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Designated according to Article 29 of Regulation (EU) No 305/2011

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# European Technical Assessment

# ETA-10/0309 of 01/10/2015

*English translation prepared by CSTB - Original version in French language*

## General Part

**Technical Assessment Body issuing the ETA and designated according to Article 29 of the Regulation (EU) No 305/2011:**

| | |
|---|---|
| Nom commercial<br>*Trade name* | **Injection system SPIT EPCON C8 XTREM for cracked concrete** |
| Famille de produit<br>*Product family* | **Cheville à scellement de type "à injection" pour fixation dans le béton fissuré et non fissuré : tiges filetées M8 à M30 et barres d'armatures Ø8 à Ø32.**<br>***Bonded injection type anchor for use in cracked and non-cracked concrete: Threaded rods M8 to M30 and rebars Ø8 to Ø32*** |
| Titulaire<br>*Manufacturer* | Société SPIT<br>Route de Lyon<br>F-26501 BOURG-LES-VALENCE<br>France |
| Usine de fabrication<br>*Manufacturing plant* | Société SPIT<br>Route de Lyon<br>F-26501 BOURG-LES-VALENCE<br>France |
| Cette evaluation contient:<br>*This Assessment contains* | 25 pages incluant 21 pages d'annexes qui font partie intégrante de cette évaluation<br>*25 pages including 21 pages of annexes which form an integral part of this assessment* |
| Base de l'ETE<br>*Basis of ETA* | ETAG 001, Version April 2013, utilisée en tant que EAD<br>*ETAG 001, Edition April 2013 used as EAD* |
| Cette evaluation remplace:<br>*This Assessment replaces* | ATE-10/0309 valide du 11/10/2010 au 11/10/2015<br>ETA-10/0309 with validity from 11/10/2010 to 11/10/2015 |

## Specific part

### 1 Technical description of the product

The Injection system SPIT EPCON C8 XTREM is an adhesive anchor consisting of a two component system delivered in unmixed condition in cartridges and of a steel element.

The steel element can be made of zinc plated carbon steel, reinforcing bar, stainless steel, or high corrosion resistant stainless steel (HCR).

The steel element is placed into a rotary/percussion drilled hole filled with the injection mortar and is anchored via the bond between the metal part and concrete.

An illustration of the product is provided in Annexes A.

### 2 Specification of the intended use

The performances given in Section 3 are only valid if the anchor is used in compliance with the specifications and conditions given in Annexes B.

The provisions made in this European Technical Assessment are based on an assumed working life of the anchor of 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

### 3 Performance of the product

### 3.1 Mechanical resistance and stability (BWR 1)

| Essential characteristic | Performance |
|---|---|
| Characteristic resistance under tension loads in non-cracked concrete acc. TR029 or CEN/TS 1992-4, for threaded rods | See Annex C1 |
| Characteristic resistance under tension loads in cracked concrete acc. TR029 or CEN/TS 1992-4, for threaded rods | See Annex C2 |
| Characteristic resistance under shear loads in concrete acc. TR029 or CEN/TS 1992-4, for threaded rods | See Annex C 3 |
| Displacements for threaded rods | See Annex C4 |
| Characteristic resistance under tension loads in non-cracked concrete acc. TR029 or CEN/TS 1992-4, for rebars | See Annex C5 |
| Characteristic resistance under tension loads in cracked concrete acc. TR029 or CEN/TS 1992-4, for rebars | See Annex C6 |
| Characteristic resistance under shear loads in concrete acc. TR029 or CEN/TS 1992-4, for rebars | See Annex C7 |
| Displacements for rebars | See Annex C8 |
| Characteristic resistance under seismic action C1 acc. TR045, for threaded rods | See Annex C11 |

### 3.2 Safety in case of fire (BWR 2)

| Essential characteristic | Performance |
|---|---|
| Reaction to fire | Anchorages satisfy requirements for Class A1 |
| Resistance to fire | No performance determined (NPD) |

### 3.3 Hygiene, health and the environment (BWR 3)

Regarding dangerous substances contained in this European Technical Assessment, there may be requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the Construction Products Directive, these requirements need also to be complied with, when and where they apply.

### 3.4 Safety in use (BWR 4)

For Basic requirement Safety in use the same criteria are valid as for Basic Requirement Mechanical resistance and stability.

### 3.5 Protection against noise (BWR 5)

Not relevant.

### 3.6 Energy economy and heat retention (BWR 6)

Not relevant.

### 3.7 Sustainable use of natural resources ( (BWR 7)

For the sustainable use of natural resources no performance was determined for this product.

### 3.8 General aspects relating to fitness for use

Durability and Serviceability are only ensured if the specifications of intended use according to Annex B1 are kept.

## 4 Assessment and verification of constancy of performance (AVCP)

According to the Decision 96/582/EC of the European Commission [1], as amended, the system of assessment and verification of constancy of performance (see Annex V to Regulation (EU) No 305/2011) given in the following table apply.

| Product | Intended use | Level or class | System |
|---|---|---|---|
| Metal anchors for use in concrete | For fixing and/or supporting to concrete, structural elements (which contributes to the stability of the works) or heavy units | — | 1 |

## 5 Technical details necessary for the implementation of the AVCP system

Technical details necessary for the implementation of the Assessment and verification of constancy of performance (AVCP) system are laid down in the control plan deposited at Centre Scientifique et Technique du Bâtiment.

The manufacturer shall, on the basis of a contract, involve a notified body approved in the field of anchors for issuing the certificate of conformity CE based on the control plan.

**The original French version is signed by**

Charles Baloche
Technical Director

1 Official Journal of the European Communities L 254 of 08.10.1996

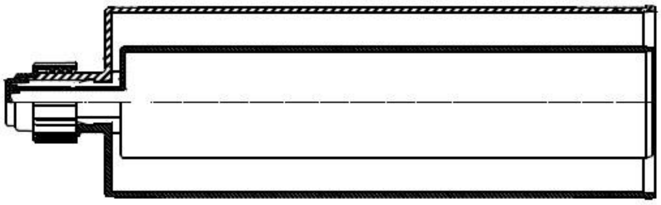
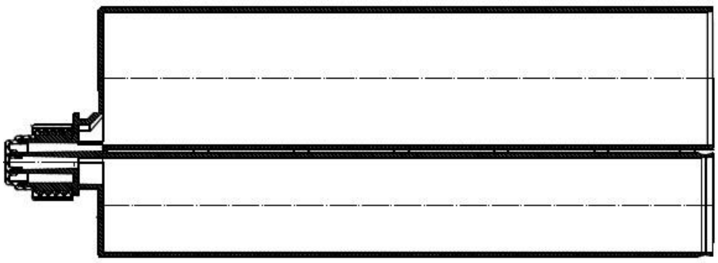
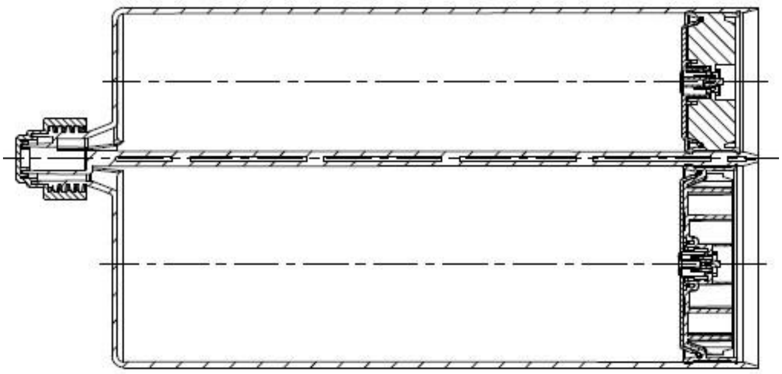
## Injection mortar

Two component epoxy system


### Marking

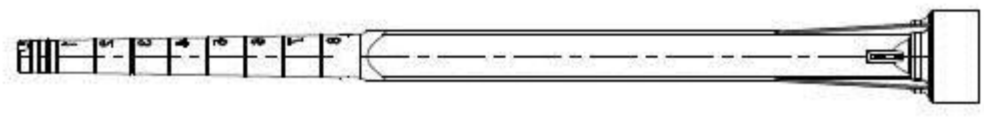
- Identifying mark of the producer **SPIT**
- Trade name **EPCON C8 XTREM**
- Expire date
- Curing and processing time
- Charge code number

### Cartridges

| | |
|---|---|
| 400ml coaxial cartridge |  |
| 450ml side by side cartridge |  |
| 900ml side-by-side cartridge |  |

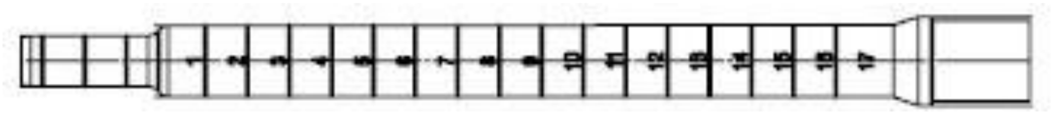
| | |
|---|---|
| **SPIT EPCON C8 XTREM** | **Annex A1** |
| **Product description**<br>Mortar cartridges | |

## Mixing nozzles

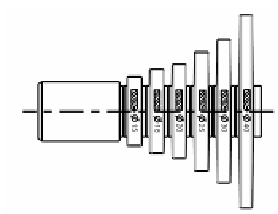


**Standard 400-450-900**


**High flow mixing nozzle**



**Reduction for mixing nozzles**



**Piston Plug**

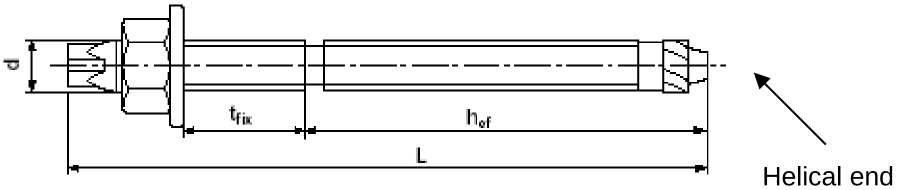
## Extensions

| Ø Drilling | Plastic extension for mixing nozzle | Mixing nozzle | |
|---|---|---|---|
| | $\phi_{ext}$ x l | | |
| [mm] | [mm] | [-] | [-] |
| 10 to 40 | 9x196<br>9x1000 | standard mixing nozzle 400-450-900 | |
| 15 to 40 | 13x1000 | standard mixing nozzle 400-450-900 | High flow mixing nozzle + Reduction |
| 25 to 40 | 20 x 1000 | High flow mixing nozzle | |

