulations.

The anchor is intended to be used for anchorages which are designed based on the characteristic performances given in ETA or – if applicable – based on the results of job site tests according to TR 051 [19] under the responsibility of an engineer experienced in anchorages for ETICS or VETURE kits.

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.

The functioning of a plastic anchor, including its ability to sustain its design load with an appropriate safety factor and to limit displacements, shall not be adversely affected by temperatures near to the surface of the base material within a base material temperature range:

0 °C to +40 °C   (minimum installation temperature specified by the manufacturer: normally 0°C to +5 °C, max short term temperature: +40 °C and max long term temperature: +24 °C)

1.2.2   Base materials

Attention is drawn to the fact that the standards for masonry structures are not very restrictive with regard to details of units (e.g. type, dimensions and location of perforations, number and thickness of webs). As load resistance and load displacement behaviour, however, decisively depend on these influences, an assessment of the plastic anchor is only possible for each particular well-defined masonry unit concerned. For the assessment of the behaviour of the plastic anchor in other less well-defined masonry or hollow / perforated bricks, hollow blocks or other different base materials, tests on the construction site are to be carried out according to national requirements or TR 051 [19].

This EAD applies to applications where the minimum thickness of the base materials in which plastic anchors are installed is at least h = 100 mm. In case of thin skins (weather resistant skin) of external wall panels the minimum thickness of the base material may be reduced to 40 mm, if the influence of the setting position of the plastic anchor is considered according to Figure 2.1.

Base material groups are defined as a function of base materials as follows:

Table 1.1 Definition of base material groups

Base material group	Base material	Remark
A	**normal weight concrete**	This EAD applies to the use of plastic anchors in normal weight concrete between strength classes C12/15 and C50/60, inclusively, according to EN 206 [5]. This EAD does not cover anchorages made in screeds or toppings, which can be uncharacteristic of the concrete and/or excessively weak.
B	**solid masonry**	This EAD applies to masonry units consisting of solid units according to EN 771-1,-2,-3,-5 [3], which do not have any holes or cavities other than those inherent in the material.
C	**hollow or perforated masonry**	This EAD applies to masonry units consisting of hollow or perforated units according to EN 771-1,-2,-3,-5 [3], which have a certain volume percentage of voids which pass through the masonry unit.
D	**lightweight aggregate concrete with open structure**	This EAD applies to the use of plastic anchors in lightweight aggregate concrete with open structure between strength classes LAC 2 and LAC 25, inclusively, according to EN 1520 [6] reinforced components of lightweight aggregate concrete with open structure and in lightweight aggregate concrete blocks.
E	**autoclaved aerated concrete**	This EAD applies to the use of plastic anchors in autoclaved aerated concrete according to EN 771-4 [3] autoclaved aerated concrete masonry units or according to EN 12602 [7] reinforced components of autoclaved aerated concrete. The strength class of the autoclaved aerated concrete defined in [7] has to lie in between AAC 2 and AAC 7, inclusively.

1.2.3   Working life

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 plastic anchor for ETICS for the intended use of 25 years when installed in the works provided that the plastic anchor for ETICS 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[1].

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.

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[1] 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.

1.3 Specific terms used in this EAD

1.3.1 General

Plastic anchor = a manufactured, assembled component for achieving anchorage between the base material and the fixture.

Fixture = component to be fixed to the base material, in this case external thermal insulation composite system.

Anchorage = an assembly comprising base material, plastic anchor and fixture.

1.3.2 Plastic anchors

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

b = width of the member of the base material

c_{min} = minimum allowable edge distance

d_0 = drill hole diameter

d_{cut} = cutting diameter of drill bit

$d_{cut,max}$ = cutting diameter at the upper tolerance limit (maximum diameter bit)

$d_{cut,min}$ = cutting diameter at the lower tolerance limit (minimum diameter bit)

$d_{cut,m}$ = medium cutting diameter of drill bit

d_f = diameter of clearance hole in the fixture

d_n = diameter of the shaft of the nail

d_{nom} = outside diameter of plastic anchor = outside diameter of plastic sleeve

d_p = diameter of the plate

h = thickness of member (wall)

h_{min} = minimum thickness of member

h_0 = depth of cylindrical drill hole at shoulder

h_1 = depth of drilled hole to deepest point

h_{ef} = effective anchorage depth

h_{nom} = overall plastic anchor embedment depth in the base material ($h_{nom} \geq h_{ef}$)

h_D = thickness of insulation material

L_a = length of plastic anchor

L_n = length of nail

l_s = length of special screw

s_{min} = minimum allowable spacing

T = torque moment

T_{inst} = required or maximum recommended setting torque

t_{fix} = thickness of fixture

t_{tol} = thickness of equalizing layer for compensation of tolerances or non-load bearing coating

$t_{profile}$ = thickness of profile

1.3.3 Base materials

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

1.3.4 Assessment of tests

α	=	characteristic reduction factor
α_1	=	ultimate reduction factor
$\alpha_{lifetime}$	=	reduction factor of lifetime tests
α_v	=	reduction factor of variation
γ_F	=	partial safety factor for action
γ_M	=	partial safety factor for material
$\delta(\delta N)$	=	displacement (movement) of the plastic anchor at the surface of the 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 plastic anchor slip.
$\sigma_{y,0}$	=	*Yield strength of the plastic before temperature exposure*
$\sigma_{b,0}$	=	stress *at rupture of the plastic before temperature exposure*
$\sigma_{y,t,T}$	=	*Yield strength of the plastic after a time t (for t=28 days, 180 days,…) exposure to T=90°C*
$\sigma_{y,t,T}$	=	*Yield strength of the plastic after a time t (for t=28 days, 180 days,…) exposure to T=90°C*
$\sigma_{b,t,T}$	=	stress *at rupture of the plastic after a time t (for t=28 days, 180 days,…) exposure to T=90°C*

k_s	=	statistical factor
n	=	number of tests of a test series
N	=	normal tension force
N_{Rk}	=	characteristic resistance under tension force stated in ETA
$N_{Rk,0}$	=	characteristic resistance of reference tension tests according **Table 2.3**, line 1.
$N_{Ru,m\ ln(x)}$	=	mean value of ultimate load in a test series calculated by the logarithmic test values
N_u	=	failure load in a test under tension force
$N_{u,5\%}$	=	5%-fractile of failure loads in a test series under tension force
$N_{u,m}$	=	mean failure load of a test series under tension force
req.α	=	required reduction factor
s	=	standard deviation
v	=	coefficient of variation

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1 shows how the performance of this product is assessed in relation to the essential characteristics.

Table 2.1 Essential characteristics of the product and assessment methods and criteria for the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
	Basic Works Requirement 2: Safety in case of fire		
1	Not assessed based on this EAD[2]		
	Basic Works Requirement 4: Safety in use		
2	Characteristic load bearing capacity - Characteristic resistance under tension load - Minimum edge distance - Minmum spacing	2.2.1	Level - N_{Rk} [kN] - c_{min} [mm] - s_{min} [mm]
3	Displacement - Tension load with partial factor γ_M, γ_F - Displacement	2.2.3	Level - N [kN] - $\Delta\delta_N$ [mm]
4	Plate stiffness - Diameter of the anchor plate - Load resistance of the anchor plate - Plate stiffness	TR 026 [18]	Level - Diameter of the anchor plate [mm] - Load resistance of the anchor plate [kN] - plate stiffness [kN/mm]
	Basic Works Requirement 6: Energy economy and heat retention		
5	Thermal transmittance - Point thermal transmittance of an anchor - Insulating layer thickness of the ETICS	TR 025 [17]	Level - χ [W/K] - h_D [mm]

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[2] *The anchorages are used to fix a cladding or component which is not class A 1 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 embedded in concrete/masonry 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 A 1 the plastic parts can be considered not to influence the reaction to fire class of the cladding/component.

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

The assessment methods presuppose that the product samples to be assessed are in line with the specifications given by the manufacturer. Possible tolerances have to be considered.

The assessment methods consider the manufacturer's product installation instruction. The ETA shall include information on the installation and cleaning procedures which has been used for the assessment of the product performance. Thus information could be:

- Drilling technology (e.g. hammer drilling, rotary drilling),
- Specifications on bore hole cleaning (removing drilling dust e.g. by blowing, brushing including size and material of brush),
- Conditions at installation (installation temperature, product temperature range)
- Specifications for installation as applicable (e.g. installation torque, installation tools).
- No UV-radiation during the storage

2.2.1 Characteristic load bearing capacity

The test program for the assessment consists of

- Tests for characteristic resistance/ reference and
- Functioning tests.

The purpose of the characteristic resistance/ reference tests is to determine the basic technical data required to predict the performance of the anchors under service conditions and derive corresponding design information.

Functioning tests are performed to assess the sensitivity of the anchor system regarding variations of temperature, loading (repeated loading, relaxation), installation and establish a safe, effective and robust behaviour of the anchor system.

This EAD gives the test conditions for testing of evaluation of plastic anchors for ETICS or VETURE Kits in the base material made out of concrete and/or masonry. The behaviour of the whole ETICS or VETURE Kits outside the base material and where the load transfer is into the anchor plate or collar shall be assessed according ETAG 004 [1] or ETAG 017 [2].

For most plastic anchors only one fixed anchorage depth is specified. In case of more than one anchorage depth the tests shall be performed with the most unfavorable anchorage depth.

2.2.2 The details of tests are given in Annex A.

2.2.2.1 Tests

The tests for the assessment of the plastic anchors shall be performed in the base material for which the anchor is intended to be used according to the following Table 2.2.

