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POWDER-ACTUATED FASTENER FOR THE FIXING OF ETICS IN CONCRETE

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Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

The pre-assembled fixing element consists of a plastic part made of high-density polyethylene and a powder-actuated fastener which is driven into the concrete perpendicular to the surface without previous drilling using a powder-actuated fastening tool according to EN 15895 [19] with a cartridge as propelling charge.

The powder-actuated fastener is made of zinc coated carbon steel, tempered carbon steel with non-electrolytically applied zinc flake coating according to EN ISO 10683 [20] or stainless steel in accordance with EN 10088-3:2014 [9] which in addition can be zinc plated. The shaft diameter of the powder-actuated fastener is in the range of 3 mm to 5 mm. The mean anchorage depth in uncoated concrete is at least 30 mm (without equalizing layer and adhesive)[1].

The mean anchorage depth h_v in coated concrete is at least 20 mm (without equalizing layer and adhesive)[2].

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 diameter of the plate is at least 60 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 powder-actuated fastener.
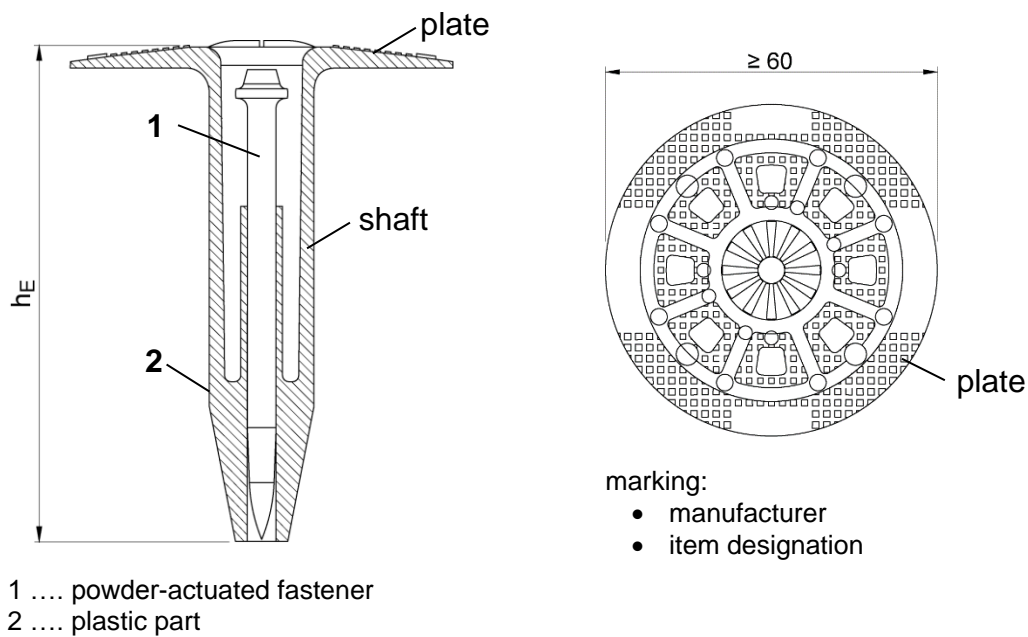
Figure 1.1, Figure 1.2 and Figure 1.3 show examples of the product.
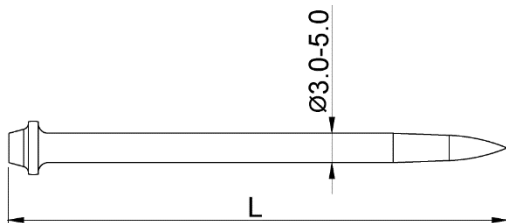
Figure 1.1 Example of a powder-actuated fastener

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[1] The minimum anchorage depth of individual fasteners amounts to 25 mm.

[2] The minimum anchorage depth of individual fasteners amounts to 18 mm.

