



...eine starke Verbindung

## DECLARATION OF PERFORMANCE

DoP Nr.: **MKT-342 - en**


- ✧ **Unique identification code of product-type:** **Injection System VMH for concrete**
- ✧ **Intended use/es:** Bonded fastener for use in concrete, see Annex B
- ✧ **Manufacturer:** MKT Metall-Kunststoff-Technik GmbH & Co.KG  
Auf dem Immel 2  
67685 Weilerbach
- ✧ **System or systems of assessment and verification of constancy of performance:** 1
- ✧ **European Assessment Document:** **EAD 330499-01-0601**  
European Technical Assessment: **ETA-17/0716, 22.11.2019**  
Technical Assessment Body: DIBt, Berlin  
Notified body/ies: NB 1343 – MPA, Darmstadt

✧ **Declared performance/s:**

Essential characteristics	Performance
<b>Mechanical resistance and stability (BWR 1)</b>	
Characteristic resistance to tension load (static and quasi-static loading)	Annex C1, C3, C6, C8
Characteristic resistance to shear load (static and quasi-static loading)	Annex C2, C4, C7, C9
Displacements (static and quasi-static loading)	Annex C11 – C13
Characteristic resistance and displacements for seismic performance category C1+C2	Annex C5, C10, C11
Durability	Annex B1
<b>Hygiene, health and the environment (BWR 3)</b>	
Content, emission and/or release of dangerous substances	No performance assessed

The performance of the product identified above is in conformity with the set of declared performance/s.  
This declaration of performance is issued, in accordance with Regulation (EU) No 305/2011, under the sole responsibility of the manufacturer identified above.

Signed for and on behalf of the manufacturer by:

  
**Stefan Weustenhagen**  
(General manager)  
**Weilerbach, 22.11.2019**

p.p.   
**Dipl.-Ing. Detlef Bigalke**  
(Head of product development)



The original of this declaration of performance was written in German. In the event of deviations in the translation, the German version shall be valid.

## Specification of intended use

Injection System VMH		Threaded rod	Internally threaded anchor rod	Rebar
Static or quasi-static action		M8 - M30 zinc plated, A2, A4, HCR	VMU-IG M6 - VMU-IG M20 zinc plated <sup>1)</sup> , A4, HCR	Ø8 - Ø32
Seismic action	performance category C1	M8 - M30 zinc plated <sup>1)</sup> , A4, HCR	-	Ø8 - Ø32
	performance category C2	M12 – M24 zinc plated <sup>1)</sup> (property class 8.8) A4, HCR (property class ≥ 70)	-	-
Base materials		compacted, reinforced or unreinforced normal weight concrete (without fibers) acc. to EN 206:2013		
		strength classes acc. to EN 206:2013: C20/25 to C50/60		
		cracked or uncracked concrete		
Temperature Range I	-40 °C to +80 °C	max. long term temperature +50 °C and max. short term temperature +80 °C		
Temperature Range II	-40 °C to +120 °C	max. long term temperature +72 °C and max. short term temperature +120 °C		
Temperature Range III	-40 °C to +160 °C	max. long term temperature +100 °C and max. short term temperature +160 °C		

<sup>1)</sup> except hot-dip galvanised

### Use conditions (Environmental conditions):

- Structures subject to dry internal conditions (all materials).
- For all other conditions according to EN 1993-1-4:2006+A1:2015 corresponding to corrosion resistance classes:
  - Stainless steel A2 according to Annex A4, Table A1: CRC II
  - Stainless steel A4 according to Annex A4, Table A1: CRC III
  - High corrosion resistant steel HCR according to Annex A4, Table A1: CRC V

### 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 are designed in accordance with EN 1992-4:2018 or Technical Report TR 055

### Installation:

- Dry or wet concrete or waterfilled drill holes (not seawater)
- Hole drilling by hammer or compressed air drill or vacuum drill mode
- Overhead installation allowed
- Anchor installation carried out by appropriately qualified personnel and under the responsibility of the person competent for technical matters on site
- Internally threaded anchor rod: Screws and threaded rods (incl. nut and washer) must at least correspond to the material and strength class of the internally threaded anchor rod used

## Injection System VMH for concrete

**Intended Use**  
Specifications

**Annex B1**

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

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Diameter of threaded rod	$d=d_{nom}$	[mm]	8	10	12	16	20	24	27	30
Nominal drill hole diameter	$d_0$	[mm]	10	12	14	18	22	28	30	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 <sup>2)</sup>	Pre-setting installation $d_f \leq$	[mm]	9	12	14	18	22	26	30	33
	Through setting installation $d_f \leq$	[mm]	12	14	16	20	24	30	33	40
Installation torque	$T_{inst} \leq$	[Nm]	10	20	40 (35) <sup>1)</sup>	60	100	170	250	300
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	75	95	115	125	140
Minimum edge distance	$c_{min}$	[mm]	35	40	45	50	60	65	75	80

<sup>1)</sup> Installation torque for M12 with steel grade 4.6

<sup>2)</sup> For applications under seismic loading the diameter of clearance hole in the fixture shall be at maximum  $d_{nom} + 1 \text{ mm}$  or alternatively the annular gap between fixture and threaded rod shall be completely filled with mortar

**Table B2: Installation parameters for internally threaded anchor rods**

Internally threaded anchor rod			IG-M 6	IG-M 8	IG-M 10	IG-M 12	IG-M 16	IG-M 20
Inner diameter of threaded rod	$d_2$	[mm]	6	8	10	12	16	20
Outer diameter of threaded rod <sup>1)</sup>	$d=d_{nom}$	[mm]	10	12	16	20	24	30
Nominal drill hole diameter	$d_0$	[mm]	12	14	18	22	28	35
Effective anchorage depth	$h_{ef,min}$	[mm]	60	70	80	90	96	120
	$h_{ef,max}$	[mm]	200	240	320	400	480	600
Diameter of clearance hole in the fixture	$d_f \leq$	[mm]	7	9	12	14	18	22
Installation torque	$T_{inst} \leq$	[Nm]	10	10	20	40	60	100
Minimum screw-in depth	$l_{IG}$	[mm]	8	8	10	12	16	20
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]	50	60	75	95	115	140
Minimum edge distance	$c_{min}$	[mm]	40	45	50	60	65	80

<sup>1)</sup> With metric thread acc. to EN 1993-1-8:2005+AC:2009

**Table B3: Installation parameters for rebar**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Diameter of rebar	$d=d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Nominal drill hole diameter <sup>1)</sup>	$d_0$	[mm]	10   12	12   14	14   16	18	20	25	32	32	35	40
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	75	80	90	96	100	112	128
	$h_{ef,max}$	[mm]	160	200	240	280	320	400	480	500	560	640
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	75	95	120	120	130	150
Minimum edge distance	$c_{min}$	[mm]	35	40	45	50	50	60	70	70	75	85