Table 2.2   Tests with several base materials of plastic anchors for ETICS

Base material group for the intended use			Tests according to
normal weight concrete	solid masonry	hollow or perforated units	
A			Table 2.3, line 1 to 8 in normal weight concrete
	B		Table 2.3, line 1 to 8 in clay or calcium silicate solid units with compressive strength about 12 N/mm^2 and density between 1,6 and 2,0 kg/dm^3
A	B		Table 2.3, line 1 to 8 in normal weight concrete and Table 2.3, line 1 in solid masonry (clay or calcium

			silicate units).
A	**B**	**C**	Table 2.3, line 1 to 8 in normal weight concrete, Table 2.3, line 1 in solid masonry (clay or calcium silicate units) and in hollow or perforated units for which it is intended to be used and Table 2.3, line 2 in the hollow or perforated unit which is most critical regarding this test.
	B	**C**	Table 2.3, line 1 to 8 in clay or/and calcium silicate solid units with compressive strength about 12 N/mm^2 and density between 1,6 and 2,0 kg/dm^3 and Table 2.3, line 1 in the hollow or perforated units for which it is intended to be used, and Table 2.3, line 2 in the hollow or perforated unit which is most critical regarding this test.
	D		Table 2.3, line 1 to 8 in lightweight aggregate concrete with open structure LAC 2 or in lightweight aggregate concrete with open structure blocks.
	E		Table 2.3, line 1 to 8 in autoclaved aerated concrete AAC 2 or in autoclaved aerated concrete blocks.

Table 2.3   Tests for plastic anchors for ETICS

line	Purpose of test (1)	Drill bit (3)	Ambient temperature	Condition of plastic sleeve (4)	Minimum number of tests per plastic anchor size	req.α	Remarks to the test procedure described in chapter
1	Characteristic resistance/ reference tension tests	$d_{cut,m}$	normal	standard	10	-	2.2.2.2
2	Functioning, with EPS layer with max. t_{fix}	$d_{cut,m}$	normal	standard	5	≥ 0,9	2.2.2.3 (2), (5)
3	Functioning, depending on the diameter of drill bit	$d_{cut,min}$	normal	standard	5	≥ 1,0	2.2.2.4 (2)
		$d_{cut,max}$	normal	standard	5	≥ 0,8	
4	Functioning under conditioning	$d_{cut,m}$	normal	dry	5	≥ 0,8	2.2.2.5 (2), (7)
		$d_{cut,m}$	normal	wet	5	≥ 0,8	
5	Functioning, Effect of temperature	$d_{cut,m}$	min t (6)	standard	5	≥ 1,0	2.2.2.6 (2)
		$d_{cut,m}$	+40 °C	standard	5	≥ 0,8	
6	Functioning under repeated loads	$d_{cut,m}$	normal	standard	3	≥ 1,0	2.2.2.7 (2)
7	Functioning relaxation 500 h	$d_{cut,m}$	normal	standard	5	≥ 1,0	2.2.2.8 (2)
8	Maximum torque moment	$d_{cut,m}$	normal	standard	10	-	2.2.2.9 (2), (8)
9	Lifetime of plastics	2.2.2.10 (9)					
10	Corrosion of metal parts	2.2.2.11					
11	High alkalinity of plastic sleeve	2.2.2.12					

Notes to Table 2.3:

(1)   The tests according to line 1 and line 3 to 10 are carried out without the external thermal insulation composite system. Instead of an ETICS a layer of EPS (see Annex A, Figure A.7.1) is applied for testing to line 2.

(2)   For normal weight concrete the tests have to be performed in C20/25.

(3)   Normal ambient temperature: +21 ± 3 °C (plastic anchor and concrete)

(4)   Conditioning of plastic anchor sleeve according to 2.2.2.5

(5)   For nailed-in plastic anchors only

(6)   Minimum installation temperature as specified by the manufacturer; normally 0 °C to +5 °C

(7)   For polyethylene PE or polypropylene PP these tests are not necessary.

(8)   For screwed-in plastic anchors only

(9)   For non-virgin materials only

2.2.2.2   Characteristic resistance/ reference tension tests

For determination of characteristic resistance of the plastic anchor to action (tension) in normal weight concrete (base material group A) the tests according to Table 2.3, line 1 are to be used. From the required 10 tests, 5 tests shall be performed in C20/25 and 5 tests in C50/60; the lower obtained value shall be used to determine the characteristic resistance for all strength classes ≥ C16/20. The tension tests in C20/25 are needed also as reference tests for the evaluation of the results of the functioning tests.

10 tension tests each are necessary for the determination of characteristic resistance of the anchors in base material group B, C, D and E, see Table 2.2.

If the anchor is intended to be used also in thin weather resistant skin with 100 m > h ≥ 40 mm, the possible negative effect of the reduced thickness of the base material must be taken into account by testing.

If the anchor can be set in a range of setting depth (same length of the anchor with two different t_{fix}), the anchor may extend beyond the thin member (see Figure 2.1 b) and, hence, may negatively affect the loadbearing capacity. In this case the most unfavourable setting position shall be considered in additional testing according to Table 2.3, line 1, under laboratory condition.

If the anchor has an embedment depth ≥ 40 mm the anchor may extend beyond the thin member and, hence, may negatively affect the loadbearing capacity. In this case also the smallest thickness of the thin weather resistant skin in which the anchor is intended to be used shall be considered in additional testing acc. to Table 2.3, line 1, under laboratory condition.
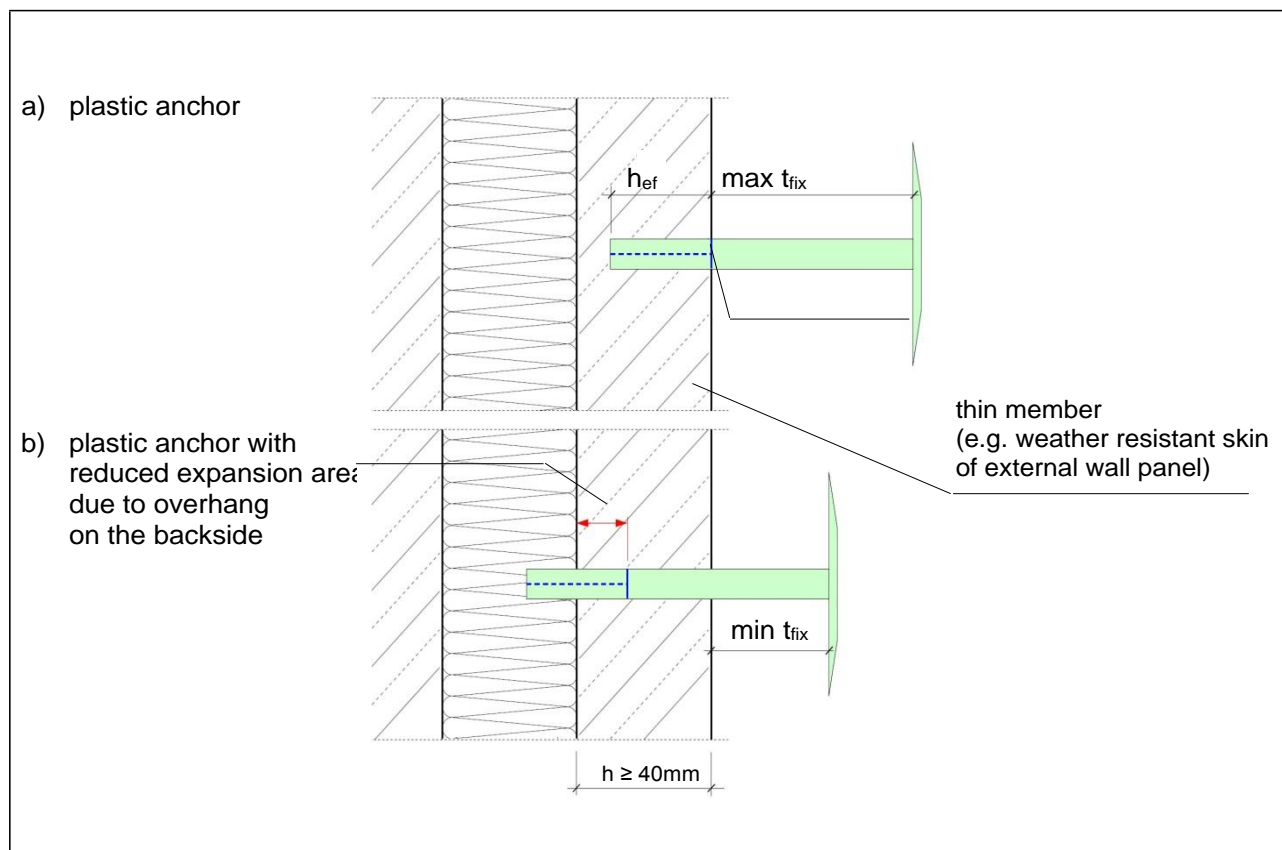

Figure 2.1   Example for different setting positions of plastic anchors in thin members

2.2.2.3   Functioning with EPS layer with max. t_{fix}

These tests are for nailed-in plastic anchors only.

The tests have to be performed with a layer of EPS (see Annex A, Figure A.7.1) with the maximum t_{fix} of the nailed-in plastic anchor.

The tension tests shall be carried out according to Annex A.

2.2.2.4   Functioning, depending on the diameter of drill bit

For the drill hole the maximum $d_{cut,max}$ and the minimum $d_{cut,min}$ diameter of drill bit according to Annex A, A.3 is to be used.

The tension tests shall be carried out according to Annex A.

2.2.2.5   Functioning under conditioning

The moisture content of the plastic material <u>may have</u> an influence on plastic anchor's behaviour, e.g anchors made of polyamide.

For the tests 3 different humidity levels are defined.

3 different humidity levels must be considered:

Standard: …is the equilibrium water content the plastic would have after storing at 23°C and 50% rel. humidity (e.g. for PA6 2.5 +/-0.2 weight%)

Dry: …is the lowest possible water content which is usually present right after injection moulding of the parts. It's reasonable to assume that a moisture content ≤ 0.2 weight% is representative for dry PA6.