1 …. powder-actuated fastener
2 …. plastic part

Figure 1.2 Example of a plastic part (cross-section and top view)
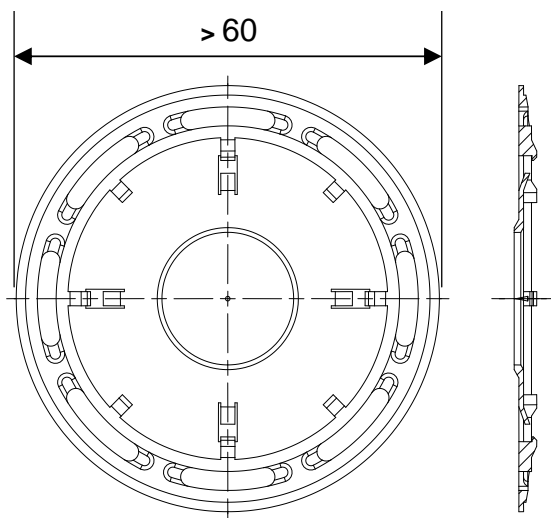
Figure 1.3 Example of an additional larger plate

The operation of the powder-actuated fastening tool has to allow the detection of setting defects. Therefore, only the specified fastener guide belonging to the powder-actuated fastening tool is used for installation. 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 fixing element is exposed to a check loading.

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(s) of the construction product

1.2.1   Intended use(s)

The fixing element is intended for multiple use only for the anchorage of external thermal insulation composite systems (ETICS) according to ETAG 004 [2]. As insulation material expanded polystyrene [10] or mineral wool [11] are used for the ETICS.

The system is intended to be used either in coated or in uncoated concrete (use conditions are given in Table 1.1) based on the characteristic performances given in ETA or – if applicable – based on the results of job site tests according to TR 052 [7] under the responsibility of an engineer experienced in anchorages for ETICS or VETURE kits.

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

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

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

Within the ETICS the fixing element is only used for transmission of tension loads due to wind actions. The fixing element is not be 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 powder-actuated fastener are used:

(1)   Fixing of ETICS with rendering for use in structures subject to dry, internal conditions:

Powder-actuated fastener made of carbon steel with zinc coating with a minimum thickness of 5 microns

(2)   Fixing of ETICS with rendering for use in structures subject to external atmospheric exposure:

Powder-actuated fastener made of tempered carbon steel with non-electrolytically applied zinc flake coating according to EN ISO 10683 [20] with 960 h salt spray testing without red rust

(3)   Fixing of ETICS 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:

Powder-actuated fasteners made of stainless steel material 1.4401, 1.4404, 1.4578, 1.4571, 1.4362, 1.4062, 1.4162, 1.4662, 1.4439, 1.4462 or 1.4539 according to EN 10088-3 [9]

The concrete strength class of the base material made of reinforced or unreinforced normal concrete shall correspond to at least C 12/15 and to at maximum C 35/45 according to EN 206-1:2000 [8]. An anchorage of the fixing element in weather-beaten concrete and exposed aggregate concrete is not covered by this EAD.

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 1.1.

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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).