<sup>1)</sup> For diameter Ø8, Ø10 and Ø12 both nominal drill hole diameter can be used

**Injection System VMH for concrete**


**Intended use**  
Installation parameters

**Annex B2**

**Table B4: Parameter cleaning and setting tools**

Threaded rod	Internally threaded anchor rod	Rebar	Drill bit Ø	Brush Ø	min. Brush Ø
					
[-]	[-]	Ø [mm]	d <sub>0</sub> [mm]	d <sub>b</sub> [mm]	d <sub>b,min</sub> [mm]
M8		8	10	11,5	10,5
M10	VMU-IG M 6	8 / 10	12	13,5	12,5
M12	VMU-IG M 8	10 / 12	14	15,5	14,5
		12	16	17,5	16,5
M16	VMU-IG M10	14	18	20,0	18,5
		16	20	22,0	20,5
M20	VMU-IG M12		22	24,0	22,5
		20	25	27,0	25,5
M24	VMU-IG M16		28	30,0	28,5
M27			30	31,8	30,5
		24/25	32	34,0	32,5
M30	VMU-IG M20	28	35	37,0	35,5
		32	40	43,5	40,5

**Table B5: Retaining washer**

Drill bit Ø		Installation direction and use		
d <sub>0</sub> [mm]	[-]	↓	→	↑
10	No retaining washer required			
12				
14				
16				
18	VM-IA 18	h <sub>ef</sub> > 250mm	h <sub>ef</sub> > 250mm	all
20	VM-IA 20			
22	VM-IA 22			
25	VM-IA 25			
28	VM-IA 28			
30	VM-IA 30			
32	VM-IA 32			
35	VM-IA 35			
40	VM-IA 40			


**Vacuum drill bit**

Drill bit diameter (d<sub>0</sub>): all diameters  
 Vacuum drill bit (MKT Hollow drill bit SB, Würth Saugbohrer or Heller Duster Expert) and a class M vacuum with minimum negative pressure of 253 hPa and a flow rate of minimum 42 l/s


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

Drill bit diameter (d<sub>0</sub>): all diameters


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

Drill bit diameter (d<sub>0</sub>): 10 mm to 20 mm  
 Drill hole depth (h<sub>0</sub>): ≤ 10 d<sub>nom</sub>  
 for uncracked concrete

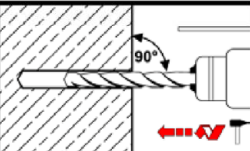
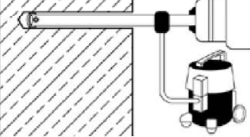
**Injection System VMH for concrete**

**Intended Use**  
 Cleaning and setting tools

**Annex B3**

# Installation Instructions

## Drilling of the hole

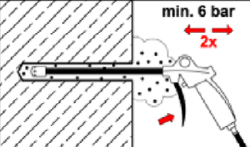
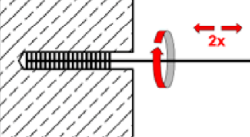
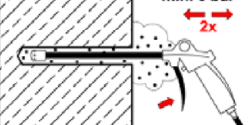
1	1a		<b>Hammer drill oder compressed air drill</b> Drill with hammer drill or compressed air drill a hole into the base material to the size required by the selected anchor (Table B1, B2 or B3). Continue with <a href="#">step 2</a> . In case of aborted drill hole, the drill hole shall be filled with mortar.
	1b		<b>Vacuum drill bit:</b> see Annex B3 Drill hole into the base material to the embedment size and embedment depth required by the selected anchor (table B1, B2 or B3). This drilling system removes dust and cleans the drill hole during drilling. Continue with <a href="#">step 3</a> . In case of aborted hole, the drill hole shall be filled with mortar.

## Cleaning (not applicable when using a vacuum drill)

**Attention! Standing water in the drill hole must be removed before cleaning!**


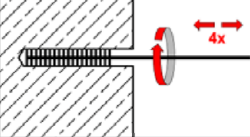

### Cleaning with compressed air

all substrates and diameters according to Annex B1

2a		Starting from the bottom or back of the drill hole, blow out the hole with compressed air (min. 6 bar) a minimum of <b>two</b> times until return air stream is free of noticeable dust. If the drill hole ground is not reached, an extension must be used.
		Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush $\geq d_{b,min}$ (Table B4) a minimum of <b>two</b> times. If the drill hole ground is not reached with the brush, an appropriate brush extension must be used.
		Starting from the bottom or back of the drill hole, blow out the hole with compressed air (min. 6 bar) again a minimum of <b>two</b> times until return air stream is free of noticeable dust. If the drill hole ground is not reached, an extension must be used.

### 2 Manual cleaning

uncracked concrete, dry and wet drill holes; drill hole diameter  $d_0 \leq 20\text{mm}$  and drill hole depth  $h_0 \leq 10 d_{nom}$

2a		Starting from the bottom or back of the drill hole, blow out the hole with the blow-out pump a minimum of <b>four</b> times.
		Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush $\geq d_{b,min}$ (Table B4) a minimum of <b>four</b> times. If the drill hole ground is not reached with the brush, an appropriate brush extension must be used.
		Starting from the bottom or back of the drill hole blow out the hole again a minimum of <b>four</b> times.

After cleaning, the drill hole has to be protected against re-contamination in an appropriate way, until dispensing the mortar in the drill hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must not contaminate the drill hole again.

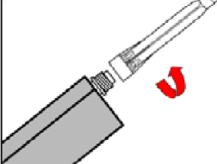
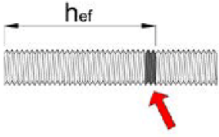
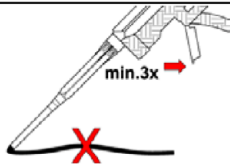
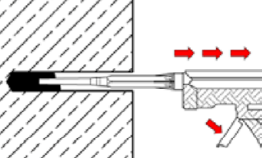
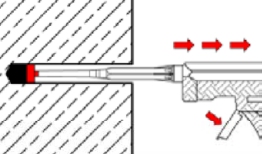
## Injection System VMH for concrete

**Intended Use**  
Installation instructions

**Annex B4**



## Installation instructions (continuation)

Injection		
3		Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time (Table B6) as well as for new cartridges, a new static-mixer shall be used.
4		Prior to inserting the rod into the filled drill hole, the position of the embedment depth shall be marked on the threaded rod or rebar
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.
6a		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 air pockets. If the drill hole ground is not reached, an appropriate extension nozzle shall be used. Observe working times given in Table B6.
6b		Retaining washer and mixer nozzle extensions shall be used according to Table B5 for the following applications: <ul style="list-style-type: none"> <li>• Horizontal installation (horizontal direction) and ground installation (vertical downwards direction): Drill bit-<math>\varnothing d_0 \geq 18 \text{ mm}</math> and anchorage depth <math>h_{ef} &gt; 250 \text{ mm}</math></li> <li>• Overhead installation: Drill bit-<math>\varnothing d_0 \geq 18 \text{ mm}</math></li> </ul>