Wet: is the equilibrium water content the plastic would have after storing in water at 23°C. It's reasonable to assume that a moisture content ≥ 6.0 weight% is representative for PA6.

Plastic parts can be exposed to conditioning parameters according to ISO 1110 [8] for gaining standard conditioning state. Drying the samples at 70°C can be applied for gaining dry conditioning state. If the mass loss in 3 consecutive measurement every 24 h is smaller than 0,1 % it can be assumed that dry conditioning state is reached. Submerge the plastic parts in water at raised temperature (e.g. 50°C) can be applied for gaining the wet condition state. If the mass increase in 3 consecutive measurement every 24 h is smaller than 0,1 % it can be assumed that wet conditioning state is reached.

2.2.2.6   Functioning, effect of temperature

a) Effect of increased temperature

The tests shall be carried out at the following temperature. Temperature range: maximum short term temperature up to +40 ℃:

Tests are performed with the maximum short term temperature at +40 ℃. The maximum long term temperature at approximately +24 ℃ is checked by the tests at normal ambient temperature.

The tests are carried out in slabs or, where space of the heating chamber is restricted, in cubes. Splitting of the concrete shall be prevented by means of specimen size or reinforcement.

After installation of the plastic anchors at normal ambient temperature raise the test specimen temperature to the required test temperature at a rate of approximately 20 K per hour. Maintain the test specimen at this temperature for 24 hours.

While maintaining the temperature of the test member in the area of the plastic anchor at a distance of 1d from the concrete surface at ±2 K of the required value, carry out tension tests.

b) Effect of minimum installation temperature

The plastic anchor shall be installed at the lowest installation temperature (plastic anchor and base material) specified by the manufacturer. The pullout tests shall be performed immediately after setting to avoid any major increase of the temperature of the test specimen.

2.2.2.7 Functioning under repeated loads

The plastic anchor is subjected to 10^5 load cycles with a maximum frequency of approximately 6 Hz. During each cycle the load shall follow a sine curve between max N and min N according to equation (2.1) and (2.2) respectively. The displacement shall be measured during the first loading up to max N and either continuously or at least after 1, 10, 100, 1000, 10000 and 100000 load cycles.

$$\text{max N} \quad = \quad \text{smaller value of} \quad 0{,}6 \cdot N_{Rk} \quad \text{and} \quad 0{,}8 \cdot A_s \cdot f_{yk} \quad \quad (2.1)$$

$$\text{max N} \quad = \quad \text{higher value of} \quad 0{,}25 \cdot N_{Rk} \quad \text{and} \quad N_{Rk} - A_S \cdot \Delta\sigma_S \quad \quad (2.2)$$

with

N_{Rk} = Characteristic tensile resistance in concrete C20/25 evaluated according to Equation (2.13) or (2.14)

A_S = stressed expansion element cross section

$\Delta\sigma_S$ = 120 N/mm

After completion of the load cycles the plastic anchor shall be unloaded, the displacement measured and a tension test performed.

2.2.2.8 Functioning relaxation 500h

The plastic anchors are installed in the test member and left there unloaded for 500 h. After that tension tests shall be carried out.

2.2.2.9 Maximum torque moment

The screwed-in plastic anchor shall be installed with a screw driver. The torque moment shall be measured with a calibrated torque moment transducer. The torque moment shall be increased until the failure of the plastic anchor.

The torque moment is measured depending on the time. From the curve gradient two moments can be determined, the one if the screw is fully attached to the plastic anchor collar (T_{inst}) and the other if the plastic anchor fails (T_u).

2.2.2.10 Lifetime of plastics

General

Based on long-term experience it is assumed that the resistance against Thermal Oxidative Degradation of virgin plastic materials according to section 1.1 is given over a period of 25 years without additional proof.

In case that non-virgin plastic is used, the resistance against Thermal-Oxidative Degradation needs to be tested for bringing evidence of a sufficient lifetime of the plastic. The lifetime assessment is based on material tests according section A.9.1 and tests on the anchor according section A.9.2.

If it is intended to use re-worked non-virgin plastic (e.g. inhouse re-use of sprue from non-virgin plastic) for mass production, the samples used for test of lifetime shall contain the same share of re-worked plastic as it is intended for mass production. The admissible share of reworked non-virgin plastic shall be specified in production control plans and monitored in production.

For non-virgin materials the approach laid out in section A.9 needs to be applied.

Assessing results of lifetime tests

a) Basic material

Ductile plastics: $\alpha_{lifetime,material} = \dfrac{\sigma_{y,180d,90°C}}{\sigma_{y,28d,90°C}}$ (2.3)

or

Brittle plastics: $\alpha_{lifetime,material} = \dfrac{\sigma_{b,180d,90°C}}{\sigma_{b,28d,90°C}}$ (2.4)

where

$\sigma_{y,180d,90°C}$, $\sigma_{y,28d,90°C}$, $\sigma_{b,180d,90°C}$ and $\sigma_{b,28d,90°C}$ are gained in section A.9.1-3)

b) Anchor

$\alpha_{lifetime,anchor} = \dfrac{N_{u,m,180d}}{N_{u,m,5d}}$ (2.5)

where

$N_{u,m,180d}$ = mean value of ultimate pull-out failure load after 180 days in the oven with 80°C

$N_{u,m,5d}$ = mean value of ultimate pull-out failure load after 5 days in the oven with 80°C

2.2.2.11 Corrosion of metal parts

The assessment/testing required with respect to corrosion resistance will depend on the specification of the plastic anchor in relation to its use for ETICS or VETURE Kits. Supporting evidence that corrosion will not occur is not required if the plastic anchors are protected against corrosion of steel parts, as set out below:

(1) Plastic anchor for fixing of external thermal insulation composite systems with rendering intended for use in structures subject to dry, internal conditions:

No special corrosion protection is necessary for steel parts as coatings provided for preventing corrosion during storage prior to use and for ensuring proper functioning (zinc coating with a minimum thickness of 5 microns) is considered sufficient.

(2) Plastic anchor for fixing of external thermal insulation composite systems with rendering for use in structures subject to external atmospheric exposure (including industrial and marine environments), or exposure in permanently damp internal conditions, if no particular aggressive conditions[3]. exist :

Metal parts of the anchor made of stainless steel material 1.4401, 1.4404, 1.4578, 1.4571, 1.4362, 1.4062, 1.4162, 1.4662, 1.4439, 14462 or 1.4539 according to EN 10088-4 and 5:2014 [15] can be used.

If the metal parts of the plastic anchors consist of steel with zinc coating, this is considered to be sufficiently durable against any moisture (the head covers the sleeve which generally prevents moisture from entering the sleeve). The protection of the head of the metal part made of steel with zinc coating is not necessary, if the metal part of the plastic anchor is covered by at least 50 mm insulation material (e.g. fixing of profiles).

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3   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).

2.2.2.12 High alkalinity of plastic sleeve

The durability of the plastic sleeve material shall be tested against high alkalinity (pH = 13,2).

The assessment methods are only valid for PA 6, PP, PE or other polymeric materials, if the requirements according to Table 2.4 in comparison with the test results in section A.8 are fulfilled.

Table 2.4   Limits for susceptibility to environmental stress cracking

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

[1] ISO 527 [10]

2.2.2.13 Assessment of characteristic load bearing capacity

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

The 5%-fractile of the ultimate loads measured in a test series is to be calculated according to statistical procedures for a confidence level of 90 %. If a precise verification does not take place, a logarithmical normal distribution and an unknown standard deviation of the population shall be assumed.

$$N_{u,5\%} \;=\; N_{um} (1-k_s \cdot v) \tag{2.6}$$

eg.:

n   = 5   tests: ks = 3,40

n   = 10   tests: ks = 2,57

Conversion of ultimate loads to take account of concrete, masonry and steel strength

The influence of the concrete strength C16/20 to C50/60 is not taken into account in the evaluation of the tests. For concrete C12/15 the reduction factor 0,7 has to be taken for the ultimate loads.

The influence of the masonry compressive strength ≥ 12 N/mm^2 is not taken into account in the evaluation of the tests. For masonry material with compressive strength < 12 N/mm^2 and for lightweight aggregate and autoclaved concrete a linear conversion to the nominal compressive strength is to be used.

In the case of steel failure the failure load shall be converted to the nominal steel strength by Equation (2.7)

$$N_{Ru}(f_{uk}) = f_{Ru}^t \cdot \frac{f_{uk}}{f_{u,test}} \tag{2.7}$$

where:

N_{Ru} (f_{uk}) = failure load at nominal steel ultimate strength

Criteria for all tests

In all tests the following criteria shall be considered:

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

$$\alpha_v = \frac{1}{1 + (v(\%) - 20) \cdot 0{,}03} \tag{2.8}$$

with

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

b) In the tests according to Table 2.3 line 2 to 7 the factor α shall be larger than the value given below:

α = lower value of

$$\frac{N_{u,m,t}}{N_{u,m,r}} \tag{2.9}$$

and

$$\frac{N_{u,5\%,t}}{N_{u,5\%,r}} \tag{2.10}$$

where

$N_{u,m,t}$; $N_{u,5\%,t}$ = mean value or 5%-fractile, respectively, of the ultimate loads in a test series according Table 2.3, line 2 to line 7

$N_{u,m,r}$; $N_{u,5\%,r}$ = mean value or 5%-fractile, respectively, of failure load in the test for service conditions according to Table 2.3, line 1.

Equation (2.10) 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 (2.10) 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 (Table 2.3, line 1) or if the coefficient of variation is $v \leq 15$ % in the tests.