Figure 1.4 and Figure 1.5 show the installed product.
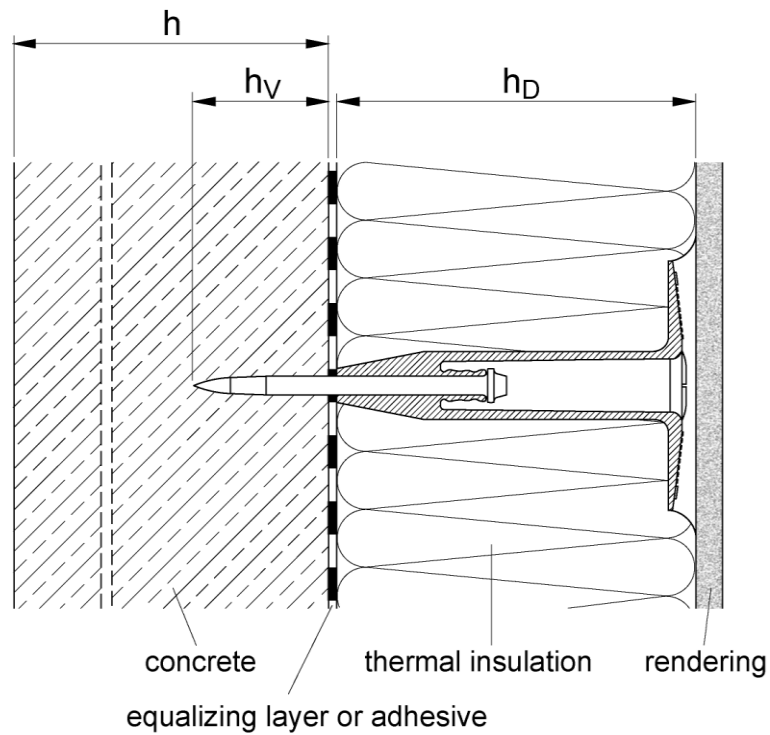
Figure 1.4 Installed condition of the fixing element in case of uncoated concrete
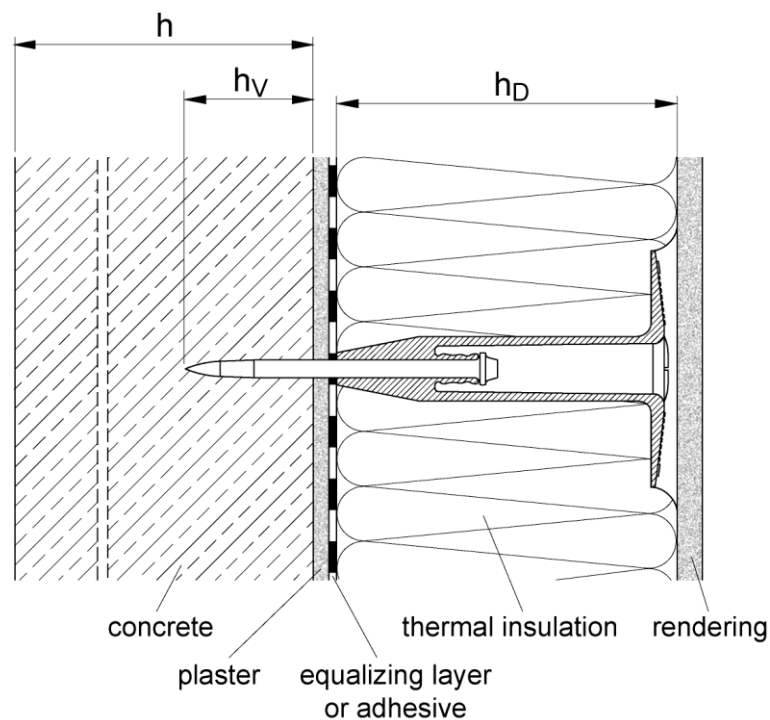
Figure 1.5 Installed condition of the fixing element in case of coated concrete

Table 1.1 summarizes the application conditions.
Painted concrete without plaster is equivalent with uncoated concrete.

Table 1.1 Intended use conditions

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

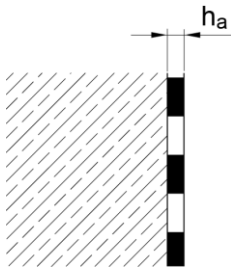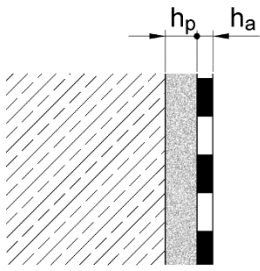For the installation of the product the necessary tools foreseen by the manufacturer are to be used and the relevant manufacturer's instructions must be followed to the detail. The performance of the fastener is assessed under the assumption that both these preconditions are met.

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

The fixing element can be used in the temperature range -20 °C to + 60 °C. The minimum setting temperature of the fixing element is +5 °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 fixing element for the intended use of 25 years when installed in the works (provided that the fixing element 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[4].

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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[4]   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 (if necessary in addition to the definitions in CPR, Art 2)

General

Powder-actuated fastener / Fastener	=	a steel part achieving anchorage between the base material (concrete) and the fixing element
Plastic part	=	consisting of a shaft and a plate for holding the thermal insulation, made of high-density polyethylene
Fixing element	=	consisting of the plastic part achieving connection with the insulation of the ETICS and a fastener which is driven into the concrete using a powder-actuated fastening tool with a cartridge as propelling charge
Fixture	=	component to be fixed to the concrete member (here ETICS, respectively insulation of ETICS)

Fasteners

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

h	=	thickness of concrete member
h_D	=	thickness of insulation material
h_p	=	thickness of plaster of coated concrete
h_a	=	thickness of adhesive and equalizing layer
L	=	overall length of the powder-actuated fastener
h_V	=	mean anchorage depth in the concrete
c	=	edge distance
c_{min}	=	minimum allowable edge distance
s	=	spacing of the fixing elements
s_{min}	=	minimum allowable spacing

