

# European technical assessment

MKT Injection system VMU Plus for concrete

valid for

**Injection anchor XV Plus**

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Approval body for construction products  
and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and  
Laender Governments



## European Technical Assessment

**ETA-11/0415**  
**of 13 November 2015**

English translation prepared by DIBt - Original version in German language

### General Part

Technical Assessment Body issuing the  
European Technical Assessment:

Deutsches Institut für Bautechnik

Trade name of the construction product

Injection System VMU plus for concrete

Product family  
to which the construction product belongs

Bonded Anchor for use in concrete

Manufacturer

MKT  
Metall-Kunststoff-Technik GmbH & Co. KG  
Auf dem Immel 2  
67685 Weilerbach  
DEUTSCHLAND

Manufacturing plant

MKT  
Metall-Kunststoff-Technik GmbH & Co. KG  
Auf dem Immel 2  
67685 Weilerbach  
DEUTSCHLAND

This European Technical Assessment  
contains

24 pages including 3 annexes which form an integral part  
of this assessment

This European Technical Assessment is  
issued in accordance with Regulation (EU)  
No 305/2011, on the basis of

Guideline for European technical approval of "Metal  
anchors for use in concrete", ETAG 001 Part 5: "Bonded  
anchors", April 2013,  
used as European Assessment Document (EAD)  
according to Article 66 Paragraph 3 of Regulation (EU)  
No 305/2011.

**European Technical Assessment**

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English translation prepared by DIBt

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## Specific Part

### 1 Technical description of the product

The "Injection system VMU plus for concrete" is a bonded anchor consisting of a cartridge with injection mortar VMU plus or VMU plus Polar and a steel element. The steel element consist of a commercial threaded rod with washer and hexagon nut in the range of M8 to M30 or a reinforcing bar in the range of diameter 8 to 32 mm.

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

The product description is given in Annex A.

### 2 Specification of the intended use in accordance with the applicable European Assessment Document

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

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the anchor of at least 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 and references to the methods used for its assessment

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

Essential characteristic	Performance
Characteristic resistance tension and shear loads	See Annex C 1 to C 8
Displacements under tension and shear loads	See Annex C 9 / C 10

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

Essential characteristic	Performance
Reaction to fire	Anchorage satisfy requirements for Class A1
Resistance to fire	No performance assessed

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

Regarding dangerous substances there may be requirements (e.g. transposed European legislation and national laws, regulations and administrative provisions) applicable to the products falling within the scope of this European Technical Assessment. In order to meet the provisions of Regulation (EU) No 305/2011, these requirements need also to be complied with, when and where they apply..

#### 3.4 Safety in use (BWR 4)

The essential characteristics regarding Safety in use are included under the Basic Works Requirement Mechanical resistance and stability.



**4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base**

In accordance with guideline for European technical approval ETAG 001, April 2013 used as European Assessment Document (EAD) according to Article 66 Paragraph 3 of Regulation (EU) No 305/2011 the applicable European legal act is: [96/582/EC].

The system to be applied is: 1

**5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD**

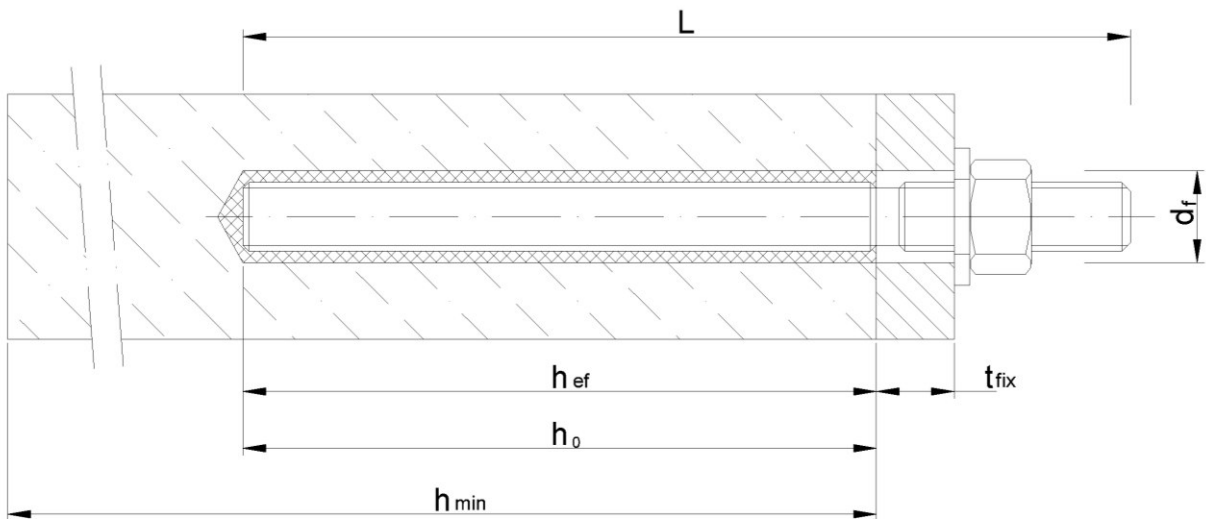
Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 13 November 2015 by Deutsches Institut für Bautechnik

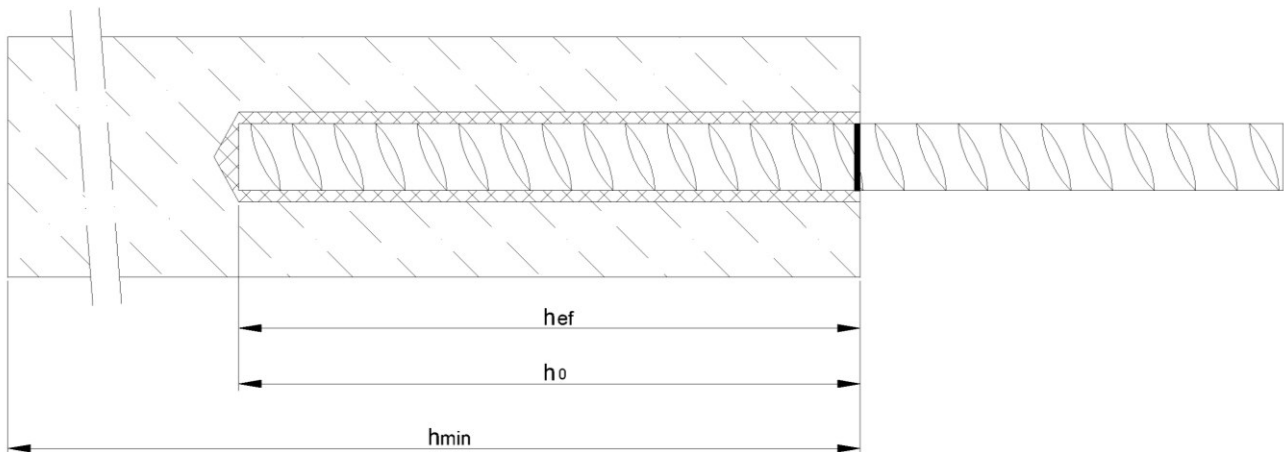
Uwe Bender  
Head of Department

*beglaubigt:*  
G. Lange

Installation situation threaded rod



Installation situation reinforcing bar



- $d_f$  = diameter of clearance hole in the fixture  
 $t_{fix}$  = thickness of fixture  
 $h_{ef}$  = effective anchorage depth  
 $h_0$  = depth of drill hole  
 $h_{min}$  = minimum thickness of member