If the criteria for the required value of α (see Table 2.3) are not met in a test series, then the factor α_1 shall be calculated.

$$\alpha_1 = \frac{\alpha}{req.\,\alpha} \qquad \leq 1{,}0 \tag{2.11}$$

where

α = lowest value according to Equations (2.9) and (2.10) in the test series

$req.\,\alpha$ = required value of α according to Table 2.3

Repeated loading

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

The displacement after the cycling shall be less than the medium displacement for the ultimate load in the reference tests.

Maximum torque moment

The installation of the screwed-in plastic anchor shall be practicable without steel failure or turn-through (spinning) in the hole.

The ratio of the failure moment T_u to the installation moment T_{inst} shall be checked. The ratio shall be at least 1,5 in 90 % of the tests and shall be $\geq$ 1,3 in 10 % of the tests.

Tests with EPS layer with max t_{fix}

The installed anchor shall be either flush with the surface of the EPS-block (anchor types for mounting on the surface) or countersunk in the EPS-block (anchor types for deep mounting) in accordance with the installation instruction supplied by the manufacturer, see figure A.7.3.

After removing the EPS-block the anchor shaft shall not show any cracks and/or breaks that influence the performance of the anchor. Cracks and/or breaks have to be assessed regarding their influence on the load carrying capacity of the anchor as well as the corrosion outside of the base material.

Lifetime of plastics

Determination of ultimate reduction factor of lifetime of plastics $\alpha_{1,lifetime}$.

Table 2.5

$\alpha_{lifetime,material}$ [a]	$\alpha_{1,lifetime,material}$
≥ 0,9	1,00
< 0,9	0,10

[a] $\alpha_{lifetime,material}$ = See Equation (2.3) or (2.4)

$$\alpha_{1,lifetime} = min\left\{\alpha_{1,lifetime,material}; \frac{\alpha_{lifetime,anchor}}{req.\,\alpha_{lifetime}}\right\} \leq 1,0 \tag{2.12}$$

where

$\alpha_{1,lifetime,material}$ = See Table 2.5

$\alpha_{lifetime,anchor}$ = See Equation (2.5)

req. $\alpha_{lifetime}$ = 0,9

Characteristic resistance of single plastic anchor

The characteristic resistance N_{Rk} for single plastic anchors under tension load shall be calculated as follows:

for nailed-in plastic anchors:

$$N_{Rk} = N_{Rk,0} \bullet \alpha_{1,line\,2} \bullet min\alpha_{1,line\,4,5} \bullet min\alpha_{1,line\,3,6,7} \bullet \alpha_{1,lifetime} \bullet \alpha_v \tag{2.13}$$

for screwed-in plastic anchors:

$$N_{Rk} = N_{Rk,0} \bullet min\alpha_{1,line\,4,5} \bullet min\alpha_{1,line\,3,6,7} \bullet \alpha_{1,lifetime} \bullet \alpha_v \tag{2.14}$$

with

N_{Rk} = characteristic resistance, These values shall be rounded down to the following numbers [kN] :

0,10 / 0,15 / 0,20 / 0,25 / 0,30 / 0,35 / 0,40 / 0,45 / 0,50 / 0,55 / 0,60 / 0,65 / 0,70 / 0,75 / 0,80 / 0,85 / 0,90 / 0,95 / 1,0 / 1,1 / 1,2 / 1,3 / 1,4 / 1,5

| $N_{Rk,0}$ | = | concrete: | characteristic resistance of reference tension tests according to Table 2.3, line 1 in normal weight concrete |
| | | other materials: | characteristic resistance of reference tension tests according to Table 2.3, line 1 in the different base materials according to Table 2.2. |

$\alpha_{1,\text{line 2}}$ = value α_1 according to Equation (2.11) of the tests of installation $\leq 1,0$

| | for base material group A and B: | value of A applies for both base material groups unless voluntary tests are also performed specifically for base material group B |
| | for base material group C: | value of the most critical material applies unless voluntary tests are carried out for different materials of this base material group |

$\min\alpha_{1,\text{line 4,5}}$ = minimum value α_1 according to Equation (2.11) of the tests under conditioning and temperature $\leq 1,0$

$\min\alpha_{1,\text{line 3,6,7}}$ = minimum value α_1 according to Equation (2.11) of the tests for functioning depending on the diameter of the drill hole, functioning under repeated loads and functioning relaxation $\leq 1,0$

$\alpha_{1,\text{lifetime}}$ = virgin materials: $\alpha_{1,\text{lifetime}} = 1,0$.

non-virgin materials: $\alpha_{1,\text{lifetime}}$ see Equation (2.12).

α_v = value α_V to represent a coefficient of variation of the ultimate loads in the tests larger than 20% (see Equation (2.8)) $\leq 1,0$

2.2.3 Displacement

As a minimum, the displacement under short term tension loading shall be given in the ETA for a load N [N = N_{Rk} / ($\gamma_M \cdot \gamma_F$)] of the plastic anchor where $\gamma_M = 2,0$ and $\gamma_F = 1,5$. These displacements are evaluated from characteristic resistance/reference tests according to Table 2.3 line 1.

Note: In the ETA an advice shall be given that the considered partial safety factors ($\gamma_M = 2,0$ and $\gamma_F = 1,5$) may be adapted to national requirements and linear interpolation between $\delta_N(N)$ and $\delta_N(0) = 0$ mm is possible.

The displacement of nailed-in anchors under short term tension loading shall be given in the ETA as the displacement increase $\Delta\delta_N$ between $N_{preload} = 0,05 \cdot N_{Rk}$ and the tension load [N = N_{Rk} / ($\gamma_M \cdot \gamma_F$)] of the plastic anchor (see Figure 2.2). These displacements of nailed-in anchors are evaluated from the mean value of tests according Table 2.3, line 2.
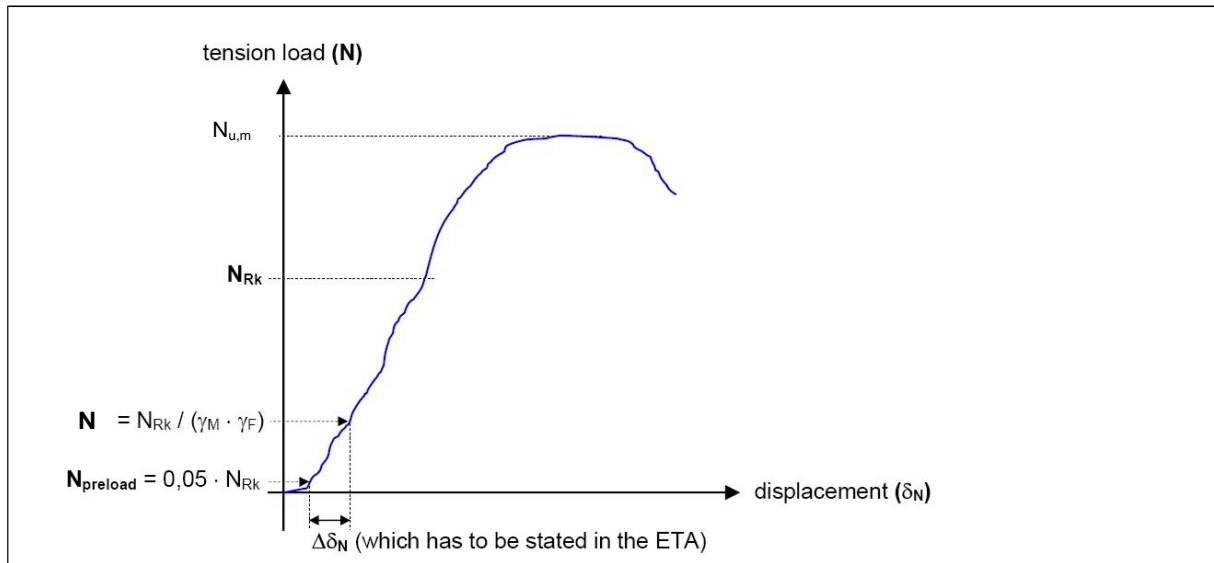
Figure 2.2   Example of load displacement diagram for a nailed-in plastic anchor. Evaluation of $\Delta\delta_N$, which has to be given in the ETA

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: 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 "Plastic anchors for fixing of external thermal insulation composite systems with rendering" in the procedure of assessment and verification of constancy of performance are laid down in Table 3.1.

Table 3.1   Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control [1]
Factory production control (FPC) **[including testing of samples taken at the factory in accordance with a prescribed test plan]***					
Expansion element made of metal					
1	Dimensions (outer diameter, inner diameter, thread length, etc.)	Caliper and/ or gauge	Laid down in control plan	3	Every manufacturing batch or 100000 expansion elements or when raw material batch has been changed
2	Tensile Load (N_p) or tensile strength (f_{uk})	According to ISO 898-1 [21]		3	
3	Zinc plating (where relevant)	x-ray measurement		3	
Expansion element, anchor sleeve and plate made of plastic					
4	Material	DSC according to ISO 11357 [24]	Tolerance: ± 5 K	2	twice yearly or each batch
5	Density	according to EN ISO 1183 [20]	-	2	
6	Only for polyamide (PA) / Molecular weight	VZ according to ISO 307 [25]	Tolerance: ± 10%	2	
7	Only for polyethylene (PE) and polypropylene (PP)/ Molecular weight	MFI according to ISO 1133 [26]	Tolerance: MFI ≤ 10: ±1 MFI > 10: ±10%	2	
8	Only for non – virgin material (PE and PP) / process stabilization	OIT	Tolerance[3]: -10%	2	
9	Only for non – virgin material (PA,PE and PP) / longterm stabilization	GC	Tolerance[3]: -10%	2	

No	Subject/type of control	Test or control method		Criteria, if any	Minimum number of samples	Minimum frequency of control [1]
Factory production control (FPC) **[including testing of samples taken at the factory in accordance with a prescribed test plan]***
10	Only for non – virgin material (PA,PE and PP) / admissible contamination [4]	Tensile tests and impact tests with normed samples	Tensile modulus	Tolerance [3]: -10%	5	
			Stress at yield [2]	Tolerance [3]: -10%	5	
			Stress at break [2]	Tolerance [3]: -10%	5	
			Impact toughness	Tolerance [3]: -10%	5	
11	Extrusion of anchor sleeve	visual inspection		Laid down in control plan	one shot of each production lot or shift	twice/coat

[1] The lower control interval is decisive

[2] Stress at yield for ductile plastics (e.g. PE, PE, PA) and stress at break for brittle plastics (e.g. PA-GF or PP-GF)

[3] The given tolerances refer to nominal specification given by the supplier. If greater tolerances are desired, anchor testing according to Table 2.3 line 1 to 10 shall be done with boundary samples.