Tests / Assessment

F_A	=	pull-out force in a test in installation safety test F1
F_R	=	frictional force in a test in installation safety test F1
$N_{5\%}^t$	=	5%-fractile of the ultimate load (normal distribution) in a test series
$N_{5\%}^r$	=	5%-fractile of the ultimate load (normal distribution), reference test
$N_{ln5\%}^t$	=	5%-fractile of the ultimate load (logarithmic distribution) in a test series
$N_{ln5\%}^r$	=	5%-fractile of the ultimate load (logarithmic distribution), reference test
$N_{Ru,m}^t$	=	mean ultimate load in a test series
$N_{Ru,m}^r$	=	mean ultimate load 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 fixing element (fastener 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

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 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 1: Mechanical resistance and stability			
1	Characteristic load bearing capacity - Characteristic resistance under tension load - Minimum edge distance - Minimum spacing	2.2.1	Level - N_{Rk} [kN] - c_{min} [mm] - s_{min} [mm]
2	Displacement - Tension load N with partial factor γ_M, γ_F - Displacement	2.2.2	Level - N [kN] - δ_0 [mm]
3	Plate stiffness - Diameter of the anchor plate - Load resistance of the anchor plate - Plate stiffness	2.2.3 TR 026 [6]	Level - Diameter of the anchor plate [mm] - Load resistance of the anchor plate [kN] - c [kN/mm]
4	Durability of the plastic parts	2.2.4	Description
Basic Works Requirement 6: Energy economy and heat retention			
5	Thermal transmittance - Point thermal transmittance of an anchor - Insulating layer thickness of the ETICS	2.2.5 TR 025 [5]	Level - χ [W/K] - h_D [mm]

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

2.2.1　Characteristic load bearing capacity

The test program for the assessment consists of:
-　Service condition tests to assess basic values of characteristic resistance
-　Functioning tests to assess the characteristic resistance regarding variations of temperature, loading and installation for the relevant application range according to the intended use.

The required tests are given in Chapter 2.2.1.1 (functioning tests) und Chapter 2.2.1.2 (service condition tests). Test methodologies are given in Annex A. The assessment (evaluation) of the test results and the determination of the characteristic resistance are given in Chapter 2.2.1.3.

2.2.1.1　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 − except F8 − displacements can be measured externally (e.g. by displacement transducers) or internally (e.g. measurement of piston stroke).

The test conditions, the number of required tests and the criteria applied to the results should be taken in accordance with Table 2.2.

Table 2.2 Functioning tests

No	Purpose of test		Concrete strength	Minimum number of tests	Tem-perature [°C]	Criteria req. α (1)	Reference test
F1	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
F3	Load resistance in concrete with an equalizing layer (2)		C 12/15 ≤ C 35/45	20	21 ± 3	0.75	A1
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 2.2.1.3
(2)　coated with equalizing layer h_a = 20 mm, see Table 1.1
(3)　coated with h_p = 15 mm and (h_p + h_a) = 25 mm, see Table 1.1

Test procedure F1: Installation safety – plastic part

Due to the positive locking or friction-tight contact between fastener guide and the fixing element 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.

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

The plastic part of the fixing element 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 2.1. 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.
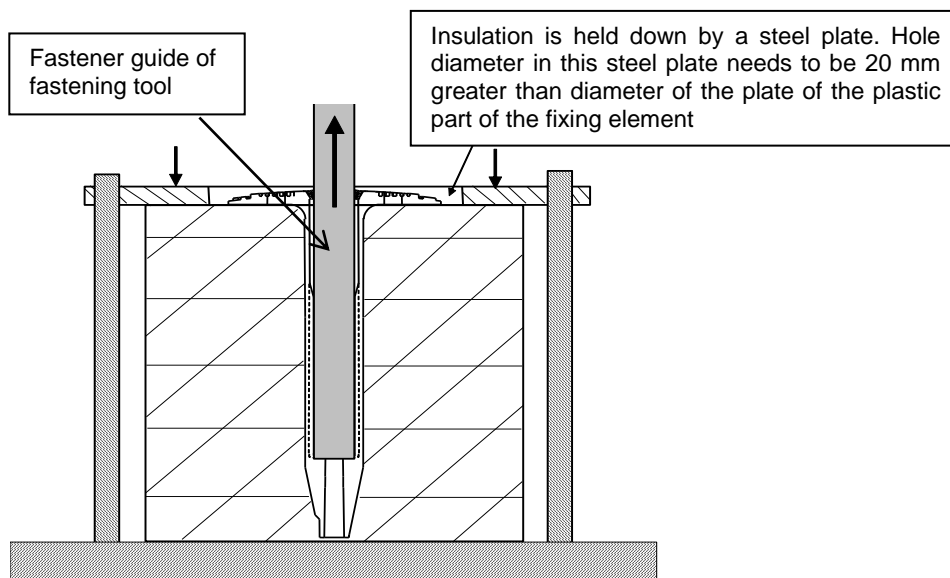
Figure 2.1 Determination of frictional forces F_R