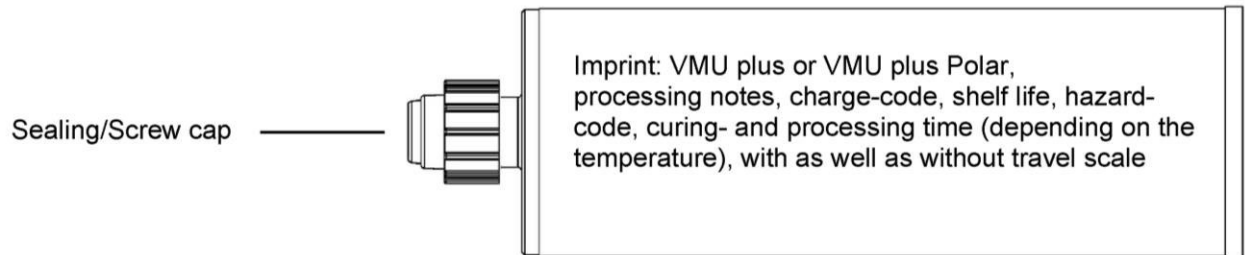
Injection sytem VMU plus for concrete

Product description  
Installation situation

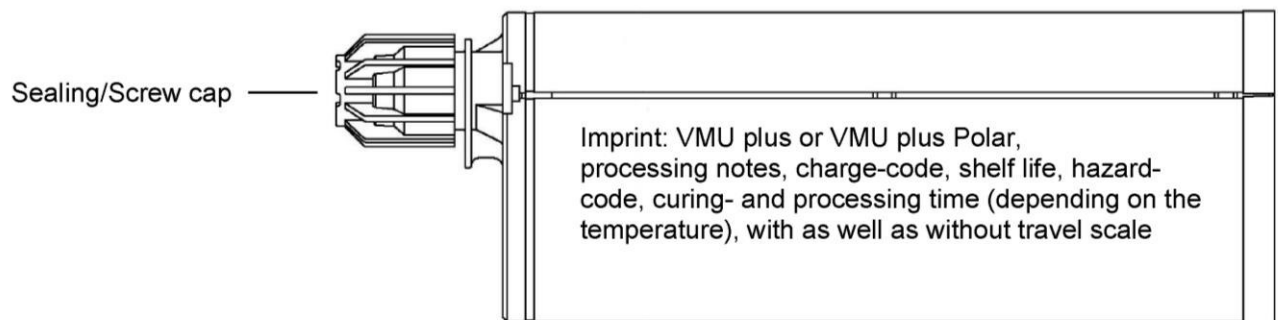
Annex A1

## Cartridge VMU plus or VMU plus Polar

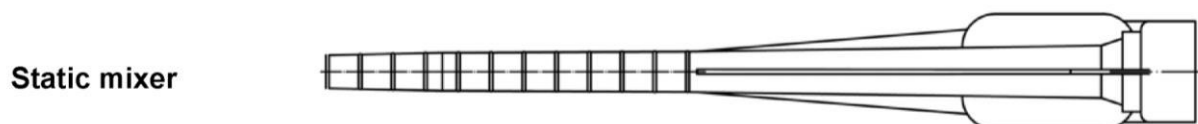
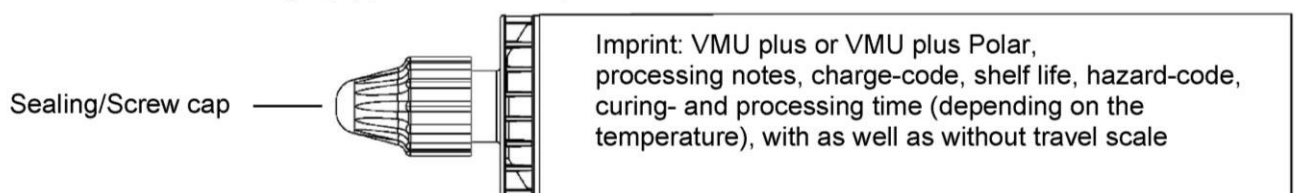
150 ml, 280 ml, 300 ml up to 333 ml and 380 ml up to 420 ml cartridge (Type: coaxial)



235 ml, 345 ml up to 360 ml and 825 ml cartridge (Type: "side-by-side")



165 ml and 300 ml cartridge (Type: "foil tube")