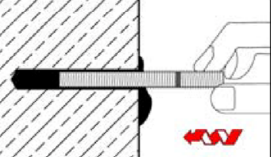
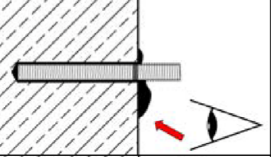
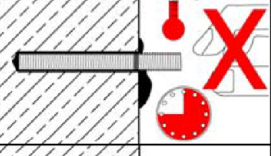
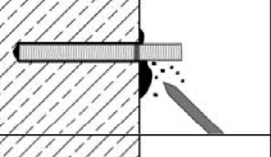
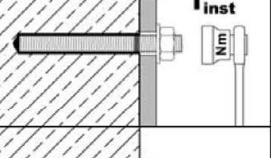
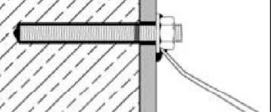
Injection System VMH for concrete

Intended Use

Installation instructions (continuation)

Annex B5

## Installation instructions (continuation)

Inserting the anchor		
7		<p>Push the fastening element into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached.</p> <p>The anchor shall be free of dirt, grease, oil or other foreign material.</p>
8		<p>After installation, the annular gap between anchor rod and concrete must be completely filled with mortar, in the case of push-through installation also in the fixture. If these requirements are not fulfilled, repeat application before end of working time!</p> <p>For overhead installation, the anchor should be fixed (e.g. by wedges).</p>
9		<p>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 B6).</p>
10		<p>Remove excess mortar.</p>
11		<p>The fixture can be mounted after curing time. Apply installation torque <math>T_{inst}</math> according to Table B1 or B2.</p>
12		<p>In case of pre-setting installation, the annular gap between anchor rod and fixture may optionally be filled with mortar. Therefore, replace regular washer by washer with bore and plug on reducing adapter on static mixer.</p> <p>Annular gap is completely filled, when excess mortar seeps out.</p>

**Table B6: Working time and curing time**

Concrete temperature	Working time	Minimum curing time	
		dry concrete	wet concrete
-5°C to -1°C	50 min	5 h	10 h
0°C to +4°C	25 min	3,5 h	7 h
+5°C to +9°C	15 min	2 h	4 h
+10°C to +14°C	10 min	1 h	2 h
+15°C to +19°C	6 min	40 min	80 min
+20°C to +29°C	3 min	30 min	60 min
+30°C to +40°C	2 min	30 min	60 min
Cartridge temperature	+ 5°C to + 40°C		

### Injection System VMH for concrete

#### Intended Use

Installation instructions (continuation)  
Working and curing time

**Annex B6**

**Table C1: Characteristic steel resistance for threaded rods under tension load**

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Cross sectional area $A_s$ [mm <sup>2</sup> ]				36,6	58,0	84,3	157	245	353	459	561
Characteristic resistance under tension load <sup>1)</sup>											
Steel, zinc plated	Property class 4.6 and 4.8	$N_{Rk,s}$	[kN]	15 (13)	23 (21)	34	63	98	141	184	224
	Property class 5.6 and 5.8	$N_{Rk,s}$	[kN]	18 (17)	29 (27)	42	78	122	176	230	280
	Property class 8.8	$N_{Rk,s}$	[kN]	29 (27)	46 (43)	67	125	196	282	368	449
Stainless steel	A2, A4 and HCR Property class 50	$N_{Rk,s}$	[kN]	18	29	42	79	123	177	230	281
	A2, A4 and HCR Property class 70	$N_{Rk,s}$	[kN]	26	41	59	110	171	247	-	-
	A4 and HCR Property class 80	$N_{Rk,s}$	[kN]	29	46	67	126	196	282	-	-
Partial factor <sup>2)</sup>											
Steel, zinc plated	Property class 4.6	$\gamma_{Ms,N}$	[-]	2,0							
	Property class 4.8	$\gamma_{Ms,N}$	[-]	1,5							
	Property class 5.6	$\gamma_{Ms,N}$	[-]	2,0							
	Property class 5.8	$\gamma_{Ms,N}$	[-]	1,5							
	Property class 8.8	$\gamma_{Ms,N}$	[-]	1,5							
Stainless steel	A2, A4 and HCR Property class 50	$\gamma_{Ms,N}$	[-]	2,86							
	A2, A4 and HCR Property class 70	$\gamma_{Ms,N}$	[-]	1,87						-	-
	A4 and HCR Property class 80	$\gamma_{Ms,N}$	[-]	1,6						-	-

<sup>1)</sup> The characteristic resistances apply for all anchor rods with the cross sectional area  $A_s$  specified here: VMU-A, V-A, VM-A  
For commercial standard threaded rods with a smaller cross sectional area (e.g. hot-dip galvanized threaded rods M8, M10 according to EN ISO 10684:2004 + AC:2009), the values in brackets are valid.

<sup>2)</sup> In absence of other national regulations

#### Injection System VMH for concrete

#### Performance

Characteristic values for **threaded rods** under **tension loads**

**Annex C1**



**Table C2: Characteristic steel resistance for threaded rods under shear load**

Threaded rod				M 8	M 10	M 12	M 16	M 20	M 24	M 27	M 30	
Steel failure												
Cross sectional area				A <sub>s</sub> [mm²]	36,5	58,0	84,3	157	245	353	459	561
Characteristic resistances under shear load <sup>1)</sup>												
Steel failure <u>without</u> lever arm												
Steel, zinc plated	Property class 4.6 and 4.8	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	9 (8)	14 (13)	20	38	59	85	110	135	
	Property class 5.6 and 5.8	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	11 (10)	17 (16)	25	47	74	106	138	168	
	Property class 8.8	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	15 (13)	23 (21)	34	63	98	141	184	224	
Stainless steel	A2, A4 and HCR, property class 50	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	9	15	21	39	61	88	115	140	
	A2, A4 and HCR, property class 70	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	13	20	30	55	86	124	-	-	
	A4 and HCR, property class 80	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	15	23	34	63	98	141	-	-	
Steel failure <u>with</u> lever arm												
Steel, zinc plated	Property class 4.6 and 4.8	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	15 (13)	30 (27)	52	133	260	449	666	900	
	Property class 5.6 and 5.8	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	19 (16)	37 (33)	65	166	324	560	833	1123	
	Property class 8.8	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	30 (26)	60 (53)	105	266	519	896	1333	1797	
Stainless steel	A2, A4 and HCR, property class 50	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	19	37	66	167	325	561	832	1125	
	A2, A4 and HCR, property class 70	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	26	52	92	232	454	784	-	-	
	A4 and HCR, property class 80	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	30	59	105	266	519	896	-	-	
Partial factor <sup>2)</sup>												
Steel, zinc plated	Property class 4.6	γ <sub>Ms,V</sub>	[-]	1,67								
	Property class 4.8	γ <sub>Ms,V</sub>	[-]	1,25								
	Property class 5.6	γ <sub>Ms,V</sub>	[-]	1,67								
	Property class 5.8	γ <sub>Ms,V</sub>	[-]	1,25								
	Property class 8.8	γ <sub>Ms,V</sub>	[-]	1,25								
Stainless steel	A2, A4 and HCR, property class 50	γ <sub>Ms,V</sub>	[-]	2,38								
	A2, A4 and HCR, property class 70	γ <sub>Ms,V</sub>	[-]	1,56						-	-	
	A4 and HCR, property class 80	γ <sub>Ms,V</sub>	[-]	1,33						-	-	