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 should correspond to one of the options shown in Figure 2.2.
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 4 hours.
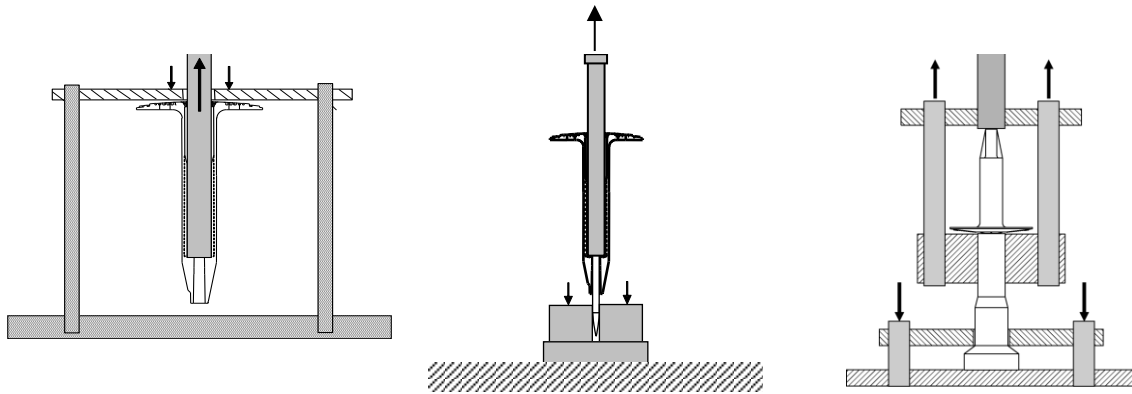
Figure 2.2 Determination of pull-out force F_A of fastener guide from plastic part

Test procedure F2: Load resistance in carbonated concrete

The tests shall be carried out in concrete with a depth of carbonation of ≥ 5 mm. The concrete strength, the grain size of aggregates as well as the thickness of the carbonated layer shall be determined.

Test procedure F3: Load resistance in concrete with an equalizing layer

The tests shall be carried out in concrete coated with a 20 mm thick equalizing layer, e.g. bonding mortar. After setting, this layer shall be removed and the fixing element 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[5] 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.

Test procedure F4: Load resistance in coated concrete

The tests shall be carried out 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 [12].

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 must be increased.

Test procedure F5: Functioning under repeated loads

The tests shall be carried out in uncoated concrete C12/15.

The single fastener 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:

$$\text{max N} = 0{,}6\ N_{Rk} \qquad (2.1)$$
$$\text{min N} = 0{,}25\ N_{Rk} \qquad (2.2)$$

with: N_{Rk} =   characteristic tension resistance evaluated from the results of test A1 according to Table 2.3.

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.

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[5] With a minimum requirement for individual fasteners of 25 mm.

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} should be reduced with the factor max N (applied) / max N.

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

Test procedure F6: Load resistance after relaxation

The tests shall be carried out in uncoated concrete. The load resistance shall be determined immediately after setting, after 1 month and after 3 months.

Test procedure F7: Load resistance of the plastic part - shaft

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 2.3. The inner diameter of the ring is acceptable to be less than 30 mm in order to avoid premature failure of the plastic plate.
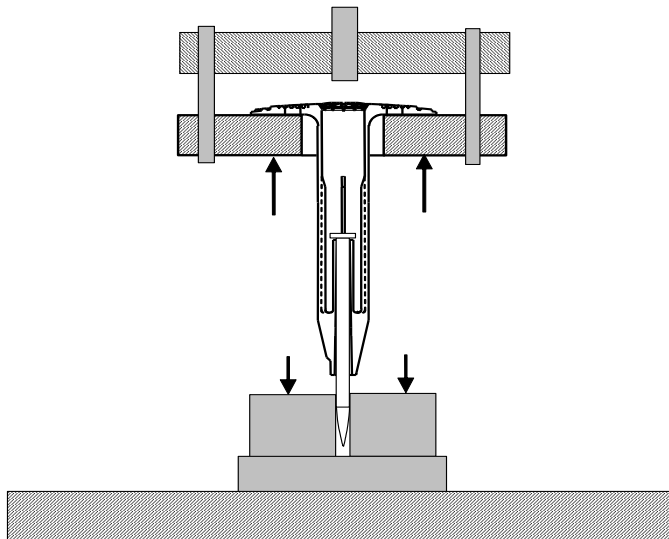
Figure 2.3 Determination of tension resistance of the shaft

The powder-actuated fastener 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.