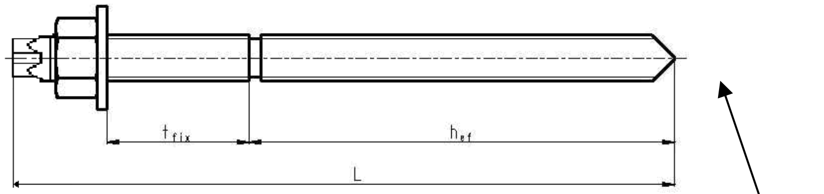
## Dispensers

- Electric dispenser EGI 450
- Pneumatic dispenser P450 / P900 / P400
- Manual dispenser M450 / M450 premium / M400

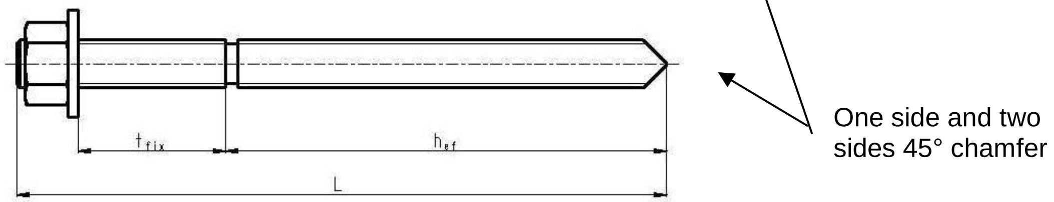
## Assembled anchor:




**Anchor rods SPIT MAXIMA M8 to M16 (Electroplated version)**




**Anchor rods SPIT MAXIMA M8 to M16 (Stainless steel version)**



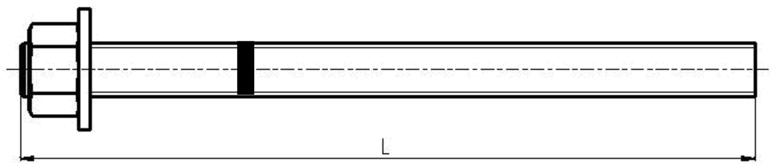

**Anchor rods SPIT MAXIMA M20 to M30 (Electroplated / Stainless steel versions)**

Marking on the anchor rod SPIT MAXIMA : letter S, bolt diameter and maximum thickness of the fixture:
Ex: S M10 / 20

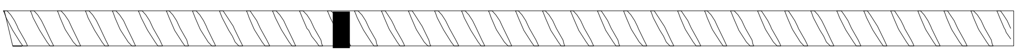
| M | d | L | Standard | |
|---|---|---|---|---|
| | | | $h_{ef,std}$ | $t_{fix\ max}$ (1) |
| **M8** | 8 | 110 | 80 | 15 |
| **M10** | 10 | 130 | 90 | 20 |
| **M12** | 12 | 160 | 110 | 25 |
| **M16** | 16 | 190 | 125 | 35 |
| **M20** | 20 | 260 | 170 | 65 |
| **M24** | 24 | 300 | 210 | 63 |
| **M30** | 30 | 380 | 280 | 70 |

**Dimensions Anchor rods SPIT MAXIMA**

(1) Maximum thickness of the fixture for threaded rods SPIT MAXIMA only




**Commercial standard threaded rods M8 to M30** with identifying mark of the embedment depth: Electroplated carbon steel grade 5.8 to 10.9, Stainless steel A4 and HCR.



**Rebars Ø8, Ø10, Ø12, Ø16, Ø20, Ø25, Ø28, Ø30, Ø32** with properties acc. Annex C of EN 1992-1-1

| | |
|---|---|
| **SPIT EPCON C8 XTREM** | **Annex A3** |
| **Product description**<br>Steel elements | |

## Table A1 : Material properties for threaded rods

| Designation | Size | Material and EN/ISO reference |
|---|---|---|
| **Electroplated Version** | | |
| Threaded rods | M8 to M30<br>(standard commercial rods ) | Carbon steel grade 5.8, 8.8 and 10.9 according to ISO 898<br>Zinc coating 5µm min. NF E25-009<br>Hot dip galvanized NF EN ISO 1461 |
| | MAXIMA M8<br>(produced by the manufacturer) | DIN 1654 part 2 or 4, cold formed steel or NFA 35053, cold formed steel.<br>Zinc coating 5µm min. NF E25-009 |
| | MAXIMA M10 to M16<br>(produced by the manufacturer) | NFA 35053 cold formed steel<br>Zinc coating 5µm min. NF E25-009 |
| | MAXIMA M20 to M30<br>(produced by the manufacturer) | 11SMnPb37 according to NF A35-561<br>Zinc coating 5µm min. NF E25-009 |
| Nut | - | Steel, EN 20898-2<br>Grade 6 or 8<br>Zinc coating 5µm min. NF E25-009 |
| Washer | - | Steel DIN 513<br>Zinc coating 5µm min. NF E25-009 |
| **Stainless steel version** | | |
| Threaded rods<br>(Maxima or std commercial rods) | Grade A4-80: M8 to M24<br>Grade A4-70: M30 | X2CrNiMo 17.12.2 according to EN 10088-3 |
| Nut | | Stainless steel A4-80 according to EN 20898-2 |
| Washer | | Stainless steel A4 according to EN 20898-2 |
| **High resistance corrosion version (HCR)** | | |
| Threaded rods | M8 to M30 | Stainless steel HCR acc. EN 10088, 1.4529 / 1.4565<br>Rm ≥ 650 MPa acc. EN 10088 |
| Nut | - | Stainless steel HCR acc. EN 10088, 1.4529 / 1.4565<br>Rm ≥ 650 MPa acc. EN 10088 |
| Washer | - | Stainless steel HCR acc. EN 10088, 1.4529 / 1.4565<br>EN ISO 7089 |

## Table A2: Material properties for rebars

**(Refer to EN 1992-1-1 Annex C Table C.1 and C.2N)**

| **Product form** | | **Bars and de-coiled rods** | |
|---|---|---|---|
| Class | | B | C |
| Characteristic yield strength $f_{yk}$ or $f_{0,2k}$ (MPa) | | 400 to 600 | |
| Minimum value of $k = (f_t/f_y)_k$ | | ≥ 1,08 | ≥ 1,15<br>< 1,35 |
| Characteristic strain at maximum force, $\varepsilon_{uk}$ (%) | | ≥ 5,0 | ≥ 7,5 |
| Bendability | | Bend / Rebend test | |
| Maximum deviation from nominal mass (individual bar or wire) (%) | Nominal bar size (mm)<br>≤ 8<br>> 8 | ± 6,0<br>± 4,5 | |
| Minimum relative rib area, $f_{R,min}$ ($mm^2$) | Nominal bar size (mm)<br>8 to 12<br>> 12 | 0,040<br>0,056 | |

**High of the rib $h_{rib}$:**

The high of the rib $h_{rib}$ must satisfy the equation $0{,}05\ d \leq h_{rib} \leq 0{,}07\ d$
with d = nominal diameter of the rebar.

| | |
|---|---|
| **SPIT EPCON C8 XTREM** | **Annex A5** |
| **Product description**<br>Rebars | |

## Specifications of intended use

**Anchorages subject to:**

- Static and quasi-static loads.
- Seismic loads (performance categories C1 for threaded rods of sizes M10, M12 and M16),

**Base materials:**

- Cracked concrete and non-cracked concrete.
- Reinforced or unreinforced normal weight concrete of strength classes C20/25 at least to C50/60 at most according to EN 206-1: 2000-12.

**Temperature Range:**

- Ta: - 40°C to +40°C (max. short term temperature +40°C and max. long term temperature +24°C)
- Tb: - 40°C to +80°C (max. short term temperature +80°C and max. long term temperature +50°C)

**Use conditions (Environmental conditions):**

- Structures subject to dry internal conditions (zinc coated steel, stainless steel, high corrosion resistance steel).
- Structures subject to permanently damp internal condition, if no particular aggressive conditions exist (stainless steel, high corrosion resistance steel).
- Structures subject to external atmospheric exposure including industrial and marine environment if no particular aggressive conditions exist (stainless steel, high corrosion resistance steel).
- Structures subject to any of the three above conditions, with particular aggressive conditions (high corrosion resistance steel).

*Note: 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).*

**Design:**

- The anchorages are designed in accordance with the EOTA Technical Report TR 029 "Design of bonded anchors" or CEN/TS 1992-4-5" Design of fastenings for use in concrete" under the responsibility of an engineer experienced in anchorages and concrete work.
- For seismic applications the anchorages are designed in accordance with TR045 "Design of Metal Anchors For Use In Concrete Under Seismic Actions".
- Verifiable calculation notes and drawings are prepared taking account of the loads to be anchored. The position of the anchor is indicated on the design drawings.

**Installation:**

- Dry or wet concrete (use category 1) and in flooded holes (use category 2).
- Installation in cracked concrete for all sizes of threaded rods and rebars.
- All the diameters may be used in all the direction (floor, wall, overhead).
- Anchor installation carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.
- Use of the anchor only as supplied by the manufacturer without exchanging the components of an anchor.
- Anchor installation in accordance with the manufacturer's specifications and drawings and using the appropriate tools (Annexes B2 to B5).
- Effective anchorage depth, edge distances and spacing not less than the specified values without minus tolerances.
- Hole drilling by hammer drill
- In case of aborted drill hole: the drill hole shall be filled with mortar.

- For overhead installation, piston plugs shall be used, embedded metal parts shall be fixed during the curing time, e.g. with wedges.