<sup>1)</sup> The characteristic resistances apply for all anchor rods with the cross sectional area  $A_s$  specified here: VMU-A, V-A, VM-A  
For commercial standard threaded rods with a smaller cross sectional area (e.g. hot-dip galvanized threaded rods M8, M10 according to EN ISO 10684:2004 + AC:2009), the values in brackets are valid

<sup>2)</sup> In absence of other national regulations

### Injection System VMH for concrete

#### Performance

Characteristic values for **threaded rods** under **shear loads**

### Annex C2

**Table C3:** Characteristic values of **tension loads** for **threaded rods**  
under static or quasi-static action

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Characteristic resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$ or see Table C1							
Partial factor		$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure											
Characteristic bond resistance in <u>uncracked</u> concrete C20/25											
Temperature range I:		80°C / 50°C	$\tau_{Rk,ucr}$ [N/mm²]	17	17	16	15	14	13	13	13
Temperature range II:		120°C / 72°C	$\tau_{Rk,ucr}$ [N/mm²]	15	14	14	13	12	12	11	11
Temperature range III:		160°C / 100°C	$\tau_{Rk,ucr}$ [N/mm²]	12	11	11	10	9,5	9,0	9,0	9,0
Characteristic bond resistance in <u>cracked</u> concrete C20/25											
Temperature range I:		80°C / 50°C	$\tau_{Rk,cr}$ [N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
Temperature range II:		120°C / 72°C	$\tau_{Rk,cr}$ [N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
Temperature range III:		160°C / 100°C	$\tau_{Rk,cr}$ [N/mm²]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
Reduction factor $\psi^0_{sus}$ in concrete C20/25											
Temperature range I:		80°C / 50°C	$\psi^0_{sus}$	[-]	0,79						
Temperature range II:		120°C / 72°C	$\psi^0_{sus}$	[-]	0,75						
Temperature range III:		160°C / 100°C	$\psi^0_{sus}$	[-]	0,66						
Increasing factors for concrete			$\psi_c$	C25/30	1,02						
				C30/37	1,04						
				C35/45	1,07						
				C40/50	1,08						
				C45/55	1,09						
				C50/60	1,10						
Concrete cone failure											
Factor $k_1$	uncracked concrete		$k_{ucr,N}$	[-]	11,0						
	cracked concrete		$k_{cr,N}$	[-]	7,7						
Splitting failure											
Edge distance	$h/h_{ef} \geq 2,0$		$c_{cr,sp}$	[mm]	$1,0 h_{ef}$						
	$2,0 > h/h_{ef} > 1,3$				$2 \cdot h_{ef} (2,5 - h / h_{ef})$						
	$h/h_{ef} \leq 1,3$				$2,4 h_{ef}$						
Spacing			$s_{cr,sp}$	[mm]	$2 c_{cr,sp}$						
Installation factor											
dry or wet concrete	Vacuum cleaning		$\gamma_{inst}$	[-]	1,2						
	Manual cleaning		$\gamma_{inst}$	[-]	1,2			NPA			
	Compressed air		$\gamma_{inst}$	[-]	1,0						
water filled drill hole		cleaning	$\gamma_{inst}$	[-]	1,4						

#### Injection System VMH for concrete

**Performance**  
Characteristic values of **tension loads** for **threaded rods**

**Annex C3**

**Table C4:** Characteristic values of **shear loads** for **threaded rods**  
under static or quasi-static action

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Steel failure <u>without</u> lever arm										
Characteristic resistance Steel, zinc plated Class 4.6, 4.8, 5.6 and 5.8	$V_{Rk,s}^0$	[kN]	$0,6 \cdot A_s \cdot f_{uk}$ or see Table C2							
Characteristic resistance Steel, zinc plated, class 8.8, stainless steel A2, A4 and HCR	$V_{Rk,s}^0$	[kN]	$0,5 \cdot A_s \cdot f_{uk}$ or see Table C2							
Ductility factor	$k_7$	[-]	1,0							
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C2							
Steel failure <u>with</u> lever arm										
Characteristic bending resistance	$M_{Rk,s}^0$	[Nm]	$1,2 \cdot W_{el} \cdot f_{uk}$ or see Table C2							
Elastic section modulus	$W_{el}$	[mm <sup>3</sup> ]	31	62	109	277	541	935	1387	1874
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C2							
Concrete pry-out failure										
Pry-out factor	$k_8$	[-]	2,0							
Concrete edge failure										
Effective length of anchor	$l_f$	[mm]	$\min (h_{ef}; 12 d_{nom})$						$\min (h_{ef}; 300\text{mm})$	
Outside diameter of anchor	$d_{nom}$	[mm]	8	10	12	16	20	24	27	30
Installation factor	$\gamma_{inst}$	[-]	1,0							

**Injection System VMH for concrete**

**Performance**  
Characteristic values of **shear loads** for **threaded rods**

**Annex C4**

**Table C5:** Characteristic values of **tesion loads** for **threaded rods**  
under **seismic action**, performance category **C1 + C2** <sup>1)</sup>

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Characteristic resistance		$N_{Rk,s,eq,C1}$	[kN]	$1,0 \cdot N_{Rk,s}$							
		$N_{Rk,s,eq,C2}$	[kN]	NPA		$1,0 \cdot N_{Rk,s}$				NPA	
Partial factor		$\gamma_{Ms,N}$	[-]	siehe Tabelle C1							
Combined pull-out and concrete failure											
Characteristic bond resistance											
Temperatur- range	I: 80°C / 50°C	$\tau_{Rk,eq,C1}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
		$\tau_{Rk,eq,C2}$	[N/mm²]	NPA		3,6	3,5	3,3	2,3	NPA	
	II: 120°C / 72°C	$\tau_{Rk,eq,C1}$	[N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
		$\tau_{Rk,eq,C2}$	[N/mm²]	NPA		3,1	3,0	2,8	2,0	NPA	
	III: 160°C / 100°C	$\tau_{Rk,eq,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
		$\tau_{Rk,eq,C2}$	[N/mm²]	NPA		2,5	2,7	2,5	1,8	NPA	
Installation factor											
Compressed air cleaning	dry or wet concrete	$\gamma_{inst}$	[-]	$1,0$							
	water filled drill hole			$1,4$							
Vacuum cleaning	dry or wet concrete	$\gamma_{inst}$	[-]	$1,2$							