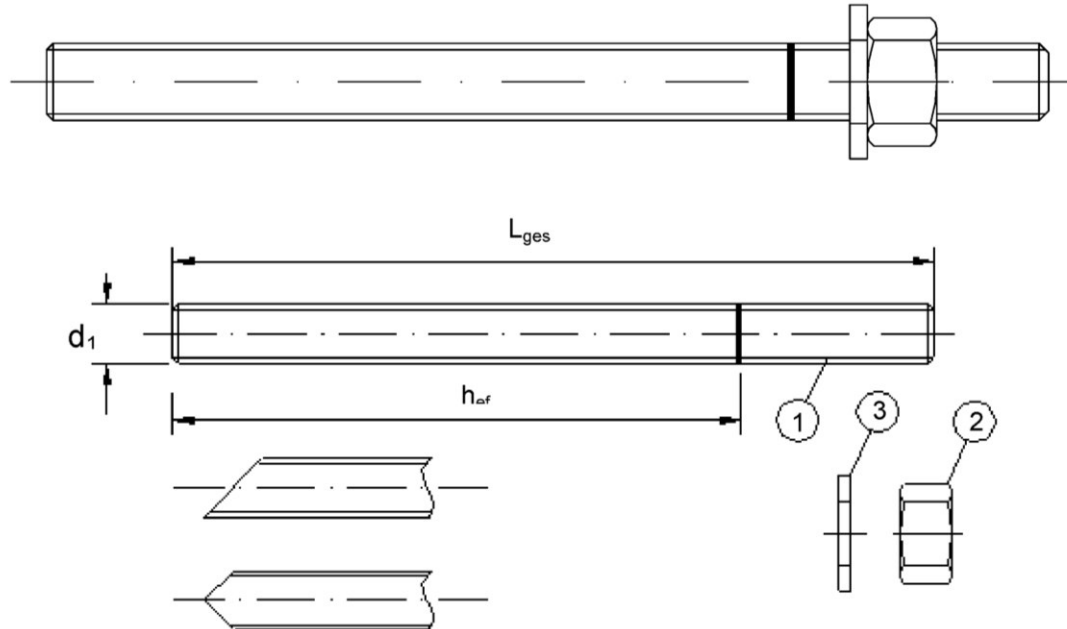


Injection sytem VMU plus for concrete

Product description  
Injection system

Annex A2

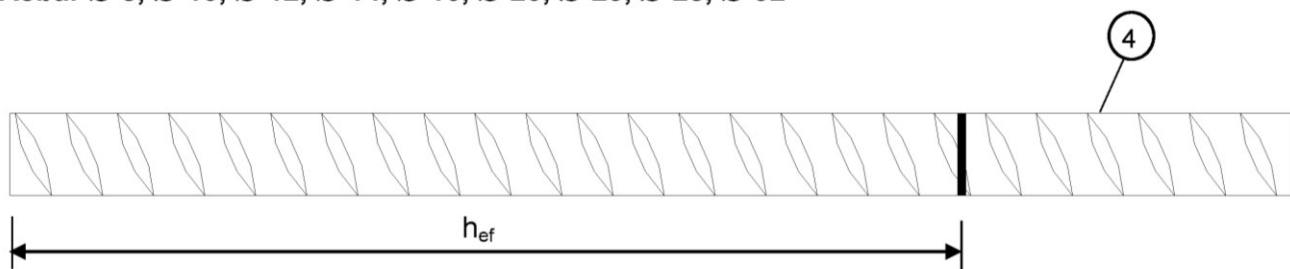
### Threaded rod M8, M10, M12, M16, M20, M24, M27, M30 with washer and hexagon nut



Commercial standard threaded rod with:

- Materials, dimensions and mechanical properties acc. Table A1
- Inspection certificate 3.1 acc. to EN 10204:2004
- Marking of embedment depth

### Rebar $\varnothing 8$ , $\varnothing 10$ , $\varnothing 12$ , $\varnothing 14$ , $\varnothing 16$ , $\varnothing 20$ , $\varnothing 25$ , $\varnothing 28$ , $\varnothing 32$



- Minimum value of related rip area  $f_{R,min}$  according to EN 1992-1-1:2004+AC:2010
- Rib height of the bar shall be in the range  $0,05d \leq h \leq 0,07d$   
(d: Nominal diameter of the bar; h: Rib height of the bar)

### Injection sytem VMU plus for concrete

**Product description**  
Treaded rod and rebar

**Annex A3**

**Table A1: Materials**

Part	Designation	Material
<b>Steel, zinc plated <math>\geq 5 \mu\text{m}</math> acc. to EN ISO 4042:1999 or Steel, hot-dip galvanised <math>\geq 40 \mu\text{m}</math> acc. to EN ISO 1461:2009 and EN ISO 10684:2004+AC:2009</b>		
1	Anchor rod	Steel, EN 10087:1998 or EN 10263:2001 Property class 4.6, 4.8, 5.8, 8.8, EN 1993-1-8:2005+AC:2009 $A_5 > 8 \%$ fracture elongation
2	Hexagon nut	Steel acc. to EN 10087:1998 or EN 10263:2001 Property class 4 (for class 4.6 or 4.8 rod) EN ISO 898-2:2012, Property class 5 (for class 5.8 rod) EN ISO 898-2:2012, Property class 8 (for class 8.8 rod) EN ISO 898-2:2012
3	Washer, EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Steel, zinc plated or hot-dip galvanised
<b>Stainless steel</b>		
1	Anchor rod	Material 1.4401 / 1.4404 / 1.4571 / 1.4362, EN 10088-1:2005, > M24: Property class 50 EN ISO 3506-1:2009 $\leq$ M24: Property class 70 EN ISO 3506-1:2009 $A_5 > 8 \%$ fracture elongation
2	Hexagon nut	Material 1.4401 / 1.4404 / 1.4571 / 1.4362, EN 10088:2005, > M24: Property class 50 (for class 50 rod) EN ISO 3506-2:2009 $\leq$ M24: Property class 70 (for class 70 rod) EN ISO 3506-2:2009
3	Washer, EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Material 1.4401, 1.4404, 1.4571 or 1.4362, EN 10088-1:2005
<b>High corrosion resistant steel</b>		
1	Anchor rod	Material 1.4529 / 1.4565, EN 10088-1:2005, > M24: Property class 50 EN ISO 3506-1:2009 $\leq$ M24: Property class 70 EN ISO 3506-1:2009 $A_5 > 8 \%$ fracture elongation
2	Hexagon nut	Material 1.4529 / 1.4565 EN 10088-1:2005, > M24: Property class 50 (for class 50 rod) EN ISO 3506-2:2009 $\leq$ M24: Property class 70 (for class 70 rod) EN ISO 3506-2:2009
3	Washer, EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Material 1.4529 / 1.4565, EN 10088-1:2005
<b>Rebar</b>		
4	Rebar EN 1992-1-1:2004+AC:2010, Annex C	Bars and de-coiled rods class B or C $f_{yk}$ and $k$ according to NDP or NCL of EN 1992-1-1/NA:2013 $f_{tk} = f_{tk} = k \cdot f_{yk}$

**Injection sytem VMU plus for concrete**

**Product description**  
Materials

**Annex A4**



## Specification of intended use

### Anchorage subject to:

- Static and quasi-static loads: M8 to M30, Rebar Ø8 to Ø32.
- Seismic action for Performance Category C1: M8 to M30, Rebar Ø8 to Ø32.

### Base materials:

- Reinforced or unreinforced normal weight concrete according to EN 206-1:2000.
- Strength classes C20/25 to C50/60 according to EN 206-1:2000.
- Cracked and non-cracked concrete: M8 to M30, Rebar Ø8 to Ø32.