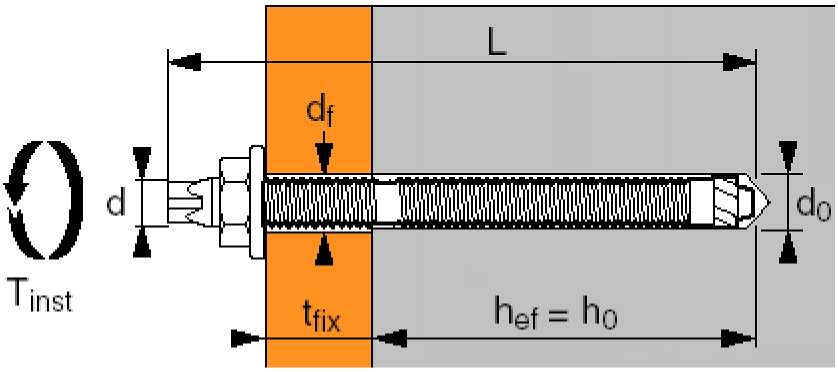
Note:

Rebars may be used as anchor designed in accordance with the EOTA Technical Report TR 029 only. The basic assumptions for the design according to anchor theory shall be observed. This includes the consideration of tension and shear loads and the corresponding failure modes as well as the assumption that the base material (concrete structural element) remains essentially in the serviceability limit state (either non-cracked or cracked) when the connection is loaded to failure. Such applications are e.g. concrete overlay or shear dowel connections or the connections of a wall predominantly loaded by shear and compression forces with the foundation, where the rebars act as dowels to take up shear forces.

## Table B1a: Installation data with standard, minimum and maximum embedment depth for threaded rods

| **Anchor size** | | | **M8** | **M10** | **M12** | **M16** | **M20** | **M24** | **M30** |
|---|---|---|---|---|---|---|---|---|---|
| Diameter of anchor rod | $d$ | [mm] | 8 | 10 | 12 | 16 | 20 | 24 | 30 |
| Range of anchorage depth $h_{ef}$ and bore hole depth $h_o$ | min | [mm] | 40 | 40 | 48 | 64 | 80 | 96 | 120 |
| | max | [mm] | 160 | 200 | 240 | 320 | 400 | 480 | 600 |
| | std (1) | [mm] | 80 | 90 | 110 | 125 | 170 | 210 | 280 |
| Nominal diameter of drill bit | $d_o$ | [mm] | 10 | 12 | 14 | 18 | 25 | 28 | 35 |
| Diameter of clearance hole in the fixture | $d_f$ | [mm] | 9 | 12 | 14 | 18 | 22 | 26 | 33 |
| Torque moment | $T_{inst}$ | [Nm] | 10 | 20 | 30 | 60 | 120 | 200 | 400 |
| Minimum thickness of concrete member | $h_{min}$ | [mm] | Max($h_{ef}$ + 30 ; 100) | | | $h_{ef} + 2d_o$ | | | |
| Minimum spacing | $S_{min}$ | [mm] | 40 | 50 | 60 | 80 | 100 | 120 | 150 |
| Minimum edge distance | $C_{min}$ | [mm] | 40 | 50 | 60 | 80 | 100 | 120 | 150 |

(1) Effective anchoring depth for SPIT MAXIMA threaded rods.




**SPIT EPCON C8 XTREM**

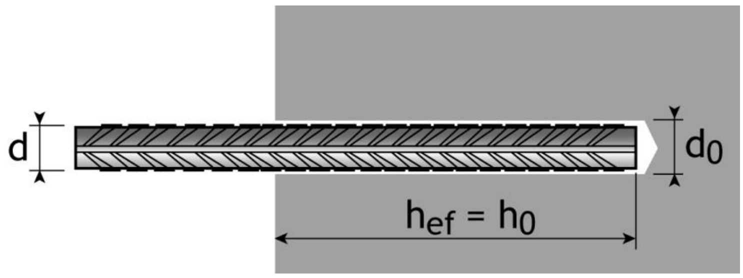
**Intended Use**

Installation data for threaded rods

**Annex B2**

## Table B1b: Installation data with standard, minimum and maximum embedment depth for rebars

| Rebar size | | | Ø8 | Ø10 | Ø12 | Ø16 | Ø20 | Ø25 | Ø26 | Ø28 | Ø32 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter of rebar | d | [mm] | 8 | 10 | 12 | 16 | 20 | 25 | 26 | 28 | 32 |
| Range of anchorage depth $h_{ef}$ and bore hole depth $h_o$ | min | [mm] | 40 | 60 | 70 | 80 | 90 | 100 | 104 | 112 | 128 |
| | max | [mm] | 160 | 200 | 240 | 320 | 400 | 500 | 520 | 560 | 640 |
| Nominal diameter of drill bit | $d_o$ | [mm] | 10 | 12 | 15 | 20 | 25 | 30 | 30 | 35 | 40 |
| Minimum thickness of concrete member | $h_{min}$ | [mm] | Max($h_{ef}$ + 30 ; 100) | | | $h_{ef}$ + 2$d_o$ | | | | | |
| Minimum spacing | $S_{min}$ | [mm] | 40 | 50 | 60 | 80 | 100 | 125 | 130 | 140 | 160 |
| Minimum edge distance | $C_{min}$ | [mm] | 40 | 50 | 60 | 80 | 100 | 125 | 130 | 140 | 160 |




**SPIT EPCON C8 XTREM**

**Intended Use**

Installation data for rebars

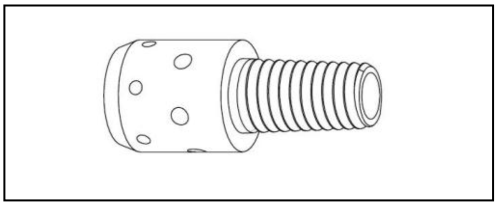
**Annex B3**

## Table B2a and Table B2b: Dimensions of the cleaning tools

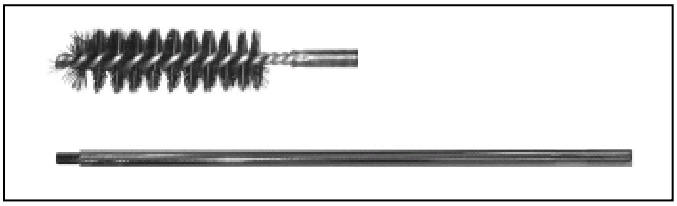
| | Threaded rods | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dimensions | | M8 | M10 | M12 | M16 | M20 | M24 | M30 |
| Ø drilled hole | [mm] | 10 | 12 | 14 | 18 | 25 | 28 | 35 |
| Ø Air nozzle | [mm] | 6 | 8 | 12 | 14 | 20 | 24 | 29 |
| Ø Brush | [mm] | 11 | 13 | 15 | 20 | 26 | 30 | 37 |

| | Rebars | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Dimensions | | Ø8 | Ø10 | Ø12 | Ø16 | Ø20 | Ø25 | Ø26 | Ø28 | Ø32 |
| Ø drilled hole | [mm] | 10 | 12 | 15 | 20 | 25 | 30 | 30 | 35 | 40 |
| Ø Air nozzle | [mm] | 6 | 8 | 12 | 14 | 20 | 24 | 24 | 29 | 29 |
| Ø Brush | [mm] | 11 | 13 | 16 | 22 | 26 | 32 | 32 | 37 | 42 |

**Air nozzle**



**Metal brush and extension**



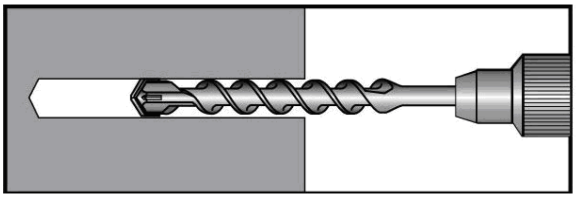
## Table B3: Curing time

| Temperature of base material | Gel time | Curing time | |
|---|---|---|---|
| | | in dry concrete | in wet concrete |
| 5°C to 9°C | 20 min | 30 h | 60 h |
| 10°C to 19°C | 14 min | 23 h | 46 h |
| 20°C to 24°C | 11 min | 16 h | 32 h |
| 25°C to 29°C | 8 min | 12 h | 24 h |
| 30°C to 39°C | 5 min | 8 h | 16 h |
| 40°C | 5 min | 6 h | 12 h |

## Installation instruction

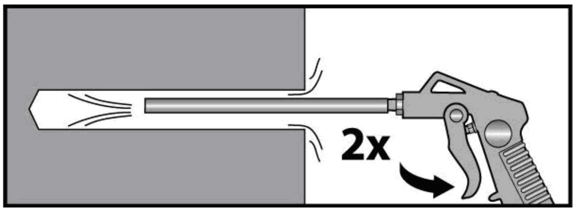
### Bore hole drilling

**1** Drill hole of diameter ($d_0$) and depth ($h_0$) with a hammer drill set in rotation-hammer mode using an appropriately carbide drill bit.

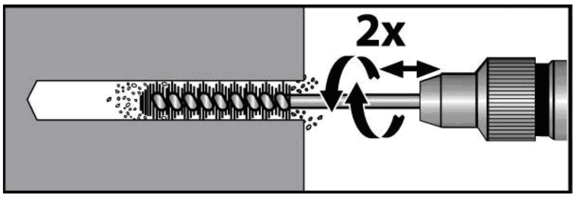


### Bore hole cleaning

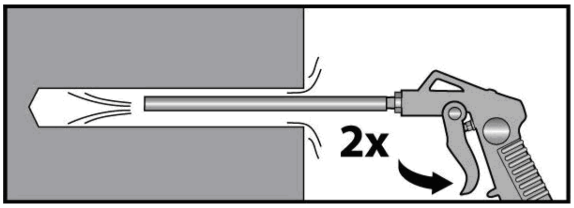
**2** Using compress air cleaning (mini 6 bars), use the appropriate extension and air nozzle, starting from the bottom of the hole blow out at least 2 times and until no dust is evacuated




**3** Using the relevant SPIT brush and extension fitted on a drilling machine (brush dimensions in Tables B2), starting from the top of the hole in rotation, move downward to the bottom of the hole then move upward to the top of the hole. Repeat this operation.