<sup>1)</sup> Materials and property classes according to Annex B1

**Table C6:** Characteristic values of **tesion loads** for **threaded rods**  
under **seismic action**, performance category **C1 + C2** <sup>1)</sup>

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure <u>without</u> lever arm											
Characteristic resistance	$V_{Rk,s,eq,C1}$	[kN]	$0,7 \cdot V^0_{Rk,s}$								
	$V_{Rk,s,eq,C2}$	[kN]	NPA			$0,7 \cdot V^0_{Rk,s}$				NPA	
Partial factor	$\gamma_{Ms,N}$	[-]	siehe Tabelle C2								
Steel failure <u>without</u> lever arm											
Charactersitic bending resistance	$M^0_{Rk,s,eq}$	[Nm]	No Performance Assessed (NPA)								
Installation factor	$\gamma_{inst}$	[-]	1,0								
Factor for anchorages	without hole clearance	$\alpha_{gap}$	[-]	1,0							
	with hole clearance between fastener and fixture	$\alpha_{gap}$	[-]	0,5							

<sup>1)</sup> Materials and property classes according to Annex B1

## Injection System VMH for concrete

### Performance

Characteristic values under **seismic action** for **threaded rods**

**Annex C5**

**Table C7:** Characteristic values of **tension loads** for **internally threaded anchor rod** under static or quasi-static action

Internally threaded anchor rod				VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20	
Steel failure <sup>1)</sup>										
Characteristic resistance, steel, zinc plated, property class	5.8	N <sub>Rk,s</sub>	[kN]	10	17	29	42	76	123	
	8.8	N <sub>Rk,s</sub>	[kN]	16	27	46	67	121	196	
Partial factor		γ <sub>Ms,N</sub>	[-]	1,5						
Characteristic resistance, stainless steel A4 / HCR, property class	70	N <sub>Rk,s</sub>	[kN]	14	26	41	59	110	124 <sup>2)</sup>	
Partial factor		γ <sub>Ms,N</sub>	[-]	1,87						2,86
Combined pull-out and concrete failure										
Characteristic bond resistance in <u>uncracked</u> concrete C20/25										
Temperature range	I: 80°C / 50°C	τ <sub>Rk,ucr</sub>	[N/mm <sup>2</sup> ]	17	16	15	14	13	13	
	II: 120°C / 72°C	τ <sub>Rk,ucr</sub>	[N/mm <sup>2</sup> ]	14	14	13	12	12	11	
	III: 160°C / 100°C	τ <sub>Rk,ucr</sub>	[N/mm <sup>2</sup> ]	11	11	10	9,5	9,0	9,0	
Characteristic bond resistance in <u>cracked</u> concrete C20/25										
Temperature range	I: 80°C / 50°C	τ <sub>Rk,cr</sub>	[N/mm <sup>2</sup> ]	7,5	8,0	9,0	8,5	7,0	7,0	
	II: 120°C / 72°C	τ <sub>Rk,cr</sub>	[N/mm <sup>2</sup> ]	6,5	7,0	7,5	7,0	6,0	6,0	
	III: 160°C / 100°C	τ <sub>Rk,cr</sub>	[N/mm <sup>2</sup> ]	5,5	6,0	6,5	6,0	5,5	5,5	
Reduction factor ψ <sup>0</sup> <sub>sus</sub> in concrete C20/25										
Temperature range	I: 80°C / 50°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,79						
	II: 120°C / 72°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,75						
	III: 160°C / 100°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,66						
Increasing factors for concrete		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						
Concrete cone failure										
Factor k <sub>1</sub>	uncracked concrete	k <sub>ucr,N</sub>	[-]	11,0						
	cracked concrete	k <sub>cr,N</sub>	[-]	7,7						
Splitting failure										
Edge distance	h/h <sub>ef</sub> ≥ 2,0	c <sub>cr,sp</sub>	[mm]	1,0 h <sub>ef</sub>						
	2,0> h/h <sub>ef</sub> > 1,3			2 • h <sub>ef</sub> (2,5 – h / h <sub>ef</sub> )						
	h/h <sub>ef</sub> ≤ 1,3			2,4 h <sub>ef</sub>						
Spacing		s <sub>cr,sp</sub>	[mm]	2 c <sub>cr,sp</sub>						
Installation factor										
dry or wet concrete	vaccum cleaning	γ <sub>inst</sub>	[-]	1,2						
	manual cleaning	γ <sub>inst</sub>	[-]	1,2			NPA			
	compressed air	γ <sub>inst</sub>	[-]	1,0						
waterfilled drill hole	cleaning	γ <sub>inst</sub>	[-]	1,2						

<sup>1)</sup> Fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod. The characteristic tension resistance for steel failure of the given strength class are valid for the internally threaded anchor rod and the fastening element

<sup>2)</sup> For VMU-IG M20: property class 50

#### Injection System VMH for concrete

#### Performance

Characteristic values of **tension loads** for **internally threaded anchor rod**

**Annex C6**

**Table C8:** Characteristic values of **shear loads** for **internally threaded anchor rod** under static or quasi-static action

Internally threaded anchor rod					VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20	
Steel failure <u>without</u> lever arm <sup>1)</sup>											
Steel, zinc plated	Characteristic resistance	property class 5.8	$V_{Rk,s}^0$	[kN]	5	9	15	21	38	61	
	Characteristic resistance	property class 8.8	$V_{Rk,s}^0$	[kN]	8	14	23	34	60	98	
	Partial factor		$\gamma_{Ms,V}$	[-]	1,25						
Stainless steel	Characteristic resistance A4 / HCR	property class 70	$V_{Rk,s}^0$	[kN]	7	13	20	30	55	62 <sup>2)</sup>	
	Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38	
Ductility factor				k <sub>7</sub>	[-]	1,0					
Steel failure <u>with</u> lever arm <sup>1)</sup>											
Steel, zinc plated	Characteristic bending resistance	property class 5.8	$M_{Rk,s}^0$	[Nm]	8	19	37	66	167	325	
	Characteristic bending resistance	property class 8.8	$M_{Rk,s}^0$	[Nm]	12	30	60	105	267	519	
	Partial factor		$\gamma_{Ms,V}$	[-]	1,25						
Stainless steel	Characteristic bending resistance A4 / HCR	property class 70	$M_{Rk,s}^0$	[Nm]	11	26	53	92	234	643 <sup>2)</sup>	
	Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38	
Concrete pry-out failure											
Pry-out factor				k <sub>8</sub>	[-]	2,0					
Concrete edge failure											
Effective length of anchor				l <sub>f</sub>	[mm]	min (h <sub>ef</sub> ; 12 d <sub>nom</sub> )					min (h <sub>ef</sub> ; 300mm)
Outside diameter of anchor				d <sub>nom</sub>	[mm]	10	12	16	20	24	30
Installation factor				$\gamma_{inst}$	[-]	1,0					