### Temperature Range:

- I: - 40 °C to +40 °C (max long term temperature +24 °C and max short term temperature +40 °C)
- II: - 40 °C to +80 °C (max long term temperature +50 °C and max short term temperature +80 °C)
- III: - 40 °C to +120 °C (max long term temperature +72 °C and max short term temperature +120 °C)

### Use conditions (Environmental conditions):

- Structures subject to dry internal conditions (zinc coated steel, stainless steel or high corrosion resistant steel).
- Structures subject to external atmospheric exposure (including industrial and marine environment) and to permanently damp internal condition, if no particular aggressive conditions exist (stainless steel or high corrosion resistant steel).
- Structures subject to external atmospheric exposure and to permanently damp internal condition, if other particular aggressive conditions exist (high corrosion resistant 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:

- 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 (e. g. position of the anchor relative to reinforcement or to supports, etc.).
- Anchorages are designed under the responsibility of an engineer experienced in anchorages and concrete work.
- Anchorages under static or quasi-static actions are designed in accordance with:
  - EOTA Technical Report TR 029 "Design of bonded anchors", Edition September 2010 or
  - CEN/TS 1992-4:2009
- Anchorages under seismic actions (cracked concrete) are designed in accordance with:
  - EOTA Technical Report TR 045 "Design of Metal Anchors under Seismic Action", Edition February 2013
  - Anchorages shall be positioned outside of critical regions (e.g. plastic hinges) of the concrete structure.
  - Fastenings in stand-off installation or with a grout layer are not allowed.

### Installation:

- Dry or wet concrete: M8 to M30, Rebar Ø8 to Ø32.
- Flooded holes (not sea water): M8 to M16, Rebar Ø8 to Ø16.
- Hole drilling by hammer or compressed air drill mode.
- Overhead installation allowed.
- Anchor installation carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.

## Injection system VMU plus for concrete

Intended Use  
Specifications

Annex B1

**Table B1: Installation parameters for threaded rod**

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Nominal drill hole diameter	$d_0 =$	[mm]	10	12	14	18	24	28	32	35
Effective anchorage depth	$h_{ef,min} =$	[mm]	60	60	70	80	90	96	108	120
	$h_{ef,max} =$	[mm]	160	200	240	320	400	480	540	600
Diameter of clearance hole in the fixture	$d_f \leq$	[mm]	9	12	14	18	22	26	30	33
Diameter of steel brush	$d_b$	[mm]	12	14	16	20	26	30	34	37
Torque moment	$T_{inst} \leq$	[mm]	10	20	40	80	120	160	180	200
Thickness of fixture	$t_{fix,min} >$	[mm]	0							
	$t_{fix,max} <$	[mm]	1500							
Minimum thickness of member	$h_{min}$	[mm]	$h_{ef} + 30 \text{ mm}$ $\geq 100 \text{ mm}$				$h_{ef} + 2d_0$			
Minimum spacing	$s_{min}$	[mm]	40	50	60	80	100	120	135	150
Minimum edge distance	$c_{min}$	[mm]	40	50	60	80	100	120	135	150

**Table B2: Installation parameters for rebar**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Nominal drill hole diameter	$d_0 =$	[mm]	12	14	16	18	20	24	32	35	40
Effective anchorage depth	$h_{ef,min} =$	[mm]	60	60	70	75	80	90	100	112	128
	$h_{ef,max} =$	[mm]	160	200	240	280	320	400	480	540	640
Diameter of steel brush	$d_b$	[mm]	14	16	18	20	22	26	34	37	41,5
Minimum thickness of member	$h_{min}$	[mm]	$h_{ef} + 30 \text{ mm}$ $\geq 100 \text{ mm}$				$h_{ef} + 2d_0$				
Minimum spacing	$s_{min}$	[mm]	40	50	60	70	80	100	125	140	160
Minimum edge distance	$c_{min}$	[mm]	40	50	60	70	80	100	125	140	160

**Injection sytem VMU plus for concrete**

**Intended Use**  
Installation parameters

**Annex B2**

## Steel brush



Table B3: Parameter cleaning and setting tools

Threaded Rod	Rebar	$d_0$ Drill bit - Ø	$d_b$ Brush - Ø	$d_{b,min}$ min. Brush - Ø	Retaining washer
[mm]	[mm]	[mm]	[mm]	[mm]	[-]
M8		10	12	10,5	No Retaining washer required
M10	8	12	14	12,5	
M12	10	14	16	14,5	
	12	16	18	16,5	
M16	14	18	20	18,5	
	16	20	22	20,5	
M20	20	24	26	24,5	VM-IA 24
M24		28	30	28,5	VM-IA 28
M27	25	32	34	32,5	VM-IA 32
M30	28	35	37	35,5	VM-IA 35
	32	40	41,5	40,5	VM-IA 40



### Blow-out pump (volume 750ml)

Drill bit diameter ( $d_0$ ): 10 mm to 20 mm  
Effective anchorage depth ( $h_{ef}$ ): up to 240mm  
for non-cracked concrete



### Recommended compressed air tool (min 6 bar)

All applications



### Retaining washer for overhead or horizontal installation

Drill bit diameter ( $d_0$ ): 24 mm to 40 mm

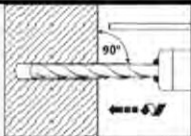
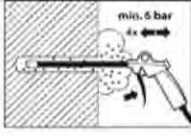
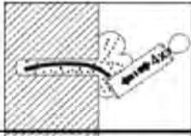
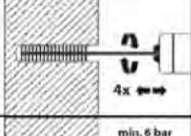
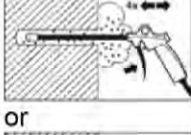
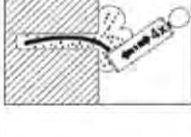
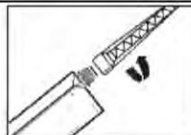
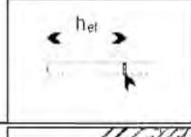

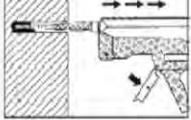
## Injection sytem VMU plus for concrete