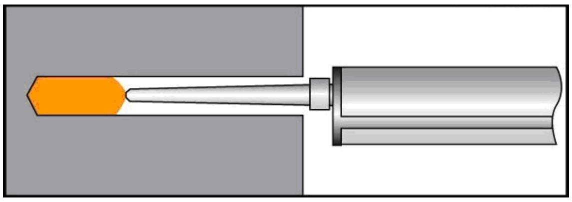



**4** Using compress air cleaning (mini 6 bars), use the appropriate extension and air nozzle, starting from the bottom of the hole blow out at least 2 times and until no dust is evacuated.

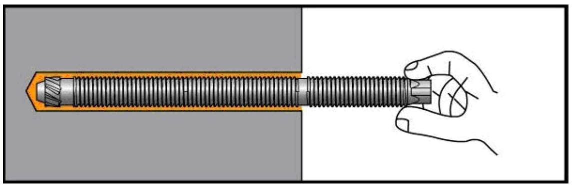



### Injection

**5** Screw the mixing nozzle onto the cartridge and dispense the first part to waste until an even colour is achieved for each new cartridge or mixing nozzle. Use tube extensions for holes deeper than 250 mm. Starting from the bottom of the hole, fill uniformly. In order to avoid air pocket, withdraw slowly the mixing nozzle while injecting the resin. Fill the hole until 1/2 full. For hole deeper than 350mm use piston plug.

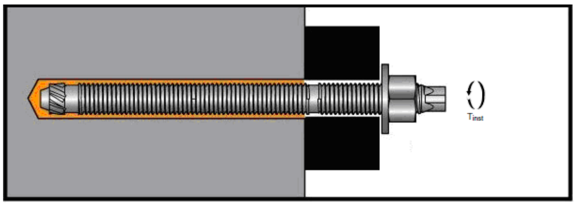


**6** Insert the rod or rebar, slowly and with a slight twisting motion in respect of the gel time indicated in Table B3. Remove excess resin from around the mouth of the hole before it sets. Control the embedment depth.



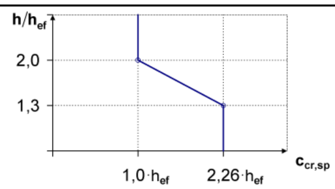
### Setting the element

Do not disturb anchor before specified cure time (acc. to Table B3)
Attach the fixture and tighten the nut at the specified torque (Table B1a)



## Table C1: Characteristic resistances in tension loads in non-cracked concrete Design method A, acc. to TR 029 or CEN/TS 1992-4 , for threaded rods

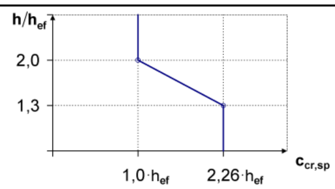
| **Threaded rods** | | | **M8** | **M10** | **M12** | **M16** | **M20** | **M24** | **M30** |
|---|---|---|---|---|---|---|---|---|---|
| **Steel failure** | | | | | | | | | |
| Characteristic resistance "Maxima" rods | $N_{Rk,s}$ | [kN] | 22 | 35 | 51 | 94 | 118 | 170 | 272 |
| Partial safety factor | $\gamma_{Ms,N}$ 1) | [-] | 1,71 | | | | 1,49 | | |
| Characteristic resistance "Grade 5.8" | $N_{Rk,s}$ | [kN] | 18 | 29 | 42 | 79 | 123 | 177 | 281 |
| Partial safety factor | $\gamma_{Ms,N}$ 1) | [-] | 1,5 | | | | | | |
| Characteristic resistance "Grade 8.8" | $N_{Rk,s}$ | [kN] | 29 | 46 | 67 | 126 | 196 | 282 | 449 |
| Partial safety factor | $\gamma_{Ms,N}$ 1) | [-] | 1,5 | | | | | | |
| Characteristic resistance "Grade 10.9" | $N_{Rk,s}$ | [kN] | 37 | 58 | 84 | 157 | 245 | 353 | 561 |
| Partial safety factor | $\gamma_{Ms,N}$ 1) | [-] | 1,4 | | | | | | |
| Characteristic resistance "Stainless steel A4" | $N_{Rk,s}$ | [kN] | 26 | 41 | 59 | 110 | 172 | 247 | 281 |
| Partial safety factor | $\gamma_{Ms,N}$ 1) | [-] | 1,87 | | | | | | 2,86 |
| Characteristic resistance "Stainless steel HCR" | $N_{Rk,s}$ | [kN] | 24 | 38 | 55 | 102 | 159 | 229 | 365 |
| Partial safety factor | $\gamma_{Ms,N}$ 1) | [-] | 2,6 | | | | | | |
| **Combined Pull-out and Concrete cone failure** 2) | | | | | | | | | |
| Characteristic bond resistance in **non-cracked** concrete C20/25 (**used category 1:** dry or wet concrete) | | | | | | | | | |
| Temperature range I 3): **40°C / 24°C** | $\tau_{Rk,uncr}$ | [N/mm²] | 16,0 | 16,0 | 16,0 | 15,0 | 14,0 | 13,0 | 13,0 |
| Temperature range II 3): **80°C / 50°C** | $\tau_{Rk,uncr}$ | [N/mm²] | 9,0 | 9,0 | 9,0 | 8,5 | 8,0 | 7,5 | 7,0 |
| Partial safety factor | $\gamma_{Mp} = \gamma_{Mc} = \gamma_{Msp}$ 1) | [-] | 1,8 4) | | | | | | |
| Characteristic bond resistance in **non-cracked** concrete C20/25 (**used category 2:** flooded bore hole) | | | | | | | | | |
| Temperature range I 3): **40°C / 24°C** | $\tau_{Rk,uncr}$ | [N/mm²] | 14,0 | 14,0 | 14,0 | 13,0 | 13,0 | 12,0 | 11,0 |
| Temperature range II 3): **80°C / 50°C** | $\tau_{Rk,uncr}$ | [N/mm²] | 8,0 | 8,0 | 8,0 | 7,5 | 7,0 | 6,5 | 6,0 |
| Partial safety factor | $\gamma_{Mp} = \gamma_{Mc} = \gamma_{Msp}$ 1) | [-] | 2,1 5) | | | | | | |
| Increasing factor for $\tau_{Rk,p}$ in **non-cracked** concrete | $\psi_c$ | C25/30 | 1,02 | 1,03 | 1,03 | 1,04 | 1,05 | 1,06 | 1,07 |
| | | C30/37 | 1,05 | 1,06 | 1,07 | 1,09 | 1,11 | 1,13 | 1,16 |
| | | C35/40 | 1,08 | 1,10 | 1,11 | 1,14 | 1,17 | 1,21 | 1,26 |
| | | C40/50 | 1,10 | 1,12 | 1,13 | 1,17 | 1,21 | 1,25 | 1,31 |
| | | C45/55 | 1,11 | 1,13 | 1,15 | 1,20 | 1,24 | 1,29 | 1,36 |
| | | C50/60 | 1,12 | 1,15 | 1,17 | 1,22 | 1,27 | 1,32 | 1,41 |
| Factor for non-cracked concrete | $k_{ucr}$ 6) or $k_8$ 7) | [-] | 10,1 | | | | | | |
| **Concrete cone failure** | | | | | | | | | |
| Characteristic edge distance | $c_{cr,N}$ | [mm] | $1,5 \cdot h_{ef}$ | | | | | | |
| Characteristic spacing | $s_{cr,N}$ | [mm] | $3 \cdot h_{ef}$ | | | | | | |
| **Splitting failure** 2) | | | | | | | | | |
| Char. edge distance $c_{cr,sp}$ [mm] for | | $h / h_{ef} \geq 2,0$ | $1,0\ h_{ef}$ | | | | | | |
| | | $2,0 > h / h_{ef} > 1,3$ | $4,6\ h_{ef} - 1,8\ h$ | | | | | | |
| with h. concrete member thickness, $h_{ef}$ effective anchorage depth | | $h / h_{ef} \leq 1,3$ | $2,26\ h_{ef}$ | | | | | | |
| Characteristic spacing | $s_{cr,sp}$ | [mm] | $2\ c_{cr,sp}$ | | | | | | |
| Partial safety factor (dry or wet concrete) | $\gamma_{Msp}$ 1) | [-] | 1,8 4) | | | | | | |
| Partial safety factor (flooded bore hole) | $\gamma_{Msp}$ 1) | [-] | 2,1 5) | | | | | | |




1) In absence of national regulations.
2) For calculation of concrete failure and splitting see Annex B1.
3) Explanation see Annex B1
4) The partial safety factor $\gamma_2 = 1,2$ is included.
5) The partial safety factor $\gamma_2 = 1,4$ is included.
6) Parameter relevant only for design according to CEN/TS 1992-4:2009
7) Parameter relevant only for design according to CEN/TS 1992-4-5:2009, eq. (8)