[4] Contaminations may influence mechanical performance thus mechanical performance has to be monitored

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.

Table 3.2 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method *(refer to 2.2 or 3.4)*	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 anchor.	-	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.	-	Laid down in control plan	-	1/year

4   REFERENCE DOCUMENTS

As far as no edition date is given in the list of standards thereafter, the standard in its current version at the time of issuing the European Technical Assessment is of relevance.

[1]   ETAG 004:
EXTERNAL THERMAL INSULATION COMPOSITE SYSTEMS (ETICS) WITH RENDERING, edition 27 June 2013

[2]   ETAG 017:
Guideline for European Technical Approval of VETURE KITS - PREFABRICATED UNITS FOR EXTERNAL WALL INSULATION, edition 16 December 2005

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

EN 771-2:2011+A1:2015 Specification for masonry units – Part 2:
Calcium silicate masonry units

EN 771-3:2011+A1:2015 Specification for masonry units – Part 3:
Aggregate concrete masonry units (Dense and light-weight aggregates)

EN 771-4:2011+A1:2015 Specification for masonry units – Part 4:
Autoclaved aerated concrete masonry units

EN 771-5:2011+A1:2015 Specification for masonry units – Part 5:
Manufactured stone masonry units

[4]   EN 1996-1-1:2013:
Design of masonry structures - part 1-1: General rules for reinforced and unreinforced masonry structures

[5]   EN 206:2013
Concrete - Specification, performance, production and conformity

[6]   EN 1520:2011
Prefabricated reinforced components of lightweight aggregate concrete with open structure.

[7]   EN 12602:2013
Prefabricated reinforced components of autoclaved aerated concrete

[8]   ISO 1110:1998-03
Plastics – Polyamides – Accelerated conditioning of test specimens

[9]   ISO 3167:2014-08
Plastics; multipurpose test specimens

[10]   ISO 527-1:2012
Plastics; determination of tensile properties; part 1: general principles

[11]   ISO 6783:1982-06
Coarse aggregates for concrete; Determination of particle density and water absorption; Hydrostatic balance method

[12]   EN 197-1:2011-11 Cement – Part 1:
Composition, specifications and conformity criteria for common cements

[13]   ISO 5468:2007-01
Rotary and rotary impact masonry drill bits with hardmetal tips. Dimensions

[14]   EN 13163:2013-13
Thermal insulation products for buildings - Factory made products of expanded polystyrene (EPS) – Specification

[15]   EN 10088-4 and -5:2014: Stainless steels – Part 4:
Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes; Part 5: Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes

[16]   ISO 2578:1993
        Plastics – Determination of time-temperature limits after prolonged exposure to heat

[17]   TR025
        Determination of point thermal transmittance of plastic anchors for the anchorage of external
        thermal insulation composite systems (ETICS)

[18]   TR026
        Evaluation of plate stiffness from plastic anchor for fixing of external thermal insulation composite
        systems with rendering (ETICS)

[19]   TR051
        Recommendations for tests of plastic anchors for fixing of external thermal insulation composite
        systems with rendering for use in masonry to be carried out on construction works

[20]   EN ISO 1183-1 to 3
        Plastics - Methods for determining the density of non-cellular plastics

[21]   EN ISO 898-1: 2013-05
        Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws
        and studs with specified property classes - Coarse thread and fine pitch thread

[22]   EN ISO 6507-1 to 4:2005-12
        Metallic materials - Vickers hardness test

[23]   EN ISO 6508-1 to 3:2015-03
        Metallic materials - Rockwell hardness test

[24]   ISO 11357
        Plastics - Differential scanning calorimetry (DSC)

[25]   EN ISO 307:2013-08
        Plastics - Polyamides - Determination of viscosity number (ISO 307:2007 + Amd 1:2013)

[26]   EN ISO 1133-1 to 2:2012-03
        Plastics - Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of
        thermoplastics

[27]   EN ISO 179-1+2
        Plastics - Determination of Charpy impact properties

[28]   EN ISO 180:2013-08
        Plastics - Determination of Izod impact strength (ISO 180:2000 + Amd.1:2006 + Amd.2:2013)

[29]   EN 13791:2007
        Assessment of in-situ compressive strength in structures and precast concrete components

[30]   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

ANNEX A   DETAILS OF METHOD AND CRITERIA FOR ASSESSMENT

A.1   Test samples

Samples shall be chosen to be representative of normal production as supplied by the manufacturer, including screws, nails and plastic sleeves.

Sometimes the tests are carried out with samples specially produced for the tests before issuing the ETA. If so, it shall be verified that the plastic anchors subsequently produced conform in all respects, particularly functioning and bearing behaviour, with the plastic anchors tested.

A.2   Test members

A.2.1   Concrete test member

Aggregates shall be of natural occurrence (i.e. non-artificial) and with a grading curve falling within the boundaries given in Figure A.2.1. The maximum aggregate size shall be 16 mm or 20 mm. The aggregate density shall be between 2.0 and 3.0 t/m^3. (see EN 206 [5] and ISO 6783 [11]).

The boundaries reported in Figure A.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.
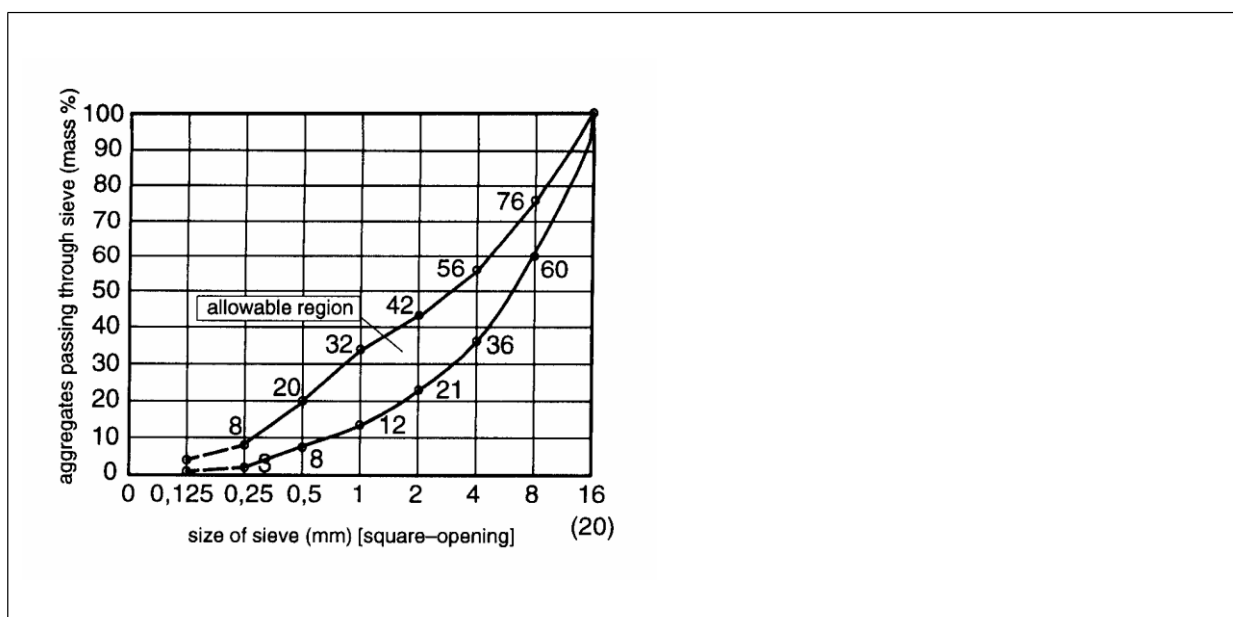

Figure A.2.1   Admissible region for the grading curve

- Cement
The concrete shall be produced using Portland cement type CEM I or Portland-Composite CEM II/A-LL, CEM II/B-LL (see EN 197-1 [12]).

- 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/m^3.

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

- 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:

The following mean compressive strengths at the time of testing plastic anchors shall be obtained:

C20/25　　f_{cm}　　=　　20-30 MPa (cylinder: diameter 150 mm, height 300 mm)

　　　　　　　　　=　　25-35 MPa (cube:150 x 150 x 150 mm)

C50/60　　f_{cm}　　=　　50-60 MPa (cylinder: diameter 150 mm, height 300 mm)

　　　　　　　　　=　　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.

$$C20/25 \quad f_{cyl} \quad = \quad \frac{1}{1,25} f_{cube150} \tag{A.2.1}$$

$$C50/60 \quad f_{cyl} \quad = \quad \frac{1}{1,25} f_{cube150} \tag{A.2.2}$$

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

$$f_{cube100} \quad = \quad \frac{1}{0,95} f_{cube150} \tag{A.2.3}$$

$$f_{cube150} \quad = \quad \frac{1}{0,95} f_{cube200} \tag{A.2.4}$$

$$f_{cube150} \quad = \quad f_{core100} \text{ (according to EN 13791 [29], section 7.1)} \tag{A.2.5}$$

Note: Additional literature for conversion is given by R. Lewandowski, [30]

For every concreting operation, specimens (cylinder, cube) shall be prepared having the dimensions mentioned in this clause; the specimens being made and treated in the same way as the test members.