**Intended Use**  
Cleaning and setting tools

**Annex B3**



## Installation instructions

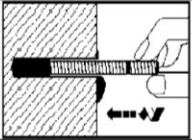
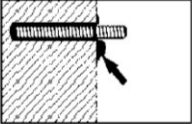
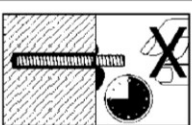
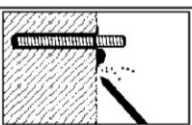
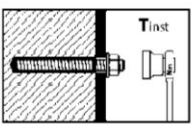
1.		Drill with hammer drill a hole into the base material to the size and embedment depth required by the selected anchor (Table B1 or Table B2). In case of aborted drill hole, the drill hole shall be filled with mortar.  <b>Attention! Standing water in the bore hole must be removed before cleaning!</b>
2a.	 or 	<b>Cleaning with compressed air:</b> Starting from the bottom or back of the bore hole, blow out the hole with compressed air (min. 6 bar) a minimum of four times. If the bore hole ground is not reached an extension must be used.  <b>Manual cleaning:</b> <u>Non cracked concrete:</u> drill bit diameter $\leq 20\text{mm}$ and effective anchorage depth $\leq 240\text{mm}$ <u>Cracked concrete:</u> M12, M16, $\varnothing 12$ , $\varnothing 14$ , $\varnothing 16$ and effective anchorage depth $\leq 240\text{mm}$ Starting from the bottom or back of the bore hole, blow out the hole a minimum of four times. The blow-out pump can be used.
2b.		Check brush diameter (Table B3) and attach the brush to a drilling machine or a battery screwdriver. Brush the hole with an appropriate sized wire brush $> d_{b,\text{min}}$ (Table B3) a minimum of four times. If the bore hole ground is not reached with the brush, a brush extension must be used.
2c.	 or 	<b>Cleaning with compressed air:</b> Starting from the bottom or back of the bore hole, blow out the hole with compressed air (min. 6 bar) a minimum of four times. If the bore hole ground is not reached an extension must be used.  <b>Manual cleaning:</b> <u>Non cracked concrete:</u> drill bit diameter $\leq 20\text{mm}$ and effective anchorage depth $\leq 240\text{mm}$ <u>Cracked concrete:</u> M12, M16, $\varnothing 12$ , $\varnothing 14$ , $\varnothing 16$ and effective anchorage depth $\leq 240\text{mm}$ Starting from the bottom or back of the bore hole blow out the hole a minimum of four times. The blow-out pump can be used.  <b>After cleaning, the bore hole has to be protected against re-contamination in an appropriate way, until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar.</b> <b>In-flowing water must not contaminate the bore hole again.</b>
3.		Attach a supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. Cut off the foil tube clip before use. For every working interruption longer than the recommended working time (Table B4 or Table B5) as well as for new cartridges, a new static-mixer shall be used.
4.		Prior to inserting the anchor rod into the filled bore hole, the position of the embedment depth shall be marked on the anchor rods.
5.		Prior to dispensing into the drill hole, squeeze out separately a minimum of three full strokes and discard non-uniformly mixed adhesive components until the mortar shows a consistent grey colour. For foil tube cartridges is must be discarded a minimum of six full strokes.
6.		Starting from the bottom or back of the cleaned drill hole fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. For embedment larger than 190 mm an extension nozzle must be used. For overhead and horizontal installation a retaining washer (Annex B3) and extension nozzle shall be used. Observe the gel-/ working times given in Table B4 or Table B5.

### Injection sytem VMU plus for concrete

Intended Use  
Installation instructions

Annex B4

## Installation instructions (continuation)

7.		Push the threaded rod or reinforcing bar into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached.  The anchor shall be free of dirt, grease, oil or other foreign material.
8.		Make sure that the anchor is fully seated up to the full embedment depth and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For overhead installation the anchor should be fixed (e.g. wedges).
9.		Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured (attend Table B4 or Table B5).
10.		Remove excess mortar.
11.		The fixture can be mounted after curing time. Apply installation torque $T_{inst}$ according to Table B1 by using a calibrated torque wrench.

Injection sytem VMU plus for concrete

**Intended Use**  
Installation instructions (continuation)

**Annex B5**

**Table B4: Maximum processing time and minimum curing time, VMU plus**

Concrete temperature	Maximum processing time	Minimum curing time in dry concrete <sup>1)</sup>
-10°C to -6°C	90 min <sup>2)</sup>	24 h <sup>2)</sup>
-5°C to -1°C	90 min	14 h
0°C to +4°C	45 min	7 h
+5°C to +9°C	25 min	2 h
+10°C to +19°C	15 min	80 min
+20°C to +29°C	6 min	45 min
+30°C to +34°C	4 min	25 min
+35°C to +39°C	2 min	20 min
+ 40°C	1,5 min	15 min
Cartridge temperature	+ 5°C to + 40°C	

<sup>1)</sup> In wet concrete the curing time must be doubled.

<sup>2)</sup> Cartridge temperature must be at min. + 15°C.

**Table B5: Maximum processing time and minimum curing time, VMU plus Polar**

Concrete temperature	Maximum processing time	Minimum curing time in dry concrete <sup>1)</sup>
- 20°C to -16°C	75 min	24 h
-15°C to -11°C	55 min	16 h
-10°C to -6°C	35 min	10 h
-5°C to -1°C	20 min	5 h
0°C to +4°C	10 min	2,5 h
+5°C to +9°C	6 min	80 min
+10°C	6 min	60 min
Cartridge temperature	- 20°C to + 10°C	

<sup>1)</sup> In wet concrete the curing time must be doubled.

**Injection sytem VMU plus for concrete**

**Intended Use**  
Processing time and curing time

**Annex B6**



**Table C1: Characteristic values for threaded rods under tension loads in cracked concrete**

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Characteristic tension resistance		N <sub>Rk,s</sub>	[kN]	A <sub>s</sub> • f <sub>uk</sub>							
Combined pull-out and concrete cone failure											
Characteristic bond resistance in cracked concrete C20/25											
Temperature range I: 40°C/24°C	dry and wet concrete	τ <sub>Rk,cr</sub>	[N/mm²]	4,0	5,0	5,5	5,5	5,5	5,5	6,5	6,5
	flooded bore hole	τ <sub>Rk,cr</sub>	[N/mm²]	4,0	4,0	5,5	5,5	not admissible			
Temperature range II: 80°C/50°C	dry and wet concrete	τ <sub>Rk,cr</sub>	[N/mm²]	2,5	3,5	4,0	4,0	4,0	4,0	4,5	4,5
	flooded bore hole	τ <sub>Rk,cr</sub>	[N/mm²]	2,5	3,0	4,0	4,0	not admissible			
Temperature range III: 120°C/72°C	dry and wet concrete	τ <sub>Rk,cr</sub>	[N/mm²]	2,0	2,5	3,0	3,0	3,0	3,0	3,5	3,5
	flooded bore hole	τ <sub>Rk,cr</sub>	[N/mm²]	2,0	2,5	3,0	3,0	not admissible			
Increasing factor for τ <sub>Rk,cr</sub>		ψ <sub>c</sub>	C25/30	1,02							
			C30/37	1,04							
			C35/45	1,07							
			C40/50	1,08							
			C45/55	1,09							
			C50/60	1,10							
Factor according to CEN/TS 1992-4-5		k <sub>8</sub>	[-]	7,2							
Concrete cone failure											
Factor according to CEN/TS 1992-4-5		k <sub>cr</sub>	[-]	7,2							
Edge distance		c <sub>cr,N</sub>	[mm]	1,5 h <sub>ef</sub>							
Axial distance		s <sub>cr,N</sub>	[mm]	3,0 h <sub>ef</sub>							
Installation safety factor (dry and wet concrete)		γ <sub>2</sub> = γ <sub>inst</sub>	[-]	1,0	1,2						
Installation safety factor (flooded bore hole)		γ <sub>2</sub> = γ <sub>inst</sub>	[-]	1,4					not admissible		