## Table C2: Characteristic resistances for tension loads in cracked concrete Design method A, acc. to TR 029 or CEN/TS 1992-4, for threaded rods

| Threaded rods | | | M8 | M10 | M12 | M16 | M20 | M24 | M30 |
|---|---|---|---|---|---|---|---|---|---|
| **Steel failure** | | | | | | | | | |
| Characteristic resistance "Maxima" rods | $N_{Rk,s}$ | [kN] | 22 | 35 | 51 | 94 | 118 | 170 | 272 |
| Partial safety factor | $\gamma_{Ms,N}$ [1] | [-] | 1,71 | | | | 1,49 | | |
| Characteristic resistance "Grade 5.8" | $N_{Rk,s}$ | [kN] | 18 | 29 | 42 | 79 | 123 | 177 | 281 |
| Partial safety factor | $\gamma_{Ms,N}$ [1] | [-] | 1,5 | | | | | | |
| Characteristic resistance "Grade 8.8" | $N_{Rk,s}$ | [kN] | 29 | 46 | 67 | 126 | 196 | 282 | 449 |
| Partial safety factor | $\gamma_{Ms,N}$ [1] | [-] | 1,5 | | | | | | |
| Characteristic resistance "Grade 10.9" | $N_{Rk,s}$ | [kN] | 37 | 58 | 84 | 157 | 245 | 353 | 561 |
| Partial safety factor | $\gamma_{Ms,N}$ [1] | [-] | 1,4 | | | | | | |
| Characteristic resistance "Stainless steel A4" | $N_{Rk,s}$ | [kN] | 26 | 41 | 59 | 110 | 172 | 247 | 281 |
| Partial safety factor | $\gamma_{Ms,N}$ [1] | [-] | 1,87 | | | | | | 2,86 |
| Characteristic resistance "Stainless steel HCR" | $N_{Rk,s}$ | [kN] | 24 | 38 | 55 | 102 | 159 | 229 | 365 |
| Partial safety factor | $\gamma_{Ms,N}$ [1] | [-] | 2,6 | | | | | | |
| **Combined Pull-out and Concrete cone failure** [2] | | | | | | | | | |
| Characteristic bond resistance in **cracked** concrete C20/25 (**used category 1:** dry or wet concrete) | | | | | | | | | |
| Temperature range I [3]: **40°C / 24°C** | $\tau_{Rk,cr}$ | [N/mm²] | 9,5 | 9,5 | 9,0 | 8,5 | 8,5 | 8,5 | 7,0 |
| Temperature range II [3]: **80°C / 50°C** | $\tau_{Rk,cr}$ | [N/mm²] | 5,5 | 5,5 | 5,0 | 4,5 | 4,5 | 4,5 | 4,0 |
| Partial safety factor | $\gamma_{Mp} = \gamma_{Mc} = \gamma_{Msp}$ [1] | [-] | 1,8 [4] | | | | | | |
| Characteristic bond resistance in **cracked** concrete C20/25 (**used category 2:** flooded bore hole) | | | | | | | | | |
| Temperature range I [3]: **40°C / 24°C** | $\tau_{Rk,cr}$ | [N/mm²] | 8,5 | 8,5 | 8,0 | 7,5 | 7,5 | 7,5 | 6,0 |
| Temperature range II [3]: **80°C / 50°C** | $\tau_{Rk,cr}$ | [N/mm²] | 4,5 | 4,5 | 4,5 | 4,0 | 4,0 | 4,0 | 3,5 |
| Partial safety factor | $\gamma_{Mp} = \gamma_{Mc} = \gamma_{Msp}$ [1] | [-] | 2,1 [5] | | | | | | |
| Increasing factor for $\tau_{Rk,p}$ in **cracked** concrete | $\psi_c$ | C25/30 | 1,02 | 1,02 | 1,02 | 1,03 | 1,03 | 1,04 | 1,05 |
| | | C30/37 | 1,04 | 1,05 | 1,05 | 1,06 | 1,07 | 1,09 | 1,10 |
| | | C35/40 | 1,06 | 1,07 | 1,08 | 1,10 | 1,11 | 1,13 | 1,16 |
| | | C40/50 | 1,07 | 1,08 | 1,09 | 1,11 | 1,14 | 1,16 | 1,19 |
| | | C45/55 | 1,08 | 1,09 | 1,11 | 1,13 | 1,16 | 1,18 | 1,22 |
| | | C50/60 | 1,09 | 1,10 | 1,12 | 1,15 | 1,17 | 1,20 | 1,25 |
| Factor for **cracked** concrete | $k_{cr}$ [6] or $k_8$ [7] | [-] | 7.2 | | | | | | |
| **Concrete cone failure** | | | | | | | | | |
| Characteristic edge distance | $c_{cr,N}$ | [mm] | $1{,}5 \cdot h_{ef}$ | | | | | | |
| Characteristic spacing | $s_{cr,N}$ | [mm] | $3 \cdot h_{ef}$ | | | | | | |
| **Splitting failure** [2] | | | | | | | | | |
| Char. edge distance $c_{cr,sp}$ [mm] for | | $h / h_{ef} \geq 2{,}0$ | $1{,}0\ h_{ef}$ | | | | | | |
| | | $2{,}0 > h / h_{ef} > 1{,}3$ | $4{,}6\ h_{ef} - 1{,}8\ h$ | | | | | | |
| with h. concrete member thickness, $h_{ef}$ effective anchorage depth | | $h / h_{ef} \leq 1{,}3$ | $2{,}26\ h_{ef}$ | | | | | | |
| Characteristic spacing | $s_{cr,sp}$ | [mm] | $2\ c_{cr,sp}$ | | | | | | |
| Partial safety factor (dry or wet concrete) | $\gamma_{Msp}$ [1] | [-] | 1,8 [4] | | | | | | |
| Partial safety factor (flooded bore hole) | $\gamma_{Msp}$ [1] | [-] | 2,1 [5] | | | | | | |




1) In absence of national regulations.
2) For calculation of concrete failure and splitting see Annex B1.
3) Explanation see Annex B1
4) The partial safety factor $\gamma_2 = 1{,}2$ is included.
5) The partial safety factor $\gamma_2 = 1{,}4$ is included.
6) Parameter relevant only for design according to CEN/TS 1992-4:2009
7) Parameter relevant only for design according to CEN/TS 1992-4-5:2009, eq. (8)

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**Design according to TR 029 or CEN/TS 1992-4**

Characteristic values for tension loads in cracked concrete for threaded rods

**Annex C2**

## Table C3: Characteristic resistances for shear loads in cracked and non-cracked concrete Design method A, acc. to TR 029 or CEN/TS 1992-4, for threaded rods

| Threaded rods | | | M8 | M10 | M12 | M16 | M20 | M24 | M30 |
|---|---|---|---|---|---|---|---|---|---|
| **Steel failure without lever arm** | | | | | | | | | |
| Factor considering ductility [1)] | $k_2$ | [-] | 1,0 | | | | | | |
| Characteristic resistance “Maxima” rods | $V_{Rk,s}$ | [kN] | 11 | 17 | 25 | 47 | 59 | 85 | 136 |
| Factor considering ductility [1)] | $k_2$ | [-] | 0,8 | | | | | | |
| Characteristic resistance “Grade 5.8” | $V_{Rk,s}$ | [kN] | 9 | 15 | 21 | 39 | 61 | 88 | 140 |
| Characteristic resistance “Grade 8.8” | $V_{Rk,s}$ | [kN] | 15 | 23 | 34 | 63 | 98 | 141 | 224 |
| Characteristic resistance “Grade 10.9” | $V_{Rk,s}$ | [kN] | 18 | 29 | 42 | 79 | 123 | 177 | 281 |
| Characteristic resistance “Stainless steel A4” | $V_{Rk,s}$ | [kN] | 13 | 20 | 30 | 55 | 86 | 124 | 140 |
| Characteristic resistance “Stainless steel HCR” | $V_{Rk,s}$ | [kN] | 12 | 19 | 27 | 51 | 80 | 115 | 182 |
| **Steel failure with lever arm** | | | | | | | | | |
| Characteristic resistance “Maxima” rods | $M^0_{Rk,s}$ | [Nm] | 22 | 45 | 79 | 200 | 301 | 520 | 1052 |
| Characteristic resistance “Grade 5.8” | $M^0_{Rk,s}$ | [Nm] | 19 | 37 | 66 | 166 | 325 | 561 | 1125 |
| Characteristic resistance “Grade 8.8” | $M^0_{Rk,s}$ | [Nm] | 30 | 60 | 105 | 266 | 519 | 898 | 1799 |
| Characteristic resistance “Grade 10.9” | $M^0_{Rk,s}$ | [Nm] | 37 | 75 | 131 | 333 | 649 | 1123 | 2249 |
| Characteristic resistance “Stainless steel A4” | $M^0_{Rk,s}$ | [Nm] | 26 | 52 | 92 | 233 | 454 | 786 | 1125 |
| Characteristic resistance “Stainless steel HCR” | $M^0_{Rk,s}$ | [Nm] | 24 | 49 | 85 | 216 | 422 | 730 | 1462 |
| **Partial safety factor** | | | | | | | | | |
| Partial safety factor “Maxima” rods | $\gamma_{Ms,V}$ [2)] | [-] | 1,43 | | | | 1,5 | | |
| Partial safety factor “Grade 5.8” | $\gamma_{Ms,V}$ [2)] | [-] | 1,25 | | | | | | |
| Partial safety factor “Grade 8.8” | $\gamma_{Ms,V}$ [2)] | [-] | 1,25 | | | | | | |
| Partial safety factor “Grade 10.9” | $\gamma_{Ms,V}$ [2)] | [-] | 1,5 | | | | | | |
| Partial safety factor “Stainless steel A4” | $\gamma_{Ms,V}$ [2)] | [-] | 1,56 | | | | | | 2,38 |
| Partial safety factor “Stainless steel HCR” | $\gamma_{Ms,V}$ [2)] | [-] | 2,17 | | | | | | |
| **Concrete pryout failure** | | | | | | | | | |
| k factor | $k$ [3)]<br>$k_3$ [4)] | [-] | 1,0 (for $h_{ef}$ < 60mm) or 2,0 (for $h_{ef}$ ≥ 60mm) | | | | | | |
| Partial safety factor | $\gamma_{Mcp}$ [2)] | [-] | 1,5 [5)] | | | | | | |
| **Concrete edge failure [6)]** | | | | | | | | | |
| Partial safety factor | $\gamma_{Mc}$ [2)] | [-] | 1,5 [5)] | | | | | | |

1) Parameter relevant only for design according to CEN/TS 1992-4-5:2009, 6.3.2.1
2) In absence of national regulations
3) Parameter relevant only for design according to TR 029, eq.(5.7)
4) Parameter relevant only for design according to CEN/TS 1992-4-5:2009, § 6.3.3
5) The partial safety factor $\gamma_2$ = 1,0 is included.
6) Concrete edge failure see chapter 5.2.3.4 of Technical Report TR 029.