Generally, the concrete control specimens shall be tested on the same day as the plastic anchors in the corresponding concrete test member. 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 plastic anchor tests, e.g. in general at the beginning and at the end of the tests.

The concrete strength at a certain age shall be measured on at least 3 specimens, the mean value shall be used to check compliance with the requirement.

If, when evaluating the test results, there are doubts about whether the strength of the control specimens represents the concrete strength of the test members, then at least three cores of 100 mm or 150 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 shall be converted into the strength of cubes by Equation (A.2.6):

$$f_{c,cube\ 200} \quad = \quad 0,95 \cdot f_{c,cube\ 150} \quad = \quad f_{c,core\ 100} \quad = \quad f_{c,core\ 150} \tag{A.2.6}$$

- Dimensions of test members

Generally, the tests are carried out on unreinforced test members.

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 plastic anchors 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°.

In general, the thickness of the members shall correspond to the minimum member thickness applied by the manufacturer which will be given in the ETA [at least 100 mm or 40 mm in case of e.g. weather resistant skin elements (see 1.2.2.)].

- Casting and curing of test members and specimens

In general, 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 do not cause a deterioration of the concrete compressive and tension strength. When testing the plastic anchors the concrete shall be at least 21 days old.

A.2.2   Test member for other base material

The tests shall be carried out in the base material for which the plastic anchor is intended to be used (see Table 2.2). Solid clay bricks and solid calcium silicate bricks shall have approximately the following dimensions: Length x width x height = 240 x 115 x 113 (or alternatively 71) mm and the following properties: compressive strength ≥ 12 N/mm^2 and density between 1,6 and 2,0 kg/dm^3.

The bricks of the test wall may be laid in a prestressing frame. The frame can be prestressed by hand. However it shall not restrict lateral expansion. The plastic anchor shall be installed in the centre of the brick.

A.3   Plastic anchor installation

The plastic anchors shall be installed in accordance with the installation instruction supplied by the manufacturer.

In case of concrete the tested plastic anchors shall be installed in the cast surface of the concrete test member.

The holes for plastic anchors shall be perpendicular to the surface of the member unless specifically required otherwise by the manufacturer's specifications.

In the tests the drilling tools specified by the manufacturer shall be used.

If hard metal hammer-drill bits are required, these bits shall meet the requirements of the standards ISO 5468 [13] with regard to dimensional accuracy, symmetry, symmetry of insert tip, height of tip and tolerance on concentricity.

The diameter of the cutting edges as a function of the nominal drill bit diameter is given in Figure A.3.1. The diameter of the drill bit shall be checked every 10 drilling operations to ensure continued compliance.
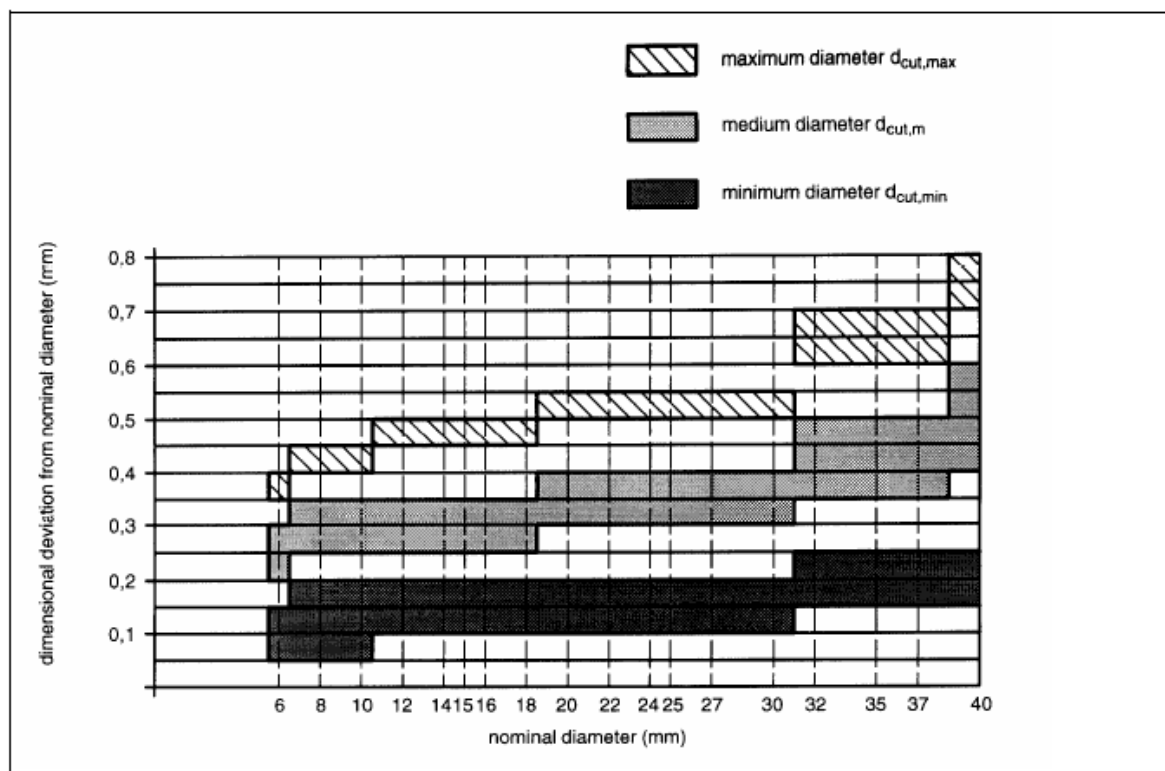
Figure A.3.1   Cutting diameter of hard metal hammer-drill bits

A.4   Test equipment

Tests shall be carried out using measuring equipment having traceable calibration. The load application equipment shall be designed to avoid a sudden increase in load especially at the beginning of the test. The measuring error of the load shall not exceed 2 % throughout the whole measuring range.

Displacements shall be recorded continuously (e.g. by means of electrical/electronic displacement) with a measuring error of less than 0,02 mm.

In general, the test rigs shall allow the formation of an unrestricted rupture cone. For this reason the clear distance between the reaction support and a plastic anchor shall be at least $2 \cdot h_{ef}$ (or $2 \cdot h_{nom}$). If the failure mode is pull- out- failure the clear distance between the reaction support and a plastic anchor could be smaller. For tests in masonry units the clear distance between the reaction support and a plastic anchor could be smaller.

During tension tests, the load shall be applied concentrically to the plastic anchor. To achieve this, hinges shall be incorporated between the loading device and the plastic anchor.

In torque tests the relation between the torque moment by installation and the torque moment at failure are measured. For this a calibrated torque moment transducer with a measuring error < 3 % throughout the whole measuring range shall be used. The plastic anchor shall be installed with an electric screwdriver.

A.5   Test procedure

The plastic anchors shall be installed in accordance with the standard instructions supplied by the manufacturer.

The standard conditioning of the plastic shall be according to the specification of the plastic manufacturer except in the tests "Functioning under conditioning". (see 2.2.2.5) The wet condition means water saturated. It can be reached by placing the plastic sleeve under water until the mass increase is smaller than 0,1 % in 3 consecutive measurements every 24 h.

After installation, the plastic anchor is connected to the test rig and loaded to failure. The displacements of the plastic anchor relative to the concrete surface at a distance of $\geq 1{,}5 \cdot h_{ef}$ (or $\geq 1{,}5 \cdot h_{nom}$) from the plastic anchor shall be measured by use of either one displacement transducer on the head of the plastic anchor or at least two displacement transducers on either side; the mean value shall be recorded in the latter case.

A.6   Test report

As a minimum requirement, the report shall include at least the following information:

General

- Plastic anchor description (dimensions, materials, coating, production method) and type of plastic anchor
- Steel part of plastic anchor:
  Dimensions, tensile strength and type of coating
- Plastic part of plastic anchor:
  Material (DSC), density, molecular weight (VZ or MFI)
- Plastic part of plastic anchor (additional for non-virgin material):
  Process stabilization (OIT), longterm stabilization (GC) and admissible contamination[4] (Tensile tests and impact tests with normed samples according to ISO 3167 [9], ISO 527 [10] and EN ISO 179 [27] or ISO 180 [28])
- 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)

Number of tests

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

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

Test members for other base materials:

- Type of material, compressive strength, density, geometry and type of holes
- Date of manufacture
- Measured value of compressive strength at the time of testing (individual results and mean value)
- Dimensions of test member

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[4] Contaminations may influence mechanical performance thus mechanical performance hast o be monitored.

Plastic anchor installation

- Information on the positioning of the plastic anchor
- Distances of plastic anchors from edges of test member and between adjacent plastic anchors
- Tools employed for plastic anchor installation, e.g. impact drilling tool, drilling hammer, other equipment
- Type of drill bit, manufacturer's mark and measured drill bit dimensions, particularly the effective diameter, d_{cut}, of the hard metal insert
- Information on the direction of drilling
- Information on cleaning of the hole
- Depth of drill hole
- Depth of anchorage
- Tightening torque or other parameters for control of installation
- Quality and type of screws and nuts employed

Measured values

- Parameters of load application (e.g. rate of increase of load or size of load increase steps)
- Displacements measured as a function of the applied load
- Any special observations concerning application of the load
- Failure load
- Failure mode
- Radius (maximum radius, minimum radius) and height of a concrete or masonry cone produced in the test (where applicable)
- Particulars of repeated load tests
  - minimum and maximum load
  - frequency of cycles
  - number of cycles
  - displacements as function of the number of cycles
- Particulars of torque test
  - maximum torque moment at installation
  - maximum torque moment at failure

The above measurements shall be recorded for each test.