<sup>1)</sup> Fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod (exception: VMU-IG M20). The characteristic shear resistance for steel failure of the given strength class are valid for the internally threaded anchor rod and the fastening element

<sup>2)</sup> For VMU-IG M20: Internally threaded rod: property class 50;  
Fastening screws or threaded rods (incl. nut and washer): property class 70

#### Injection System VMH for concrete

#### Performance

Characteristic values of **shear loads** for **internally threaded anchor rod**

**Annex C7**



**Table C9:** Characteristic values of **tension loads** for **rebar** under static or quasi-static action

Reinforcing bar				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure													
Characteristic resistance		N <sub>Rk,s</sub>	[kN]	A <sub>s</sub> • f <sub>uk</sub> <sup>1)</sup>									
Cross sectional area		A <sub>s</sub>	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor		γ <sub>Ms,N</sub>	[-]	1,4 <sup>2)</sup>									
Combined pull-out and concrete failure													
Characteristic bond resistance in <u>uncracked</u> concrete C20/25													
Temperature range	I: 80°C / 50°C	τ <sub>Rk,ucr</sub>	[N/mm²]	14	14	14	14	13	13	13	13	13	13
	II: 120°C / 72°C	τ <sub>Rk,ucr</sub>	[N/mm²]	13	12	12	12	12	11	11	11	11	11
	III: 160°C / 100°C	τ <sub>Rk,ucr</sub>	[N/mm²]	9,5	9,5	9,5	9,0	9,0	9,0	9,0	9,0	8,5	8,5
Characteristic bond resistance in <u>cracked</u> concrete C20/25													
Temperature range	I: 80°C / 50°C	τ <sub>Rk,cr</sub>	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
	II: 120°C / 72°C	τ <sub>Rk,cr</sub>	[N/mm²]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
	III: 160°C / 100°C	τ <sub>Rk,cr</sub>	[N/mm²]	4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Reduction factor ψ <sup>0</sup> <sub>sus</sub> in concrete C20/25													
Temperature range	I: 80°C / 50°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,79									
	II: 120°C / 72°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,75									
	III: 160°C / 100°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,66									
Increasing factor for concrete			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								
Concrete cone failure													
Factor k <sub>1</sub>	uncracked concrete	k <sub>ucr,N</sub>	[-]	11,0									
	cracked concrete	k <sub>cr,N</sub>	[-]	7,7									
Splitting failure													
Edge distance	h/h <sub>ef</sub> ≥ 2,0	c <sub>cr,sp</sub>	[mm]	1,0 h <sub>ef</sub>									
	2,0> h/h <sub>ef</sub> > 1,3			2 • h <sub>ef</sub> (2,5 – h / h <sub>ef</sub> )									
	h/h <sub>ef</sub> ≤ 1,3			2,4 h <sub>ef</sub>									
Spacing		s <sub>cr,sp</sub>	[mm]	2 c <sub>cr,sp</sub>									
Installation factor													
dry or wet concrete	vacuum cleaning	γ <sub>inst</sub>	[-]	1,2									
	manual cleaning	γ <sub>inst</sub>	[-]	1,2					NPA				
	compressed air	γ <sub>inst</sub>	[-]	1,0									
waterfilled drill hole	cleaning	γ <sub>inst</sub>	[-]	1,4									

<sup>1)</sup>  $f_{uk}$  shall be taken from the specifications of reinforcing bars

<sup>2)</sup> in absence of national regulation

### Injection System VMH for concrete

#### Performance

Characteristic values of **tension loads** for **rebar**

**Annex C8**

**Table C10:** Characteristic values of **shear loads** for **rebar** under static or quasi-static action

Reinforcing bar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure <u>without</u> lever arm												
Characteristic shear resistance	$V_{Rk,s}^0$	[kN]	$0,50 \cdot A_s \cdot f_{uk}^{1)}$									
Cross sectional area	$A_s$	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor	$\gamma_{Ms,V}$	[-]	$1,5^{2)}$									
Ductility factor	$k_7$	[-]	$1,0$									
Steel failure <u>with</u> lever arm												
Characteristic bending resistance	$M_{Rk,s}^0$	[Nm]	$1,2 \cdot W_{el} \cdot f_{uk}^{1)}$									
Elastic section modulus	$W_{el}$	[mm³]	50	98	170	269	402	785	1357	1534	2155	3217
Partial factor	$\gamma_{Ms,V}$	[-]	$1,5^{2)}$									
Concrete pry-out failure												
Pry-out Factor	$k_8$	[-]	$2,0$									
Concrete edge failure												
Effective length of rebar	$l_f$	[mm]	$\min (h_{ef}; 12 d_{nom})$							$\min (h_{ef}; 300mm)$		
Outside diameter of rebar	$d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Installation factor	$\gamma_{inst}$	[-]	$1,0$									

<sup>1)</sup>  $f_{uk}$  shall be taken from the specifications of reinforcing bars

<sup>2)</sup> in absence of national regulation

**Injection System VMH for concrete**

**Performance**

Characteristic values of **shear loads** for **rebar**

**Annex C9**

**Table C11:** Characteristic values of **tension loads** for **rebar** under **seismic action**, performance category **C1**

Reinforcing bar				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure													
Characteristic resistance		$N_{Rk,s,eq,C1}$	[kN]	$A_s \cdot f_{uk}^{1)}$									
Cross sectional area		$A_s$	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor		$\gamma_{Ms,N}$	[-]	$1,4^{2)}$									
Combined pull-out and concrete failure													
Characteristic bond resistance in concrete C20/25													
Temperature range	I: 80°C / 50°C	$\tau_{Rk,eq,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
	II: 120°C / 72°C	$\tau_{Rk,eq,C1}$	[N/mm²]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
	III: 160°C / 100°C	$\tau_{Rk,eq,C1}$	[N/mm²]	4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Installation factor													
dry or wet concrete	vacuum cleaning	$\gamma_{inst}$	[-]	1,2									
	compressed air	$\gamma_{inst}$	[-]	1,0									
waterfilled drill hole	cleaning	$\gamma_{inst}$	[-]	1,4									

<sup>1)</sup>  $f_{uk}$  shall be taken from the specifications of reinforcing bars

<sup>2)</sup> in absence of national regulation

**Table C12:** Characteristic values of **shear loads** for **rebar** under **seismic action**, performance category **C1**

Reinforcing bar	Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32		
Steel failure <u>without</u> lever arm												
Characteristic resistance	$V^0_{Rk,s,eq,C1}$	[kN]	$0,35 \cdot A_s \cdot f_{uk}^{1)}$									
Cross sectional area	$A_s$	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor	$\gamma_{Ms,V}$	[-]	$1,5^{2)}$									
Ductility factor	$k_7$	[-]	1,0									
Steel failure <u>with</u> lever arm												
Characteristic bending resistance	$M^0_{Rk,s,eq,C1}$	[Nm]	No Performance Assesd (NPA)									
Installation factor	$\gamma_{inst}$	[-]	1,0									