## Table C4: Displacements under tension loads [1], for threaded rods

| Threaded rods | | | M8 | M10 | M12 | M16 | M20 | M24 | M30 |
|---|---|---|---|---|---|---|---|---|---|
| **Non-cracked concrete Temperature range I [2] : 40°C / 24°C** | | | | | | | | | |
| Displacement | $\delta_{N0}$ | [mm/(N/mm²)] | 0,02 | 0,02 | 0,03 | 0,04 | 0,06 | 0,07 | 0,09 |
| Displacement | $\delta_{N\infty}$ | [mm/(N/mm²)] | 0,05 | 0,07 | 0,09 | 0,12 | 0,16 | 0,20 | 0,25 |
| **Non-cracked concrete Temperature range II [2] : 80°C / 50°C** | | | | | | | | | |
| Displacement | $\delta_{N0}$ | [mm/(N/mm²)] | 0,02 | 0,02 | 0,03 | 0,04 | 0,06 | 0,07 | 0,09 |
| Displacement | $\delta_{N\infty}$ | [mm/(N/mm²)] | 0,05 | 0,07 | 0,07 | 0,12 | 0,16 | 0,20 | 0,25 |
| **Cracked concrete Temperature range I [2] : 40°C / 24°C** | | | | | | | | | |
| Displacement | $\delta_{N0}$ | [mm/(N/mm²)] | 0,06 | 0,06 | 0,06 | 0,07 | 0,07 | 0,07 | 0,08 |
| Displacement | $\delta_{N\infty}$ | [mm/(N/mm²)] | 0,16 | 0,17 | 0,18 | 0,19 | 0,20 | 0,22 | 0,24 |
| **Cracked concrete Temperature range II [2] : 80°C / 50°C** | | | | | | | | | |
| Displacement | $\delta_{N0}$ | [mm/(N/mm²)] | 0,06 | 0,06 | 0,06 | 0,07 | 0,07 | 0,07 | 0,08 |
| Displacement | $\delta_{N\infty}$ | [mm/(N/mm²)] | 0,16 | 0,17 | 0,18 | 0,19 | 0,20 | 0,22 | 0,24 |

[1] Calculation of displacement under tension load: $\tau_{Sd}$ design value of bond stress.
Displacement under short term loading = $\delta_{N0} \cdot \tau_{Sd} / 1{,}4$
Displacement under long term loading = $\delta_{N\infty} \cdot \tau_{Sd} / 1{,}4$

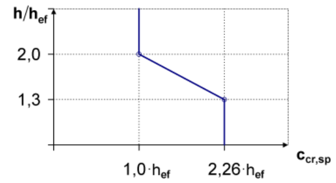
[2] Explanations see Annex B1.

## Table C5: Displacements under shear loads [1], for threaded rods

| Threaded rods | | | M8 | M10 | M12 | M16 | M20 | M24 | M30 |
|---|---|---|---|---|---|---|---|---|---|
| Displacement | $\delta_{V0}$ | [mm/kN] | 0,11 | 0,10 | 0,09 | 0,08 | 0,06 | 0,04 | 0,02 |
| Displacement | $\delta_{V\infty}$ | [mm/kN] | 0,17 | 0,15 | 0,14 | 0,12 | 0,09 | 0,06 | 0,03 |

[1] Calculation of displacement under shear load: $V_{Sd}$ design value of shear load.
Displacement under short term loading = $\delta_{V0} \cdot V_{Sd} / 1{,}4$
Displacement under long term loading = $\delta_{V\infty} \cdot V_{Sd} / 1{,}4$

## Table C6: Characteristic resistances for tension loads in non-cracked concrete Design method A, acc. to TR 029 or CEN/TS 1992-4 , for rebars

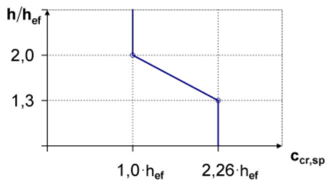
| Rebars Bst 500s | | | ϕ8 | ϕ 10 | ϕ 12 | ϕ 16 | ϕ 20 | ϕ 25 | ϕ 26 | ϕ 28 | ϕ 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Steel failure** | | | | | | | | | | | |
| Characteristic resistance [1)] | $N_{Rk,s}$ | [kN] | 28 | 43 | 62 | 111 | 173 | 270 | 292 | 339 | 442 |
| Partial safety factor [2)] | $\gamma_{Ms,N}$ [3)] | [-] | 1,4 | | | | | | | | |
| **Combined Pull-out and Concrete cone failure** [4)] | | | | | | | | | | | |
| Characteristic bond resistance in **non-cracked** concrete C20/25 (**used category 1:** dry or wet concrete) | | | | | | | | | | | |
| Temperature range I [5)]: **40°C / 24°C** | $\tau_{Rk,uncr}$ | [N/mm²] | 14,0 | 14,0 | 14,0 | 14,0 | 13,0 | 13,0 | 13,0 | 13,0 | 12,0 |
| Temperature range II [5)]: **80°C / 50°C** | $\tau_{Rk,uncr}$ | [N/mm²] | 8,0 | 8,0 | 7,5 | 7,5 | 7,5 | 7,5 | 7,0 | 7,0 | 7,0 |
| Partial safety factor | $\gamma_{Mp} = \gamma_{Mc} = \gamma_{Msp}$ [3)] | [-] | 1,8 [6)] | | | | | | | | |
| Characteristic bond resistance in **non-cracked** concrete C20/25 (**used category 2:** flooded bore hole) | | | | | | | | | | | |
| Temperature range I [5)]: **40°C / 24°C** | $\tau_{Rk,uncr}$ | [N/mm²] | 13,0 | 13,0 | 12,0 | 12,0 | 12,0 | 12,0 | 12,0 | 11,0 | 11,0 |
| Temperature range II [5)]: **80°C / 50°C** | $\tau_{Rk,uncr}$ | [N/mm²] | 7,0 | 7,0 | 7,0 | 7,0 | 6,5 | 6,5 | 6,5 | 6,5 | 6,0 |
| Partial safety factor | $\gamma_{Mp} = \gamma_{Mc} = \gamma_{Msp}$ [3)] | [-] | 2,1 [7)] | | | | | | | | |
| Increasing factor for $\tau_{Rk,p}$ in **non-cracked** concrete | $\psi_c$ | C25/30 | 1,02 | 1,03 | 1,03 | 1,04 | 1,05 | 1,06 | 1,06 | 1,07 | 1,08 |
| | | C30/37 | 1,05 | 1,06 | 1,07 | 1,09 | 1,11 | 1,14 | 1,14 | 1,15 | 1,18 |
| | | C35/40 | 1,08 | 1,10 | 1,11 | 1,14 | 1,17 | 1,22 | 1,22 | 1,24 | 1,27 |
| | | C40/50 | 1,10 | 1,12 | 1,13 | 1,17 | 1,21 | 1,26 | 1,27 | 1,29 | 1,33 |
| | | C45/55 | 1,11 | 1,13 | 1,15 | 1,20 | 1,24 | 1,30 | 1,31 | 1,33 | 1,38 |
| | | C50/60 | 1,12 | 1,15 | 1,17 | 1,22 | 1,27 | 1,34 | 1,35 | 1,38 | 1,44 |
| Factor for **non-cracked** concrete | $k_{ucr}$ [8)] or $k_8$ [9)] | [-] | 10,1 | | | | | | | | |
| **Concrete cone failure** | | | | | | | | | | | |
| Characteristic edge distance | $c_{cr,N}$ | [mm] | $1{,}5 \cdot h_{ef}$ | | | | | | | | |
| Characteristic spacing | $s_{cr,N}$ | [mm] | $3 \cdot h_{ef}$ | | | | | | | | |
| **Splitting failure** [4)] | | | | | | | | | | | |
| Char. edge distance $c_{cr,sp}$ [mm] for | | $h / h_{ef} \geq 2{,}0$ | $1{,}0\ h_{ef}$ |  | | | | | | | |
| | | $2{,}0 > h / h_{ef} > 1{,}3$ | $4{,}6\ h_{ef} - 1{,}8\ h$ | | | | | | | | |
| with h. concrete member thickness, $h^{ef}$ effective anchorage depth | | $h / h_{ef} \leq 1{,}3$ | $2{,}26\ h_{ef}$ | | | | | | | | |
| Characteristic spacing | $s_{cr,sp}$ | [mm] | $2\ c_{cr,sp}$ | | | | | | | | |
| Partial safety factor (dry or wet concrete) | $\gamma_{Msp}$ [3)] | [-] | 1,8 [6)] | | | | | | | | |
| Partial safety factor (flooded bore hole) | $\gamma_{Msp}$ [3)] | [-] | 2,1 [7)] | | | | | | | | |



1) The characteristic tension resistance $N_{Rk,s}$ for rebars that do not fulfil the requirements acc. DIN 488 shall be calculated acc. Technical Report TR029, Equation (5.1).
2) The partial safety factor $\gamma_{Ms,N}$ for rebars that do not fulfil the requirements acc. DIN 488 shall be calculated acc. TR029, Eq. (3.3a).
3) In absence of national regulations.
4) For calculation of concrete failure and splitting see Annex B1.
5) Explanations see Annex B1.
6) The partial safety factor $\gamma_2 = 1{,}2$ is included.
7) The partial safety factor $\gamma_2 = 1{,}4$ is included.
8) Parameter relevant only for design according to CEN/TS 1992-4:2009.
9) Parameter relevant only for design according to CEN/TS 1992-4-5:2009, Eq. (8).