**Injection sytem VMU plus for concrete**

**Performance**

Characteristic values for **threaded rods** under **tension loads** in **cracked concrete**

**Annex C1**

**Table C2: Characteristic values for threaded rods under tension loads in non-cracked concrete**

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Characteristic tension resistance		N <sub>Rk,s</sub>	[kN]	A <sub>s</sub> · f <sub>uk</sub>							
Combined pull-out and concrete cone failure											
Characteristic bond resistance in non-cracked concrete C20/25											
Temperature range I: 40°C/24°C	dry and wet concrete	τ <sub>Rk,ucr</sub>	[N/mm²]	10	12	12	12	12	11	10	9
	flooded bore hole	τ <sub>Rk,ucr</sub>	[N/mm²]	7,5	8,5	8,5	8,5	not admissible			
Temperature range II: 80°C/50°C	dry and wet concrete	τ <sub>Rk,ucr</sub>	[N/mm²]	7,5	9	9	9	9	8,5	7,5	6,5
	flooded bore hole	τ <sub>Rk,ucr</sub>	[N/mm²]	5,5	6,5	6,5	6,5	not admissible			
Temperature range III: 120°C/72°C	dry and wet concrete	τ <sub>Rk,ucr</sub>	[N/mm²]	5,5	6,5	6,5	6,5	6,5	6,5	5,5	5,0
	flooded bore hole	τ <sub>Rk,ucr</sub>	[N/mm²]	4,0	5,0	5,0	5,0	not admissible			
Increasing factor for τ <sub>Rk,ucr</sub>		ψ <sub>c</sub>	C25/30	1,02							
			C30/37	1,04							
			C35/45	1,07							
			C40/50	1,08							
			C45/55	1,09							
			C50/60	1,10							
Factor according to CEN/TS 1992-4-5		k <sub>8</sub>	[-]	10,1							
Concrete cone failure											
Factor according to CEN/TS 1992-4-5		k <sub>ucr</sub>	[-]	10,1							
Edge distance		c <sub>cr,N</sub>	[mm]	1,5 h <sub>ef</sub>							
Axial distance		s <sub>cr,N</sub>	[mm]	3,0 h <sub>ef</sub>							
Splitting failure											
Edge distance for		c <sub>cr,sp</sub>	[mm]	1,0 · h <sub>ef</sub> ≤ 2 · h <sub>ef</sub> $\left(2,5 - \frac{h}{h_{ef}}\right) \leq 2,4 \cdot h_{ef}$							
Axial distance		s <sub>cr,sp</sub>	[mm]	2 c <sub>cr,sp</sub>							
Installation safety factor (dry and wet concrete)		γ <sub>2</sub> = γ <sub>inst</sub>	[-]	1,0	1,2						
Installation safety factor (flooded bore hole)		γ <sub>2</sub> = γ <sub>inst</sub>	[-]	1,4				not admissible			

### Injection sytem VMU plus for concrete

#### Performance

Characteristic values for **threaded rods** under **tension loads** in **non-cracked concrete**

**Annex C2**

**Table C3: Characteristic values for threaded rods under shear loads in cracked and non-cracked concrete**

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Steel failure without lever arm										
Characteristic shear resistance	$V_{Rk,s}$	[kN]	$0,5 \cdot A_s \cdot f_{uk}$							
Ductility factor according to CEN/TS 1992-4-5	$k_2$	[-]	0,8							
Steel failure with lever arm										
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	$1,2 \cdot W_{el} \cdot f_{uk}$							
Concrete pry-out failure										
Factor k acc. to TR 029 or $k_3$ acc. to CEN/TS 1992-4-5	$k_{(3)}$	[-]	2,0							
Concrete edge failure										
Effective length of anchor	$l_f$	[mm]	$l_f = \min(h_{ef}; 8 d_{nom})$							
Outside diameter of anchor	$d_{nom}$	[mm]	8	10	12	16	20	24	27	30
Installation safety factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0							

**Injection sytem VMU plus for concrete**

**Performance**  
Characteristic value for **threaded rods** under **shear loads**

**Annex C3**

**Table C4:** Characteristic values for **threaded rods** under **seismic action**, category **C1**

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Tension load											
Steel failure											
Characteristic tension resistance		$N_{Rk,s,seis}$	[kN]	$A_s \cdot f_{uk}$							
Combined pull-out and concrete cone failure											
Characteristic bond resistance in concrete C20/25 to C50/60											
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	2,5	3,1	3,7	3,7	3,7	3,8	4,5	4,5
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	2,5	2,5	3,7	3,7	not admissible			
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	1,6	2,2	2,7	2,7	2,7	2,8	3,1	3,1
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	1,6	1,9	2,7	2,7	not admissible			
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	1,3	1,6	2,0	2,0	2,0	2,1	2,4	2,4
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	1,3	1,6	2,0	2,0	not admissible			
Increasing factor for $\tau_{Rk,seis}$		$\psi_c$	[-]	1,0							
Installation safety factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,0	1,2						
Installation safety factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4				not admissible			
Shear load											
Steel failure without lever arm											
Characteristic shear resistance		$V_{Rk,s,seis}$	[kN]	$0,35 \cdot A_s \cdot f_{uk}$							
Steel failure with lever arm											
Characteristic bending moment		$M^0_{Rk,s,seis}$	[Nm]	No Performance Determined (NPD)							

**Injection sytem VMU plus for concrete**

**Performance**

Characteristic values for **threaded rods** under **seismic action**, category **C1**