Test procedure F8: Load resistance of the plastic part - plate

The tests shall be carried out according to EOTA Technical Report TR 026 [6] for temperatures -20 °C and 60 °C. The elements to be tested shall be conditioned at -20 °C and 60 °C for at least 4 hours.

Test procedure F9: Influence of pigmenting on the plastic parts

All tests with the plastic parts 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).

2.2.1.2   Service condition tests

The types of tests for service condition tests, test conditions and the number of required tests should be taken in accordance with Table 2.3.

Table 2.3 Service condition tests

No	Purpose of test	Concrete strength	Minimum number of tests	Temperature [°C]
A1	Reference test	a) C 12/15	20	21 ± 3
		b) C 20/25	50	
		c) C 35/45	20	
A2	Characteristic spacing and edge distances	C 12/15 ≤ C 35/45	10	21 ± 3
A3	Load resistance of plastic part: shaft	-	5	21 ± 3
A4	Load resistance of plastic part: plate	-	5	21 ± 3

Test procedure A1: Reference test

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

Test procedure A2: Characteristic spacing and edge distances

The tests shall be carried out in uncoated concrete without equalizing layer or adhesives with spacing and edge distances given by the manufacturer. Spacing, edge distances and spalling of concrete shall be recorded.

These tests may be omitted if the spacing is $s_{min} \geq 200$ mm and the edge distance $c_{min} \geq 100$ mm.

Test procedure A3: Load resistance of the plastic part: shaft

The test procedure as for the functioning test F7 applies.

Test procedure A4: Load resistance of the plastic part: plate

The tests shall be carried out according to EOTA Technical Report TR 026 [6].

2.2.1.3   Assessment of test results

5%-fractile of the ultimate loads

The 5%-fractile of the ultimate pull-out loads of the fasteners 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.

$$N_{ln5\%} = N_{Ru,m\,ln(x)} - k_s \cdot s_{ln(x)} \qquad\qquad (2.3)$$

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

with: $N_{ln5\%}$ =   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

As setting defects are detected, they shall not be included in the statistical evaluation.

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.

$$N_{5\%} = N_{Ru,m} - k_s \cdot s \qquad (2.4)$$

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

Load/displacement behaviour

For the pull-out behaviour of the powder-actuated fastener the load/displacement curves shall show a steady increase (see Figure 2.4). 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:

$$N_1 = 0,4\, N_{Ru} \qquad (2.5)$$

with:

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

1 and 2 acceptable function
3   non–acceptable function
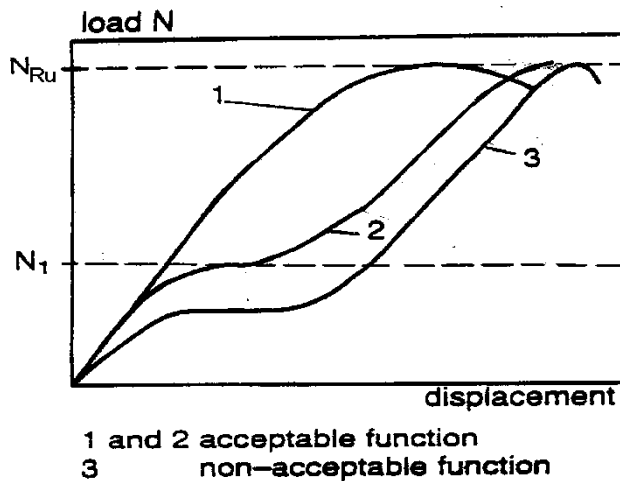
Figure 2.4 Requirements for the load/displacement curve

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

Reduction factor α

The factor α should be greater than the value given in Table 2.2.