## Table C7: Characteristic resistances for tension loads in cracked concrete Design method A, acc. to TR 029 or CEN/TS 1992-4, for rebars

| Rebars Bst 500s | | | | φ8 | φ 10 | φ 12 | φ 16 | φ 20 | φ 25 | φ 26 | φ 28 | φ 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Steel failure** | | | | | | | | | | | | |
| Characteristic resistance [1] | $N_{Rk,s}$ | [kN] | | 28 | 43 | 62 | 111 | 173 | 270 | 292 | 339 | 442 |
| Partial safety factor [2] | $\gamma_{Ms,N}$ [3] | [-] | | 1,4 | | | | | | | | |
| **Combined Pull-out and Concrete cone failure** [4] | | | | | | | | | | | | |
| Characteristic bond resistance in **cracked** concrete C20/25 (**used category 1:** dry or wet concrete) | | | | | | | | | | | | |
| Temperature range I [5]: **40°C / 24°C** | $\tau_{Rk,cr}$ | [N/mm²] | | 9,5 | 9,5 | 9,0 | 8,5 | 8,5 | 8,0 | 8,0 | 7,5 | 6,5 |
| Temperature range II [5]: **80°C / 50°C** | $\tau_{Rk,cr}$ | [N/mm²] | | 5,5 | 5,5 | 5,0 | 4,5 | 4,5 | 4,5 | 4,5 | 4,0 | 3,5 |
| Partial safety factor | $\gamma_{Mp} = \gamma_{Mc} = \gamma_{Msp}$ [3] | [-] | | 1,8 [6] | | | | | | | | |
| Characteristic bond resistance in **cracked** concrete C20/25 (**used category 2:** flooded bore hole) | | | | | | | | | | | | |
| Temperature range I [5]: **40°C / 24°C** | $\tau_{Rk,cr}$ | [N/mm²] | | 8,5 | 8,5 | 8,0 | 7,5 | 7,5 | 7,5 | 7,0 | 6,5 | 6,0 |
| Temperature range II [5]: **80°C / 50°C** | $\tau_{Rk,cr}$ | [N/mm²] | | 4,5 | 4,5 | 4,5 | 4,0 | 4,0 | 4,0 | 4,0 | 3,5 | 3,0 |
| Partial safety factor | $\gamma_{Mp} = \gamma_{Mc} = \gamma_{Msp}$ [3] | [-] | | 2,1 [7] | | | | | | | | |
| Increasing factor for $\tau_{Rk,p}$ in **cracked** concrete | $\psi_c$ | | C25/30 | 1,02 | 1,02 | 1,02 | 1,03 | 1,03 | 1,04 | 1,04 | 1,04 | 1,05 |
| | | | C30/37 | 1,04 | 1,05 | 1,05 | 1,06 | 1,07 | 1,09 | 1,09 | 1,10 | 1,11 |
| | | | C35/40 | 1,06 | 1,07 | 1,08 | 1,10 | 1,11 | 1,14 | 1,14 | 1,15 | 1,17 |
| | | | C40/50 | 1,07 | 1,08 | 1,09 | 1,11 | 1,14 | 1,16 | 1,17 | 1,18 | 1,20 |
| | | | C45/55 | 1,08 | 1,09 | 1,11 | 1,13 | 1,16 | 1,19 | 1,19 | 1,21 | 1,23 |
| | | | C50/60 | 1,09 | 1,10 | 1,12 | 1,15 | 1,17 | 1,21 | 1,22 | 1,23 | 1,26 |
| Factor for **cracked** concrete | $k_{ucr}$ [8] or $k_8$ [9] | [-] | | 7,2 | | | | | | | | |
| **Concrete cone failure** | | | | | | | | | | | | |
| Characteristic edge distance | $c_{cr,N}$ | [mm] | | $1{,}5 \cdot h_{ef}$ | | | | | | | | |
| Characteristic spacing | $s_{cr,N}$ | [mm] | | $3 \cdot h_{ef}$ | | | | | | | | |
| **Splitting failure** [4] | | | | | | | | | | | | |
| Char. edge distance $c_{cr,sp}$ [mm] for | | | $h / h_{ef} \geq 2{,}0$ | $1{,}0\ h_{ef}$ | | | | | | | | |
| | | | $2{,}0 > h / h_{ef} > 1{,}3$ | $4{,}6\ h_{ef} - 1{,}8\ h$ | | | | | | | | |
| with h. concrete member thickness, $h^{ef}$ effective anchorage depth | | | $h / h_{ef} \leq 1{,}3$ | $2{,}26\ h_{ef}$ | | | | | | | | |
| Characteristic spacing | $s_{cr,sp}$ | [mm] | | $2\ c_{cr,sp}$ | | | | | | | | |
| Partial safety factor (dry or wet concrete) | $\gamma_{Msp}$ [3] | [-] | | 1,8 [6] | | | | | | | | |
| Partial safety factor (flooded bore hole) | $\gamma_{Msp}$ [3] | [-] | | 2,1 [7] | | | | | | | | |




[1] The characteristic tension resistance $N_{Rk,s}$ for rebars that do not fulfil the requirements acc. DIN 488 shall be calculated acc. Technical Report TR029, Equation (5.1).

[2] The partial safety factor $\gamma_{Ms,N}$ for rebars that do not fulfil the requirements acc. DIN 488 shall be calculated acc. TR029, Eq. (3.3a).

[3] In absence of national regulations.

[4] For calculation of concrete failure and splitting see Annex B1.

[5] Explanations see Annex B1.

[6] The partial safety factor $\gamma_2 = 1{,}2$ is included.

[7] The partial safety factor $\gamma_2 = 1{,}4$ is included.

[8] Parameter relevant only for design according to CEN/TS 1992-4:2009.

[9] Parameter relevant only for design according to CEN/TS 1992-4-5:2009, Eq. (8).

## Table C8: Characteristic resistances for shear loads in cracked and non-cracked concrete Design method A, acc. to TR 029 or CEN/TS 1992-4, for rebars

| Rebars Bst 500s | | | ϕ8 | ϕ 10 | ϕ 12 | ϕ 16 | ϕ 20 | ϕ 25 | ϕ 26 | ϕ 28 | ϕ 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Steel failure without lever arm** | | | | | | | | | | | |
| Factor considering ductility [1] | $k_2$ | [-] | 0,8 | | | | | | | | |
| Characteristic resistance [2] | $V_{Rk,s}$ | [kN] | 14 | 22 | 31 | 55 | 86 | 135 | 146 | 169 | 221 |
| **Steel failure with lever arm** | | | | | | | | | | | |
| Characteristic resistance [3] | $M^0_{Rk,s}$ | [Nm] | 33 | 65 | 112 | 265 | 518 | 1012 | 1139 | 1422 | 2123 |
| **Partial safety factor** | | | | | | | | | | | |
| Partial safety factor [4] | $\gamma_{Ms,V}$ [5] | [-] | 1,5 | | | | | | | | |
| **Concrete pryout failure** | | | | | | | | | | | |
| k factor | $k$ [6]<br>$k_3$ [7] | [-] | 1,0 (for $h_{ef}$ < 60mm) or 2,0 (for $h_{ef} \geq$ 60mm) | | | | | | | | |
| Partial safety factor | $\gamma_{Mcp}$ [5] | [-] | 1,5 [8] | | | | | | | | |
| **Concrete edge failure [9]** | | | | | | | | | | | |
| Partial safety factor | $\gamma_{Mc}$ [5] | [-] | 1,5 [8] | | | | | | | | |

1) Parameter relevant only for design according to CEN/TS 1992-4-5:2009, 6.3.2.1
2) The characteristic tension resistance $V_{Rk,s}$ for rebars that do not fulfil the requirements acc. DIN 488 shall be calculated acc. TR 029, Eq. (5.6).
3) The characteristic bending resistance $M^0_{Rk,s}$ for rebars that do not fulfil the requirements acc. DIN 488 shall be calculated acc. TR 029, Eq. (5.6b).
4) The partial safety factor $\gamma_{Ms,V}$ for rebars that do not fulfil the requirements acc. DIN 488 shall be calculated acc. TR029, Eq. (3.3b) or (3.3c).
5) In absence of national regulations
6) Parameter relevant only for design according to TR 029, eq.(5.7)
7) Parameter relevant only for design according to CEN/TS 1992-4-5:2009, § 6.3.3
8) The partial safety factor $\gamma_2$ = 1,0 is included.
9) Concrete edge failure, see chapter 5.2.3.4 of TR 029.

## Table C9: Displacements under tension loads [1)], for rebars

| Rebars Bst 500s | | | $\phi$8 | $\phi$ 10 | $\phi$ 12 | $\phi$ 16 | $\phi$ 20 | $\phi$ 25 | $\phi$ 26 | $\phi$ 28 | $\phi$ 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Non-cracked concrete, Temperature range I [2)] : 40°C / 24°C** | | | | | | | | | | | |
| Displacement | $\delta_{N0}$ | [mm/(N/mm²)] | 0,02 | 0,02 | 0,03 | 0,04 | 0,06 | 0,07 | 0,07 | 0,08 | 0,09 |
| Displacement | $\delta_{N\infty}$ | [mm/(N/mm²)] | 0,05 | 0,07 | 0,00 | 0,12 | 0,16 | 0,20 | 0,21 | 0,23 | 0,27 |
| **Non-cracked concrete, Temperature range II [2)] : 80°C / 50°C** | | | | | | | | | | | |
| Displacement | $\delta_{N0}$ | [mm/(N/mm²)] | 0,02 | 0,02 | 0,03 | 0,04 | 0,06 | 0,07 | 0,07 | 0,08 | 0,09 |
| Displacement | $\delta_{N\infty}$ | [mm/(N/mm²)] | 0,05 | 0,07 | 0,00 | 0,12 | 0,16 | 0,20 | 0,21 | 0,23 | 0,27 |
| **Cracked concrete, Temperature range I [2)] : 40°C / 24°C** | | | | | | | | | | | |
| Displacement | $\delta_{N0}$ | [mm/(N/mm²)] | 0,06 | 0,06 | 0,06 | 0,07 | 0,07 | 0,08 | 0,08 | 0,08 | 0,08 |
| Displacement | $\delta_{N\infty}$ | [mm/(N/mm²)] | 0,16 | 0,17 | 0,18 | 0,19 | 0,20 | 0,22 | 0,22 | 0,23 | 0,24 |
| **Cracked concrete, Temperature range II [2)] : 80°C / 50°C** | | | | | | | | | | | |
| Displacement | $\delta_{N0}$ | [mm/(N/mm²)] | 0,06 | 0,06 | 0,06 | 0,07 | 0,07 | 0,08 | 0,08 | 0,08 | 0,08 |
| Displacement | $\delta_{N\infty}$ | [mm/(N/mm²)] | 0,16 | 0,17 | 0,18 | 0,19 | 0,20 | 0,22 | 0,22 | 0,23 | 0,24 |

1) Calculation of displacement under tension load: $\tau_{Sd}$ design value of bond stress.
Displacement under short term loading = $\delta_{N0} \cdot \tau_{Sd} / 1,4$
Displacement under long term loading = $\delta_{N\infty} \cdot \tau_{Sd} / 1,4$

2) Explanations, see Annex B1.