**Annex C4**



**Table C5: Characteristic values for rebar under tension loads in cracked concrete**

Rebar				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Steel failure												
Characteristic tension resistance		N <sub>Rk,s</sub>	[kN]	A <sub>s</sub> • f <sub>uk</sub> <sup>1)</sup>								
Combined pull-out and concrete cone failure												
Characteristic bond resistance in cracked concrete C20/25												
Temperature range I: 40°C/24°C	dry and wet concrete	τ <sub>Rk,cr</sub>	[N/mm²]	4,0	5,0	5,5	5,5	5,5	5,5	5,5	6,5	6,5
	flooded bore hole	τ <sub>Rk,cr</sub>	[N/mm²]	4,0	4,0	5,5	5,5	5,5	not admissible			
Temperature range II: 80°C/50°C	dry and wet concrete	τ <sub>Rk,cr</sub>	[N/mm²]	2,5	3,5	4,0	4,0	4,0	4,0	4,0	4,5	4,5
	flooded bore hole	τ <sub>Rk,cr</sub>	[N/mm²]	2,5	3,0	4,0	4,0	4,0	not admissible			
Temperature range III: 120°C/72°C	dry and wet concrete	τ <sub>Rk,cr</sub>	[N/mm²]	2,0	2,5	3,0	3,0	3,0	3,0	3,0	3,5	3,5
	flooded bore hole	τ <sub>Rk,cr</sub>	[N/mm²]	2,0	2,5	3,0	3,0	3,0	not admissible			
Increasing factors for τ <sub>Rk,cr</sub>		ψ <sub>c</sub>	C25/30	1,02								
			C30/37	1,04								
			C35/45	1,07								
			C40/50	1,08								
			C45/55	1,09								
			C50/60	1,10								
Factor acc. to CEN/TS 1992-4-5		k <sub>8</sub>	[-]	7,2								
Concrete cone failure												
Factor acc. to CEN/TS 1992-4-5		k <sub>cr</sub>	[-]	7,2								
Edge distance		c <sub>cr,N</sub>	[mm]	1,5 h <sub>ef</sub>								
Axial distance		s <sub>cr,N</sub>	[mm]	3,0 h <sub>ef</sub>								
Installation safety factor (dry and wet concrete)		γ <sub>2</sub> = γ <sub>inst</sub>	[-]	1,0	1,2							
Installation safety factor (flooded bore hole)		γ <sub>2</sub> = γ <sub>inst</sub>	[-]	1,4					not admissible			

<sup>1)</sup>  $f_{uk} = f_{tk} = k \cdot f_{yk}$

**Injection sytem VMU plus for concrete**

**Performance**

Characteristic values for rebar under tension loads in cracked concrete

**Annex C5**



**Table C6:** Characteristic values for rebar under tension loads in non-cracked concrete

Rebar				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Steel failure												
Characteristic tension resistance		N <sub>Rk,s</sub>	[kN]	A <sub>s</sub> · f <sub>uk</sub> <sup>1)</sup>								
Combined pull-out and concrete cone failure												
Characteristic bond resistance in non-cracked concrete C20/25												
Temperature range I: 40°C/24°C	dry and wet concrete	τ <sub>Rk,ucr</sub>	[N/mm²]	10	12	12	12	12	12	11	10	8,5
	flooded bore hole	τ <sub>Rk,ucr</sub>	[N/mm²]	7,5	8,5	8,5	8,5	8,5	not admissible			
Temperature range II: 80°C/50°C	dry and wet concrete	τ <sub>Rk,ucr</sub>	[N/mm²]	7,5	9	9	9	9	9	8,0	7,0	6,0
	flooded bore hole	τ <sub>Rk,ucr</sub>	[N/mm²]	5,5	6,5	6,5	6,5	6,5	not admissible			
Temperature range III: 120°C/72°C	dry and wet concrete	τ <sub>Rk,ucr</sub>	[N/mm²]	5,5	6,5	6,5	6,5	6,5	6,5	6,0	5,0	4,5
	flooded bore hole	τ <sub>Rk,ucr</sub>	[N/mm²]	4,0	5,0	5,0	5,0	5,0	not admissible			
Increasing factors for τ <sub>Rk,ucr</sub>		ψ <sub>c</sub>	C25/30	1,02								
			C30/37	1,04								
			C35/45	1,07								
			C40/50	1,08								
			C45/55	1,09								
			C50/60	1,10								
Factor acc. to CEN/TS 1992-4-5		k <sub>8</sub>	[-]	10,1								
Concrete cone failure												
Factor acc. to CEN/TS 1992-4-5		k <sub>ucr</sub>	[-]	10,1								
Edge distance		c <sub>cr,N</sub>	[mm]	1,5 h <sub>ef</sub>								
Axial distance		s <sub>cr,N</sub>	[mm]	3,0 h <sub>ef</sub>								
Splitting failure												
Edge distance for		c <sub>cr,sp</sub>	[mm]	$1,0 \cdot h_{ef} \leq 2 \cdot h_{ef} \left( 2,5 - \frac{h}{h_{ef}} \right) \leq 2,4 \cdot h_{ef}$								
Axial distance		s <sub>cr,sp</sub>	[mm]	2 c <sub>cr,sp</sub>								
Installation safety factor (dry and wet concrete)		γ <sub>2</sub> = γ <sub>inst</sub>	[-]	1,0	1,2							
Installation safety factor (flooded bore hole)		γ <sub>2</sub> = γ <sub>inst</sub>	[-]	1,4				not admissible				

<sup>1)</sup>  $f_{uk} = f_{tk} = k \cdot f_{yk}$

#### Injection sytem VMU plus for concrete

#### Performance

Characteristic values for rebar under tension loads in non-cracked concrete

**Annex C6**

**Table C7: Characteristic values for rebar under shear loads in cracked and non-cracked concrete**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Steel failure without lever arm											
Characteristic shear resistance	$V_{Rk,s}$	[kN]	$0,50 \cdot A_s \cdot f_{uk}^{1)}$								
Ductility factor according to CEN/TS 1992-4-5	$k_2$	[-]	0,8								
Steel failure with lever arm											
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	$1,2 \cdot W_{el} \cdot f_{uk}^{1)}$								
Concrete pry-out failure											
Factor k acc. to TR 029 or $k_3$ acc. to CEN/TS 1992-4-5	$k_{(3)}$	[-]	2,0								
Concrete edge failure											
Effective length of anchor	$l_f$	[mm]	$l_f = \min(h_{ef}; 8 d_{nom})$								
Outside diameter of anchor	$d_{nom}$	[mm]	8	10	12	14	16	20	25	28	32
Installation safety factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0								

<sup>1)</sup>  $f_{uk} = f_{tk} = k \cdot f_{yk}$

**Injection sytem VMU plus for concrete**

**Performance**

Characteristic values for **rebar** under **shear loads** in **cracked and non-cracked concrete**