- Particulars of product characteristic tests
  - dimensions of the parts of the plastic anchor and the drilling- and installation tools
  - properties (e.g. tensile strength, elastic limit, elongation at rupture, hardness and surface conditions of plastic anchor, if applicable)

A.7 Test with EPS layer with max. t_{fix}

a) Preparation of the test

The setting of the nailed-in plastic anchor has to be carried out using the test setup shown in Figure A.7.1 (flush or countersunk to a certain extent according to the manufacturer's installation instructions).

The drill hole in the base material has to be drilled according to A.3 with drill bit diameter $d_{cut,m}$ and the drill method (rotary drill or hammer or impact drilling) given by the manufacturer's installation instructions.

The EPS block (see Figure A.7.2) is placed into the supporting body and the tested anchor is set into the drill hole according to the manufacturer's installation instructions.

b) Thickness of fixture

5 tests with max t_{fix} (maximum thickness of the ETICS which can be fixed) have to be performed.

For anchors that take into account a tolerance layer t_{tol} (e.g. plaster, stucco, …), an intermediate layer $t_{tol} \geq 10$ mm (with t_{tol} according to manufacturer's installation instructions) may be placed between the EPS block and the base material according to Figure A.7.3. An intermediate layer could be e.g. a drywall board. Adhesives are not acceptable as they adhere to the base material and, hence, may influence the test.

$$L_a = h_{nom} + t_{fix}$$

with: $\quad t_{fix} = (t_{tol} + h_D)$

L_a = length of plastic anchor

h_{nom} = overall plastic anchor embedment depth in the base material

t_{fix} = thickness of fixture

t_{tol} = thickness of equalizing layer or non-load bearing coating

h_D = thickness of insulation material

c) Setting of the nailed-in plastic anchor

The expansion element is driven in with a defined impact energy resultant from the mass of the drop weight and the height of fall.

The mass of the drop weight shall be chosen in such a way that the anchor is installed with 3 blows at minimum and 8 blows at maximum by a free height of fall of 500 mm.

The setting is finished if the highest point of the anchor plate becomes flush with the surface of the EPS- block or 2 mm below the surface at maximum (anchor types for mounting on the surface, see Figure A.7.3) or the installed anchor is countersunk in the EPS-block with the permitted measure given by the manufacturer's installation instructions (anchor types for deep mounting).

The number of any setting failures has to be stated in the test report.

d) Execution of the tension test

After setting, the supporting body and the EPS-block (and the intermediate layer) are removed carefully. Any adverse influence on the anchor (e.g. bending) shall be avoided during this step.

Allowing for the same load transfer into the anchor shaft the tension test has to be carried out in the same way as the test for the determination of the characteristic resistance according to Table 2.3, line 1. A preload $N_{preload}$ has to be applied first.

$$N_{preload} \leq 0{,}05 \cdot N_{Rk} \qquad (N_{Rk} = \text{characteristic resistance in the ETA})$$

The tension load has to be increased continuously and constantly with a loading rate of $(1 \pm 0{,}2)$ kN/min up to failure according to A.5.

The displacement has to be measured in the direction of the anchor axis and has to be recorded continuously throughout the test.
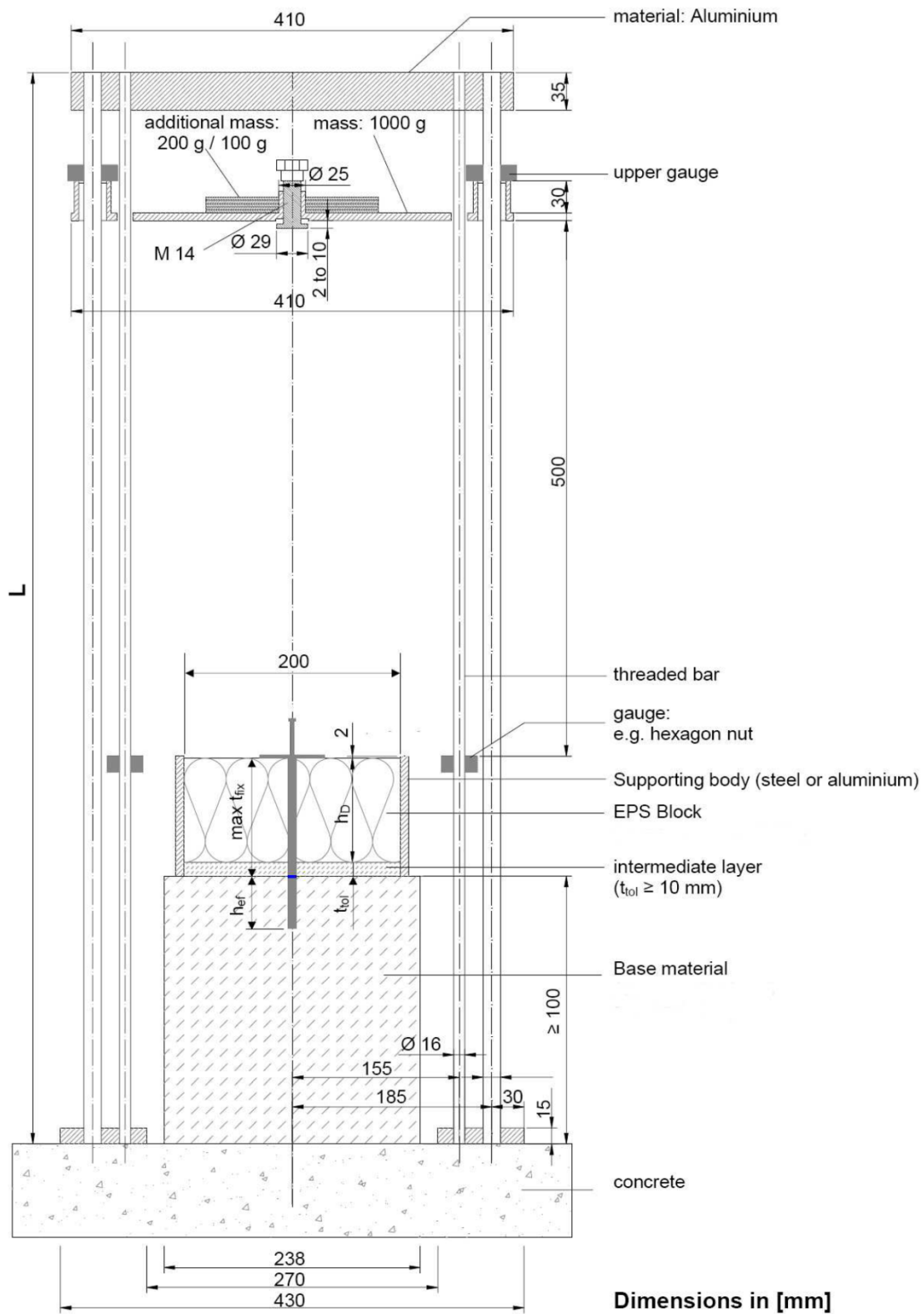
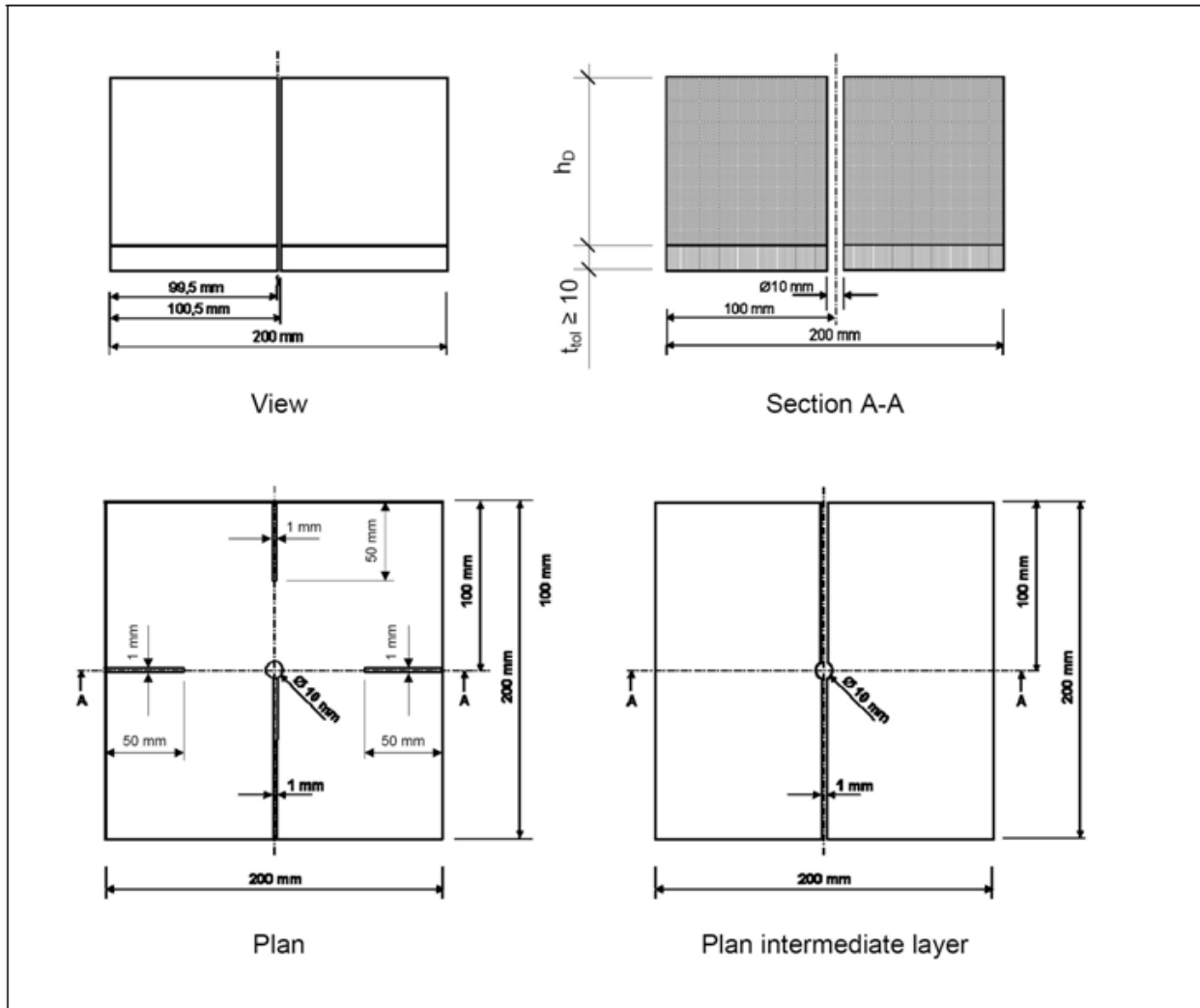Figure A.7.1:   Layout for the test setup (for nailed-in anchors)