Pull-out of the fastener:

$$\alpha = \min \left\{ \frac{N_{Ru,m}^t}{N_{Ru,m}^r} ; \frac{N_{ln5\%}^t}{N_{ln5\%}^r} \right\} \qquad (2.6)$$

Plastic part:

$$\alpha = \min \left\{ \frac{N_{Ru,m}^t}{N_{Ru,m}^r} ; \frac{N_{5\%}^t}{N_{5\%}^r} \right\} \qquad (2.7)$$

with: $N_{Ru,m}^t$; $N_{Ru,m}^r$ = mean value, in a test series or reference test series, respectively

        $N_{5\%}^t$; $N_{5\%}^r$ = 5% fractile (with a normal distribution) of the plastic part in a test series or reference test series, respectively

$N_{ln5\%}^{t}$; $N_{ln5\%}^{r}$ = 5% fractile (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 (see equation 2.12).

Installation safety – plastic part

Following condition has to be fulfilled:

$$F_{A,5\%} (0/20/40°C) \geq 1,3 \cdot F_{R,95\%} \qquad (2.8)$$

and:

$$F_{A,5\%} = F_{Au,m} - k_s \cdot s \qquad (2.9)$$
$$F_{R,95\%} = F_{Ru,m} + k_s \cdot s \qquad (2.10)$$

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

Characteristic tension resistance to pull-out failure

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

For uncoated concrete:

$$N_{Rk,p} = N_{Rk,0} \cdot \min \alpha_u \qquad (2.11)$$

For coated concrete:

$$N_{Rk,p} = N_{Rk,0} \cdot \min \alpha_u \cdot \alpha_{u,4} \qquad (2.12)$$

$N_{Rk,p}$ shall be reduced by the factor max N (applied) / max N, if the applied load (see equation (2.1) and (2.2)) 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 (2.3) of test A1a), A1b), A1c) and A2 according to Table 2.3.

min α_u = minimum α_u of the functioning tests F2, F3, F5 and F6 according to Table 2.2; ($\leq 1,0$)

$\alpha_{u,4}$ = α_u of the functioning test F4 according to Table 2.2; ($\leq 1,0$)

α_u = α / req. α \qquad (2.13)

with:

α = α-factor according to eq. (2.6) of the functioning tests F2, F3, F4, F5 and F6

req. α = required α according to Table 2.2

For determination of the design value of resistance in concrete $N_{Rd,p}$ the partial safety factor $\gamma_M = 2,0$ is recommended if corresponding national regulations do not exist.

Load resistance of the plastic part

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

$$N_{Rk,Pl} = N_{Rk,0,Pl} \cdot \alpha \, / \, req. \, \alpha \qquad\qquad (2.14)$$

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) = min $N_{5\%}$ according to equation (2.4) of tests A3 (for the shaft) and A4 (for the plate) according to Table 2.3.

α = α-factor according to eq. (2.7) of the functioning tests F7 (for the shaft) and F8 (for the plate)

req. α = required α according to Table 2.2

For determination of the design value of resistance of the plastic part $N_{Rd,Pl}$ the partial safety factor (material safety factor for polyethylene PE-HD) γ_{MPl} = 1,3 is recommended if corresponding national regulations do not exist.

2.2.2   Displacements

The displacements for short-term tension loading shall be given in the ETA for a load N [N = N_{Rk} / ($\gamma_M \cdot \gamma_F$)] with γ_M = 2,0 and γ_F = 1,5. These displacements δ_0 are evaluated from tests according to Table 2.3, test series A1, A3 and A4. They should correspond to the sum of the mean value of these test series (A1: pull-out of fastener from concrete, A3: elongation in the shaft, A4: displacements of the plate). The displacements (in mm) should be rounded up to zero or five on the first place after the decimal point.

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

2.2.3   Plate stiffness

The load resistance and plate stiffness of the anchor plate is assessed according to EOTA Technical Report TR 026 [6].

2.2.4   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 2.4 in comparison with the test results in section A.3 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_m at maximum load	≤ 20 % reduction of strain ε_m
tension test ISO 527[1]	strain ε_1 at 50 % of the maximum load	≤ 20 % reduction of strain ε_1

[1] ISO 527 [14]

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

2.2.5   Point thermal transmittance

The point thermal transmittance is assessed according to EOTA Technical Report TR 025 [5].

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

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

For the products covered by this EAD the applicable European legal act is: 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 product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.1, Table 3.2 and Table 3.3.