**Annex C7**

**Table C8:** Characteristic values for rebar under seismic action, category C1

Rebar				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Tension load												
Steel failure												
Characteristic tension resistance		$N_{Rk,s,seis}$	[kN]	$A_s \cdot f_{uk}^{1)}$								
Combined pull-out and concrete cone failure												
Characteristic bond resistance in concrete C20/25 to C50/60												
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	2,5	3,1	3,7	3,7	3,7	3,7	3,8	4,5	4,5
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	2,5	2,5	3,7	3,7	3,7	not admissible			
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	1,6	2,2	2,7	2,7	2,7	2,7	2,8	3,1	3,1
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	1,6	1,9	2,7	2,7	2,7	not admissible			
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	1,3	1,6	2,0	2,0	2,0	2,0	2,1	2,4	2,4
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	1,3	1,6	2,0	2,0	2,0	not admissible			
Increasing factor for $\tau_{Rk,seis}$		$\psi_c$	[-]	1,0								
Installation safety factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,0	1,2							
Installation safety factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4					not admissible			
Shear load												
Steel failure without lever arm												
Characteristic shear resistance		$V_{Rk,s,seis}$	[kN]	$0,35 \cdot A_s \cdot f_{uk}^{1)}$								
Steel failure with lever arm												
Characteristic bending moment		$M^0_{Rk,s,seis}$	[Nm]	No Performance Determined (NPD)								

<sup>1)</sup>  $f_{uk} = f_{tk} = k \cdot f_{yk}$

**Injection sytem VMU plus for concrete**

**Performance**  
Characteristic values for rebar under seismic action, category C1

**Annex C8**

**Table C9: Displacements under tension loads<sup>1)</sup> (threaded rod)**

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
<b>Non-cracked concrete C20/25</b>										
Temperature range I: 40°C/24°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,021	0,023	0,026	0,031	0,036	0,041	0,045	0,049
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,030	0,033	0,037	0,045	0,052	0,060	0,065	0,071
Temperature range II: 80°C/50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,050	0,056	0,063	0,075	0,088	0,100	0,110	0,119
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,072	0,081	0,090	0,108	0,127	0,145	0,159	0,172
Temperature range III: 120°C/72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,050	0,056	0,063	0,075	0,088	0,100	0,110	0,119
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,072	0,081	0,090	0,108	0,127	0,145	0,159	0,172
<b>Cracked concrete C20/25</b>										
Temperature range I: 40°C/24°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,090				0,070			
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,105				0,105			
Temperature range II: 80°C/50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,219				0,170			
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,255				0,245			
Temperature range III: 120°C/72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,219				0,170			
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,255				0,245			

<sup>1)</sup> Calculation of the displacement

$$\delta_{N0} = \delta_{N0}\text{-Faktor} \cdot \tau; \quad \tau: \text{acting bond stress for tension load}$$

$$\delta_{N\infty} = \delta_{N\infty}\text{-Faktor} \cdot \tau;$$

**Table C10: Displacements under shear load<sup>1)</sup> (threaded rod)**

Threaded rod			M 8	M 10	M 12	M 16	M 20	M24	M 27	M 30
<b>Non-cracked concrete C20/25</b>										
All temperature ranges	$\delta_{V0}$ -factor	[mm/(kN)]	0,06	0,06	0,05	0,04	0,04	0,03	0,03	0,03
	$\delta_{V\infty}$ -factor	[mm/(kN)]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05
<b>Cracked concrete C20/25</b>										
All temperature ranges	$\delta_{V0}$ -factor	[mm/(kN)]	0,12	0,12	0,11	0,10	0,09	0,08	0,08	0,07
	$\delta_{V\infty}$ -factor	[mm/(kN)]	0,18	0,18	0,17	0,15	0,14	0,13	0,12	0,10

<sup>1)</sup> Calculation of the displacement

$$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V; \quad V: \text{acting shear load}$$

$$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V;$$

**Injection sytem VMU plus for concrete**

**Performance**  
Displacements (threaded rod)

**Annex C9**



**Table C11: Displacements under tension load<sup>1)</sup> (rebar)**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
<b>Non-cracked concrete C20/25</b>											
Temperature range I: 40°C/24°C	δ <sub>N0</sub> -factor	[mm/(N/mm²)]	0,021	0,023	0,026	0,028	0,031	0,036	0,043	0,047	0,052
	δ <sub>N∞</sub> -factor	[mm/(N/mm²)]	0,030	0,033	0,037	0,041	0,045	0,052	0,061	0,071	0,075
Temperature range II: 80°C/50°C	δ <sub>N0</sub> -factor	[mm/(N/mm²)]	0,050	0,056	0,063	0,069	0,075	0,088	0,104	0,113	0,126
	δ <sub>N∞</sub> -factor	[mm/(N/mm²)]	0,072	0,081	0,090	0,099	0,108	0,127	0,149	0,163	0,181
Temperature range III: 120°C/72°C	δ <sub>N0</sub> -factor	[mm/(N/mm²)]	0,050	0,056	0,063	0,069	0,075	0,088	0,104	0,113	0,126
	δ <sub>N∞</sub> -factor	[mm/(N/mm²)]	0,072	0,081	0,090	0,099	0,108	0,127	0,149	0,163	0,181
<b>Cracked concrete C20/25</b>											
Temperature range I: 40°C/24°C	δ <sub>N0</sub> -factor	[mm/(N/mm²)]	0,090		0,070						
	δ <sub>N∞</sub> -factor	[mm/(N/mm²)]	0,105		0,105						
Temperature range II: 80°C/50°C	δ <sub>N0</sub> -factor	[mm/(N/mm²)]	0,219		0,170						
	δ <sub>N∞</sub> -factor	[mm/(N/mm²)]	0,255		0,245						
Temperature range III: 120°C/72°C	δ <sub>N0</sub> -factor	[mm/(N/mm²)]	0,219		0,170						
	δ <sub>N∞</sub> -factor	[mm/(N/mm²)]	0,255		0,245						

<sup>1)</sup> Calculation of the displacement

$$\delta_{N0} = \delta_{N0}\text{-Faktor} \cdot \tau; \quad \tau: \text{acting bond stress for tension load}$$

$$\delta_{N\infty} = \delta_{N\infty}\text{-Faktor} \cdot \tau;$$

**Table C12: Displacements under shear load<sup>1)</sup> (rebar)**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
<b>Non-cracked concrete C20/25</b>											
All temperature ranges	δ <sub>V0</sub> -factor	[mm/(kN)]	0,06	0,05	0,05	0,04	0,04	0,04	0,03	0,03	0,03
	δ <sub>V∞</sub> -factor	[mm/(kN)]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,04	0,04
<b>Cracked concrete C20/25</b>											
All temperature ranges	δ <sub>V0</sub> -factor	[mm/(kN)]	0,12	0,12	0,11	0,11	0,10	0,09	0,08	0,07	0,06
	δ <sub>V∞</sub> -factor	[mm/(kN)]	0,18	0,18	0,17	0,16	0,15	0,14	0,12	0,11	0,10

<sup>1)</sup> Calculation of the displacement

$$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V; \quad V: \text{acting shear load}$$

$$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V;$$

**Injection sytem VMU plus for concrete**

**Performance**  
Displacements (rebar)

**Annex C10**