Figure A.7.2:   EPS-block   {Materials:EPS-EN   13163-T2-L2-S2-P4-DS(70,-)2-BS100-DS(N)2-TR150 (or TR100 according to [14] }; intermediate layer being e.g. a drywall board, an adhesive is not acceptable
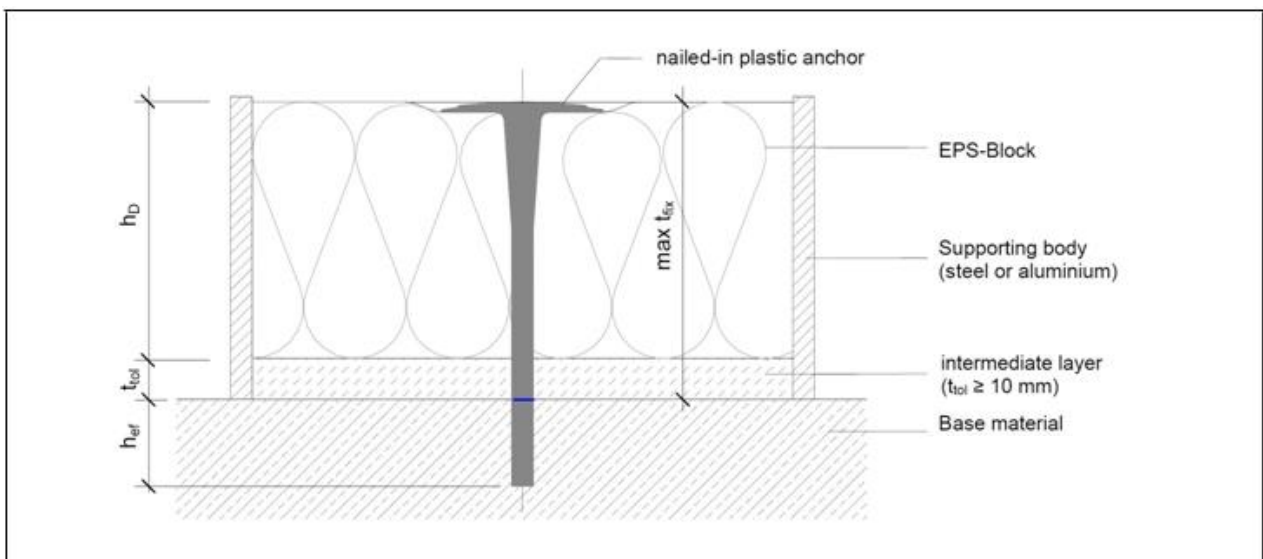

Figure A.7.3:   Installed anchor (example for installation flush with surface)

A.8 Test for the determination of high alkalinity from plastic sleeve

This shall be done for PA 6, PP, PE or other polymeric materials by the following tests:

Test specimen:

1. Manufactured of tension bars according to ISO 3167 [9].

2. If the plastic of concern has the capability of water absorption, the water content of the tension bars shall be determined (e.g. by Karl Fischer titration). If the water content is higher than that representative for a dry conditioning state, the item shall be dried, see section 2.2.2.5.

3. 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 $3,0 \pm 0,05$ mm).

4. Pressing a round pin (diameter according to A.8.1) quickly into tension bars.

5. Putting the tension bars into the different agents (see A.8.1 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 °C ± 3 °C). 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).

6. After taking the bars from high alkaline solution investigate them for cracks. If the plastic can absorb water re-dry the bars making sure they have similar water content. Perform tension tests according to ISO 527 [10].

The tests have to be carried out for each colour of the plastic anchor.

Table A.8.1   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

A.9 Influence of Thermal-Oxidative Degradation to the lifetime of plastic

If it is intended to use re-worked non-virgin plastic (e.g. inhouse re-use of sprue from non-virgin plastic) for mass production, the samples used for test of lifetime shall contain the same share of re-worked plastic as it is intended for mass production. The maximum share of reworked non-virgin plastic shall be specified in production control plans and monitored in production.

Table A.9.1   Number of tests

Test	Basic lifetime test of material		Lifetime test of anchor	
Determination of	$\sigma_{y,0}$ or $\sigma_{b,0}$	$\sigma_{y,180d,90°C}$ or $\sigma_{b,180d,90°C}$	$N_{u,m,5d}$	$N_{u,m,180d}$
Number of tests n ≥	3	3	5	5

A.9.1   Basic lifetime test of material

For purpose of material lifetime test, test specimen according to ISO 3167 [9] are exposed to 90°C under normal atmosphere (air) referring to ISO 2578 [16].

The test of plastic's lifetime shall be done according to the following instructions:

1) Determine strength $\sigma_{y,0}$ (for ductile plastics) or $\sigma_{b,0}$ (for brittle plastics) according to ISO 527-1 [10] at 23+/-3°C using plastic samples acc. to ISO 3167 [9]
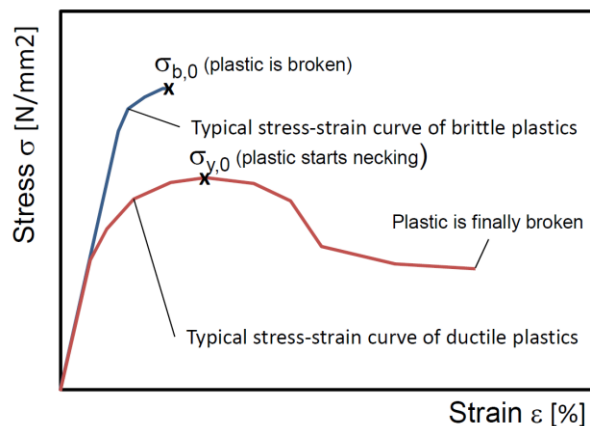

Figure A.7.2: typical stress strain curve of ductile plastics and brittle plastics

where
$\sigma_{y,0}$ … Yield strength of the plastic before temperature exposure [N/mm^2]
$\sigma_{b,0}$...Stress at rupture of the plastic before temperature exposure [N/mm^2]

2) Store plastic samples in ventilated ovens according to ISO 2578 [16] at 90+/-3°C.
3) Take samples after 28 days from the ovens and determine strength $\sigma_{y,28d,90°C}$ (for ductile plastics) or $\sigma_{b,28d,90°C}$, (for brittle plastic) of plastic samples at 23+/-3°C. Strength $\sigma_{y,28}$ and $\sigma_{b,28}$ shall be greater than or equal to $\sigma_{y,0}$ and $\sigma_{b,0}$ because it covers potential post-crystallization effects without degradation effects.

> *where*
> *$\sigma_{y,t,T}$ … Yield strength of the plastic after a time t (for t=28 days, 180 days,…) exposure to T=90°C [N/mm^2]*
> *$\sigma_{b,t,T}$...Stress at rupture of the plastic after a time t (for t=28 days, 180 days,…) exposure to T=90°C [N/mm^2]*

4) Take remaining samples from the oven after at least 180 days and determine strength $\sigma_{y,180d,90°C}$ (for ductile plastics) or $\sigma_{b,180d,90°C}$, (for brittle plastic) of plastic samples at 23+/-3°C
5) For acceptance equation (2.3) or equation (2.4) have to be matched

A.9.2   Lifetime test of anchor

If anchor's sleeve or expansion pin are made of non-virgin plastics the lifetime must be confirmed testing the anchor assembly (anchor sleeve, anchor plate, expansion pin or screw and supplementary parts e.g. drive-in pins etc.) too.

The test of plastic's lifetime shall be done according to the following instructions:

1. Set anchors according to manufacturer's instruction in concrete C20/25. Edge distance and spacing and slab thickness can be smaller than 100mm, but shall be chosen great enough that anchor's ultimate failure load is not influenced (e.g. intersecting concrete cone failure is not accepted).
2. Store the items in ventilated ovens according to ISO 2578 [16] at 80+/-3°C.
3. Take samples from the oven after 5 days and determine mean ultimate pull-out failure load $N^{r'}_{u,m,5d}$ at 23+/- 3°C
4. Take samples from the oven after 180 days and determine mean ultimate pull-out failure load $N^{t}_{u,m,180d}$ at 23+/- 3°C

If anchor's plate is made of non-virgin plastic the lifetime must be confirmed testing the anchor assembly too.

The test of plastic's lifetime shall be done according to the following instructions:

1. Expansion pin or expansion screw of the anchor shall be mounted in the anchor making sure they find the same position related to anchor's plate; they had, if the anchor would be set according to manufacturer's instruction. The anchor doesn't have to be set necessarily in concrete or any similar base material. Anchor expansion sleeve can be partly removed.
2. Store the items in ventilated ovens according to ISO 2578 [16] at 80+/-3°C.
3. Take samples from the oven after 180 days and determine tests according to section A.5 at 23+/- 3°C