## Table C10: Displacements under shear loads [1)], for rebars

| Rebars Bst 500s | | | $\phi$8 | $\phi$ 10 | $\phi$ 12 | $\phi$ 16 | $\phi$ 20 | $\phi$ 25 | $\phi$ 26 | $\phi$ 28 | $\phi$ 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Displacement | $\delta_{V0}$ | [mm/kN] | 0,11 | 0,10 | 0,09 | 0,08 | 0,06 | 0,04 | 0,03 | 0,03 | 0,03 |
| Displacement | $\delta_{V\infty}$ | [mm/kN] | 0,17 | 0,15 | 0,14 | 0,12 | 0,09 | 0,06 | 0,05 | 0,04 | 0,04 |

1) Calculation of displacement under shear load: $V_{Sd}$ design value of shear load.
Displacement under short term loading = $\delta_{V0} \cdot V_{Sd} / 1,4$
Displacement under long term loading = $\delta_{v\infty} \cdot V_{Sd} / 1,4$

The seismic performance of anchors subjected to seismic loading is categorized by performance categories C1 and C2. Seismic performance category C1 provides anchor capacities only in terms of resistances at ultimate limit state, while seismic performance category C2 provides anchor capacities in terms of both resistances at ultimate limit state and displacements at damage limitation state and ultimate limit state.

Table C11 relates the seismic performance categories C1 and C2 to the seismicity level and building importance class. The level of seismicity is defined as a function of the product $a_g \cdot S$, where $a_g$ is the design ground acceleration on Type A ground and $S$ the soil factor both in accordance with EN 1998-1.

The value of $a_g$ or that of the product $a_g \cdot S$ used in a Member State to define thresholds for the seismicity classes may be found in its National Annex of EN 1998-1 and may be different to the values given in Table C11. Furthermore, the assignment of the seismic performance categories C1 and C2 to the seismicity level and building importance classes is in the responsibility of each individual Member State.

**Table C11: Recommended seismic performance categories for metal anchors**

| **Seismicity level** [a] | | **Importance Class acc. to EN 1998-1:2004, 4.2.5** | | | |
|---|---|---|---|---|---|
| Class | $a_g \cdot S$ [c] | **I** | **II** | **III** | **IV** |
| Very low [b] | $a_g \cdot S \leq 0{,}05\ g$ | No additional requirement | | | |
| Low [b] | $0{,}05\ g < a_g \cdot S \leq 0{,}10\ g$ | C1 | C1 [d] or C2 [e] | | C2 |
| > low | $a_g \cdot S > 0{,}10\ g$ | C1 | C2 | | |

a The values defining the seismicity levels are may be found in the National Annex of EN 1988-1.

b Definition according to EN 1998-1:2004, 3.2.1.

c $a_g$ = design ground acceleration on Type A ground (EN 1998-1:2004, 3.2.1),
$S$ = soil factor (see e.g. EN 1998-1:2004, 3.2.2).

d C1 for Type 'B' connections (see TR045 §5.1) for fixings of non-structural elements to structures

e C2 for Type 'A' connections (see TR045 § 5.1) for fixings structural elements to structures

**Table C12: Reduction factor $\alpha_{seis}$**

| Loading | Failure mode | $\alpha_{seis}$- Single anchor [1)] | $\alpha_{seis}$- Anchor Group |
|---|---|---|---|
| Tension | Steel failure | 1,0 | 1,0 |
| | Pull-out failure | 1,0 | 0,85 |
| | Concrete cone failure | 0,85 | 0,75 |
| | Splitting failure | 1,0 | 0,85 |
| Shear | Steel failure | 1,0 | 0,85 |
| | Concrete edge failure | 1,0 | 0,85 |
| | Concrete pry-out failure | 0,85 | 0,75 |

[1)] In case of tension loading single anchor also addresses situations where only ONE anchor in a group of anchors is subjected to tension.

The seismic design shall be carried out according to TR045 Technical Report "Design of metal anchors for use in concrete under seismic actions". The characteristic seismic resistance $R_{k,seis}$ ($N_{Rk,seis}$, $V_{Rk,seis}$) of a fastening shall be calculated for each failure mode as follows :

$$R_{k,seis} = \alpha_{gap} \cdot \alpha_{seis} \cdot R^0_{k,seis}$$

where

$\alpha_{gap}$ Reduction factor to take into account inertia effects due to an annular gap between anchor and fixture in case of shear loading;
= 1.0 in case of no hole clearance between anchor and fixture;
= 0.5 in case of connections with standard hole clearance acc. TR 029 Table 4.1.

$\alpha_{seis}$ Reduction factor to take into account the influence of large cracks and scatter of load/displacement curves, see Table C12;

$R^0_{k,seis}$ Basic characteristic seismic resistance for a given failure mode :

For steel and pull-out failure under tension load and steel failure under shear load, $R^0_{k,seis}$ (i.e. $N_{Rk,s,seis}$, $N_{Rk,p,seis}$, $V_{Rk,s,seis}$) shall be taken from :
- Annex C11 for performance category C1

For all other failure modes $R^0_{k,seis}$ shall be determined as for the design situation for static and quasi-static loading according to ETAG 001, Annex C (i.e. $N_{Rk,c}$, $N_{Rk,sp}$, $V_{Rk,c}$, $V_{Rk,cp}$).

**Table C13: Characteristic resistances in case of seismic performance category C1 acc. TR045 "Design of Metal anchor under Seismic Actions"**

| Threaded rods | | | M8 | M10 | M12 | M16 | M20 | M24 | M30 |
|---|---|---|---|---|---|---|---|---|---|
| **Tension loads** | | | | | | | | | |
| **Steel failure** | | | | | | | | | |
| **Seismic reduction factor** | $\alpha_{N,seis}$ | [-] | - | **1,0** | | | - | - | - |
| Characteristic resistance "Maxima" rods | $N_{Rk,s,seis}$ | [kN] | | 35 | 51 | 94 | - | - | - |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 1,71 | | | | 1,49 | | |
| Characteristic resistance "Grade 5.8" | $N_{Rk,s,seis}$ | [kN] | - | 29 | 42 | 79 | - | - | - |
| Characteristic resistance "Grade 8.8" | $N_{Rk,s,seis}$ | [kN] | - | 46 | 67 | 126 | - | - | - |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 1,50 | | | | | | |
| Characteristic resistance "Grade 10.9" | $N_{Rk,s,seis}$ | [kN] | n.a. | | | | | | |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 1,4 | | | | | | |
| Characteristic resistance "Stainless steel A4" | $N_{Rk,s,seis}$ | [kN] | - | 41 | 59 | 110 | - | - | - |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 1,87 | | | | | | 2,86 |
| Characteristic resistance "Stainless steel HCR" | $N_{Rk,s,seis}$ | [kN] | - | 38 | 55 | 102 | - | - | - |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 2,6 | | | | | | |
| **Combined pullout and concrete cone failure** | | | | | | | | | |
| **Seismic reduction factor** | $\alpha_{N,seis}$ | [-] | - | **0,65** | **0,63** | **0,80** | - | - | - |
| Characteristic bond resistance in cracked concrete C20/25 (**used category 1:** dry or wet concrete) | | | | | | | | | |
| Temperature range I 2): **40°C / 24°C** | $\tau_{Rk,p,seis}$ | [N/mm²] | - | 6,2 | 5,7 | 6,8 | - | - | - |
| Temperature range II 2): **80°C / 50°C** | $\tau_{Rk,p,seis}$ | [N/mm²] | - | 3,6 | 3,2 | 3,6 | - | - | - |
| Partial safety factor | $\gamma_{Mp,seis}$ 1) | [-] | 1,8 3) | | | | | | |
| Characteristic bond resistance in cracked concrete C20/25 (**used category 2:** flooded bore hole) | | | | | | | | | |
| Temperature range I 2): **40°C / 24°C** | $\tau_{Rk,p,seis}$ | [N/mm²] | - | 5,5 | 5,1 | 6,0 | - | - | - |
| Temperature range II 2): **80°C / 50°C** | $\tau_{Rk,p,seis}$ | [N/mm²] | - | 2,9 | 2,9 | 3,2 | - | - | - |
| Partial safety factor | $\gamma_{Mp,seis}$ 1) | [-] | 2,1 4) | | | | | | |
| **Shear loads** | | | | | | | | | |
| **Steel failure without lever arm** | | | | | | | | | |
| **Seismic reduction factor** | $\alpha_{V,seis}$ | [-] | - | **0,70** *) | | | - | - | - |
| Characteristic resistance "Maxima" rods | $V_{Rk,s,seis}$ | [kN] | - | 11,.9 | 17,5 | 32,9 | - | - | - |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 1,43 | | | | 1,5 | | |
| Characteristic resistance "Grade 5.8" | $V_{Rk,s,seis}$ | [kN] | - | 10,.5 | 14,7 | 27,3 | - | - | - |
| Characteristic resistance "Grade 8.8" | $V_{Rk,s,seis}$ | [kN] | - | 16,1 | 23,8 | 44,1 | - | - | - |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 1,25 | | | | | | |
| Characteristic resistance "Grade 10.9" | $V_{Rk,s,seis}$ | [kN] | n.a. | | | | | | |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 1,5 | | | | | | |
| Characteristic resistance "Stainless steel A4" | $V_{Rk,s,seis}$ | [kN] | - | 14 | 21 | 38,5 | - | - | - |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 1,56 | | | | | | 2,38 |
| Characteristic resistance "Stainless steel HCR" | $V_{Rk,s,seis}$ | [kN] | - | 13,3 | 18,9 | 35,7 | - | - | - |
| Partial safety factor | $\gamma_{Ms,seis}$ 1) | [-] | 2,17 | | | | | | |

1) In absence of other national regulations.
2) Explanation see Annex B1.
3) The partial safety factor $\gamma_2$ = 1,2 is included.
4) The partial safety factor $\gamma_2$ = 1,4 is included.

*) Tests and assessment yield $\alpha_{V,seis}$ = [0,71 / 0,80 / 0, 7]. However, from Oct. 2014 (doc. 805), EOTA Expert Group for anchors does not allow $\alpha_{V,seis}$ > 0,7 for anchors using commercial standard rods.

The definition of seismic performance category C1 is given in Annex C9.