<sup>1)</sup>  $f_{uk}$  shall be taken from the specifications of reinforcing bars

<sup>2)</sup> in absence of national regulation

## Injection System VMH for concrete

### Performance

Characteristic values under **seismic action** for **rebar**

**Annex C10**

**Table C13: Displacements under tension load** (threaded rod)

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
<b>Displacement factor<sup>1)</sup> for uncracked concrete under static and quasi-static action</b>										
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,031	0,032	0,034	0,037	0,039	0,042	0,044	0,046
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,040	0,042	0,044	0,047	0,051	0,054	0,057	0,060
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,032	0,034	0,035	0,038	0,041	0,044	0,046	0,048
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,042	0,044	0,045	0,049	0,053	0,056	0,059	0,062
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,121	0,126	0,131	0,142	0,153	0,163	0,171	0,179
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,124	0,129	0,135	0,146	0,157	0,168	0,176	0,184
<b>Displacement factor<sup>1)</sup> for cracked concrete under static and quasi-static action</b>										
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,081	0,083	0,085	0,090	0,095	0,099	0,103	0,106
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,104	0,107	0,110	0,116	0,122	0,128	0,133	0,137
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,084	0,086	0,088	0,093	0,098	0,103	0,107	0,110
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,108	0,111	0,114	0,121	0,127	0,133	0,138	0,143
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,312	0,321	0,330	0,349	0,367	0,385	0,399	0,412
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,321	0,330	0,340	0,358	0,377	0,396	0,410	0,424
<b>Cracked concrete under seismic action (C2)</b>										
All temperature ranges	$\delta_{N,eq}$ (DLS)	[mm]	NPA	0,24		0,27	0,29	0,27	NPA	
	$\delta_{N,eq}$ (ULS)	[mm]		0,55		0,51	0,50	0,58		

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

$$\delta_{N0} = \delta_{N0}\text{-factor} \cdot \tau;$$

$\tau$ : acting bond stress for tension

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

**Table C14: Displacements under shear load** (threaded rod)

Threaded rod			M 8	M 10	M 12	M 16	M 20	M24	M 27	M 30
<b>Displacement factor<sup>1)</sup> for concrete under static and quasi-static action</b>										
All temperature ranges	$\delta_{V0}$ -Faktor	[mm/(kN)]	0,06	0,06	0,05	0,04	0,04	0,03	0,03	0,03
	$\delta_{V\infty}$ -Faktor	[mm/(kN)]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05
<b>Cracked concrete under seismic action (C2)</b>										
All temperature ranges	$\delta_{V,eq}$ (DLS)	[mm]	NPA	3,6		3,0	3,1	3,5	NPA	
	$\delta_{V,eq}$ (ULS)	[mm]		7,0		6,6	7,0	9,3		

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

$$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V;$$

V: acting shear load

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

### Injection System VMH for concrete

**Performance**  
Displacements (threaded rod)

**Annex C11**

**Table C15: Displacements under tension load** (internally threaded anchor rod)

Internally threaded anchor rod			VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20
<b>Displacement factor<sup>1)</sup> for uncracked concrete under static and quasi-static action</b>								
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,032	0,034	0,037	0,039	0,042	0,046
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,042	0,044	0,047	0,051	0,054	0,060
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,034	0,035	0,038	0,041	0,044	0,048
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,044	0,045	0,049	0,053	0,056	0,062
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,126	0,131	0,142	0,153	0,163	0,179
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,129	0,135	0,146	0,157	0,168	0,184
<b>Displacement factor<sup>1)</sup> for cracked concrete under static and quasi-static action</b>								
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,083	0,085	0,090	0,095	0,099	0,106
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,107	0,110	0,116	0,122	0,128	0,137
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,086	0,088	0,093	0,098	0,103	0,110
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,111	0,114	0,121	0,127	0,133	0,143
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,321	0,330	0,349	0,367	0,385	0,412
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,330	0,340	0,358	0,377	0,396	0,424

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

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

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

**Table C16: Displacements under shear load** (internally threaded anchor rod)

Internally threaded anchor rod			VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20
<b>Displacement factor<sup>1)</sup> under static and quasi-static action</b>								
All temperature ranges	$\delta_{V0}$ -factor	[mm/(kN)]	0,07	0,06	0,06	0,05	0,04	0,04
	$\delta_{V\infty}$ -factor	[mm/(kN)]	0,10	0,09	0,08	0,08	0,06	0,06

<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 System VMH for concrete**

**Performance**  
Displacements (internally threaded anchor rod)

**Annex C12**

**Table C17: Displacements under tension load (rebar)**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
<b>Displacement factor<sup>1)</sup> for uncracked concrete under static and quasi-static action</b>												
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,031	0,032	0,034	0,035	0,037	0,039	0,042	0,043	0,045	0,048
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,040	0,042	0,044	0,045	0,047	0,051	0,054	0,055	0,058	0,063
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,032	0,034	0,035	0,036	0,038	0,041	0,044	0,045	0,047	0,050
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,042	0,044	0,045	0,047	0,049	0,053	0,056	0,057	0,060	0,065
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,121	0,126	0,131	0,137	0,142	0,153	0,163	0,164	0,172	0,186
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,124	0,129	0,135	0,141	0,146	0,157	0,168	0,169	0,177	0,192
<b>Displacement factor<sup>1)</sup> for cracked concrete under static and quasi-static action</b>												
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,081	0,083	0,085	0,087	0,090	0,095	0,099	0,099	0,103	0,108
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,104	0,107	0,110	0,113	0,116	0,122	0,128	0,128	0,133	0,141
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,084	0,086	0,088	0,090	0,093	0,098	0,103	0,103	0,107	0,113
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,108	0,111	0,114	0,118	0,121	0,127	0,133	0,133	0,138	0,148
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,312	0,321	0,330	0,340	0,349	0,367	0,385	0,385	0,399	0,425
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,321	0,330	0,340	0,349	0,358	0,377	0,396	0,396	0,410	0,449

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

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

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

**Table C18: Displacements under shear load (rebar)**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
<b>Displacement factor<sup>1)</sup> under static and quasi-static action</b>												
All temperature ranges	$\delta_{V0}$ -factor	[mm/(kN)]	0,06	0,05	0,05	0,04	0,04	0,04	0,03	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	0,04	0,04