Table 3.1 Control plan for the manufacturer - fastener; 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: - fastener 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 „type 3.1" according to EN 10204	Specification	1	Every manufacturing batch
3	Core hardness	Rockwell hardness tests according to EN ISO 6508-1 [13]	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 3.2 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	ISO 1133-1 [16]	Laid down in control plan Tolerance: for MFI $\leq$ 10: $\pm$ 1 for MFI > 10: $\pm$ 10%	1	Every raw material batch
2	DSC-curve of raw material	EN ISO 113 57-1 [17]	Laid down in control plan Tolerance: $\pm$ 5 K	-	Every manufacturing batch or twice / year
3	Density of raw material [g/cm^3]	EN ISO 1183 [18]	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 3.3 Control plan for the manufacturer – assembled product; 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 caliper	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 product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.4.

Table 3.4 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	-	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 001:1997, amended 11/2006 and 04/2013: Guideline for European Technical Approval of metal anchors for use in concrete

[2] ETAG 004:2000, amended 08/2011 and 02/2013: Guideline for European Technical Approval of external thermal insulation composite systems (ETICS) with rendering

[3] EAD 330335-00-0604: Plastic anchors made of virgin or non-virgin material for fixing of external thermal insulation composite systems with rendering

[4] EOTA Technical Report TR 048: Details of tests for post-installed fasteners in concrete

[5] EOTA Technical Report TR 025: Determination of point thermal transmittance pf plastic anchors for the anchorage of external thermal insulation composite systems with rendering (ETICS)

[6] EOTA Technical Report TR 026: Evaluation of plate stiffness from plastic anchors for fixing of external thermal insulation composite systems with rendering (ETICS)

[7] EOTA Technical Report TR 052: Recommendations for job-site tests of powder-actuated fasteners for ETICS for use in concrete, Draft November 2016

[8] EN 206-1:2000 Concrete – Part 1: Specification, performance, production and conformity

[9] EN 10088 – part 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

[10] EN 13163:2012, amended 2015: Thermal insulation products for buildings - Factory made expanded polystyrene (EPS) products - Specification

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

[12] EN 998-1, September 2010: Specification for mortar for masonry – Part 1: Rendering and plastering mortar.

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

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

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

[16] 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

[17] EN ISO 11357-1:2009: Plastics - Differential scanning calorimetry (DSC) - Part 1: General principles

[18] EN ISO 1183: Plastics - Methods for determining the density of non-cellular plastics (Part 1, 2012: Immersion method, liquid pyknometer method and titration method; Part 2, 2004: Density gradient column method, Part 3, 1999: Gas pyknometer method)

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

[20] EN ISO 10683:2014: Fasteners – Non-electrolytically applied zinc flake coatings (ISO 10683:2014)

ANNEX A: DETAILS OF TESTS

A.1   Test procedure – general aspects

If test details are not given in the following, these details shall be taken from TR 048 [4].

The test methodologies are valid for the functioning tests (chapter 2.2.1.1) and for the service condition tests (chapter 2.2.1.2).

The fasteners should be installed according to the installation instructions of the manufacturer.

The energy to drive the fastener is to be selected such that the mean anchorage depth h_v amounts to the required anchorage depth of uncoated or coated concrete. The load should 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 should be performed later than 10 minutes after setting.

The evaluation of test results is only carried out for installed fixing elements because setting defects are always detected due to the check loading and because for the defective setting always a new fixing element is to be used.

The tests are to be carried out under laboratory conditions on test specimens of 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 32 mm of grain size (within test A1).

Tests are to be performed in non-cracked concrete only. For all tests with concrete base material the fixing element 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

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

A.2   Test report

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

General

- Fastener:
  - Dimensions: shape, length, diameter, geometry and length of tip, concentricity of fastener 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 (shape, length, thickness of shaft sleeve)
- 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

- Fixing element: Model designation, total length L of powder-actuated fastener
- Insulation: Type and thickness
- Powder-actuated fastening tool: Tool type, fastener guide, piston, cartridge and tool power setting
- Distances of fixing elements from edges of test member and between adjacent fixing elements
- Nailhead stand-off (distance from top of driven fastener to the surface of the concrete)
- anchorage depth

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.

A.3 Test for the determination of high alkalinity from plastic sleeve

Test specimen:

1. Manufactured of tension bars according to ISO 3167 [15].
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 $3,0 \pm 0,05$ mm).
3. Pressing a round pin (diameter according to Table A.1) quickly into tension bars.
4. Putting the tension bars into the different agents (see Table A.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 $\pm$ 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).

5. After taking the bars from high alkaline solution investigate them for cracks. Perform tension tests according to ISO 527 [14].

Table A.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