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

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

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

**Injection System VMH for concrete**

**Performance**  
Displacements (rebar)

**Annex C13**



## Specification of intended use

Injection System VMH		Threaded rod	Internally threaded anchor rod	Rebar
Static or quasi-static action		M8 - M30 zinc plated, A2, A4, HCR	VMU-IG M6 - VMU-IG M20 zinc plated <sup>1)</sup> , A4, HCR	Ø8 - Ø32
Seismic action	performance category C1	M8 - M30 zinc plated <sup>1)</sup> , A4, HCR	-	Ø8 - Ø32
	performance category C2	M12 – M24 zinc plated <sup>1)</sup> (property class 8.8) A4, HCR (property class ≥ 70)	-	-
Base materials		compacted, reinforced or unreinforced normal weight concrete (without fibers) acc. to EN 206:2013		
		strength classes acc. to EN 206:2013: C20/25 to C50/60		
		cracked or uncracked concrete		
Temperature Range I	-40 °C to +80 °C	max. long term temperature +50 °C and max. short term temperature +80 °C		
Temperature Range II	-40 °C to +120 °C	max. long term temperature +72 °C and max. short term temperature +120 °C		
Temperature Range III	-40 °C to +160 °C	max. long term temperature +100 °C and max. short term temperature +160 °C		

<sup>1)</sup> except hot-dip galvanised

### Use conditions (Environmental conditions):

- Structures subject to dry internal conditions (all materials).
- For all other conditions according to EN 1993-1-4:2006+A1:2015 corresponding to corrosion resistance classes:
  - Stainless steel A2 according to Annex A4, Table A1: CRC II
  - Stainless steel A4 according to Annex A4, Table A1: CRC III
  - High corrosion resistant steel HCR according to Annex A4, Table A1: CRC V

### 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 are designed in accordance with EN 1992-4:2018 or Technical Report TR 055

### Installation:

- Dry or wet concrete or waterfilled drill holes (not seawater)
- Hole drilling by hammer or compressed air drill or vacuum drill mode
- Overhead installation allowed
- Anchor installation carried out by appropriately qualified personnel and under the responsibility of the person competent for technical matters on site
- Internally threaded anchor rod: Screws and threaded rods (incl. nut and washer) must at least correspond to the material and strength class of the internally threaded anchor rod used

## Injection System VMH for concrete

**Intended Use**  
Specifications

**Annex B1**

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

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Diameter of threaded rod	$d=d_{nom}$	[mm]	8	10	12	16	20	24	27	30
Nominal drill hole diameter	$d_0$	[mm]	10	12	14	18	22	28	30	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 <sup>2)</sup>	Pre-setting installation $d_f \leq$	[mm]	9	12	14	18	22	26	30	33
	Through setting installation $d_f \leq$	[mm]	12	14	16	20	24	30	33	40
Installation torque	$T_{inst} \leq$	[Nm]	10	20	40 (35) <sup>1)</sup>	60	100	170	250	300
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	75	95	115	125	140
Minimum edge distance	$c_{min}$	[mm]	35	40	45	50	60	65	75	80

<sup>1)</sup> Installation torque for M12 with steel grade 4.6

<sup>2)</sup> For applications under seismic loading the diameter of clearance hole in the fixture shall be at maximum  $d_{nom} + 1 \text{ mm}$  or alternatively the annular gap between fixture and threaded rod shall be completely filled with mortar

**Table B2: Installation parameters for internally threaded anchor rods**

Internally threaded anchor rod			IG-M 6	IG-M 8	IG-M 10	IG-M 12	IG-M 16	IG-M 20
Inner diameter of threaded rod	$d_2$	[mm]	6	8	10	12	16	20
Outer diameter of threaded rod <sup>1)</sup>	$d=d_{nom}$	[mm]	10	12	16	20	24	30
Nominal drill hole diameter	$d_0$	[mm]	12	14	18	22	28	35
Effective anchorage depth	$h_{ef,min}$	[mm]	60	70	80	90	96	120
	$h_{ef,max}$	[mm]	200	240	320	400	480	600
Diameter of clearance hole in the fixture	$d_f \leq$	[mm]	7	9	12	14	18	22
Installation torque	$T_{inst} \leq$	[Nm]	10	10	20	40	60	100
Minimum screw-in depth	$l_{IG}$	[mm]	8	8	10	12	16	20
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]	50	60	75	95	115	140
Minimum edge distance	$c_{min}$	[mm]	40	45	50	60	65	80

<sup>1)</sup> With metric thread acc. to EN 1993-1-8:2005+AC:2009

**Table B3: Installation parameters for rebar**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Diameter of rebar	$d=d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Nominal drill hole diameter <sup>1)</sup>	$d_0$	[mm]	10   12	12   14	14   16	18	20	25	32	32	35	40
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	75	80	90	96	100	112	128
	$h_{ef,max}$	[mm]	160	200	240	280	320	400	480	500	560	640
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	75	95	120	120	130	150
Minimum edge distance	$c_{min}$	[mm]	35	40	45	50	50	60	70	70	75	85





<sup>1)</sup> For diameter Ø8, Ø10 and Ø12 both nominal drill hole diameter can be used

**Injection System VMH for concrete**



**Intended use**  
Installation parameters

**Annex B2**

**Table B4: Parameter cleaning and setting tools**

Threaded rod	Internally threaded anchor rod	Rebar	Drill bit Ø	Brush Ø	min. Brush Ø
					
[-]	[-]	Ø [mm]	d <sub>0</sub> [mm]	d <sub>b</sub> [mm]	d <sub>b,min</sub> [mm]
M8		8	10	11,5	10,5
M10	VMU-IG M 6	8 / 10	12	13,5	12,5
M12	VMU-IG M 8	10 / 12	14	15,5	14,5
		12	16	17,5	16,5
M16	VMU-IG M10	14	18	20,0	18,5
		16	20	22,0	20,5
M20	VMU-IG M12		22	24,0	22,5
		20	25	27,0	25,5
M24	VMU-IG M16		28	30,0	28,5
M27			30	31,8	30,5
		24/25	32	34,0	32,5
M30	VMU-IG M20	28	35	37,0	35,5
		32	40	43,5	40,5

**Table B5: Retaining washer**

Drill bit Ø		Installation direction and use		
				
d <sub>0</sub> [mm]	[-]	↓	→	↑
10	No retaining washer required			
12				
14				
16				
18	VM-IA 18	h <sub>ef</sub> > 250mm	h <sub>ef</sub> > 250mm	all
20	VM-IA 20			
22	VM-IA 22			
25	VM-IA 25			
28	VM-IA 28			
30	VM-IA 30			
32	VM-IA 32			
35	VM-IA 35			
40	VM-IA 40			


**Vacuum drill bit**

Drill bit diameter (d<sub>0</sub>): all diameters  
 Vacuum drill bit (MKT Hollow drill bit SB, Würth Saugbohrer or Heller Duster Expert) and a class M vacuum with minimum negative pressure of 253 hPa and a flow rate of minimum 42 l/s


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

Drill bit diameter (d<sub>0</sub>): all diameters


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

Drill bit diameter (d<sub>0</sub>): 10 mm to 20 mm  
 Drill hole depth (h<sub>0</sub>): ≤ 10 d<sub>nom</sub>  
 for uncracked concrete

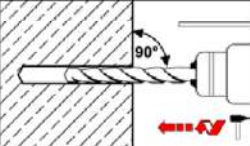
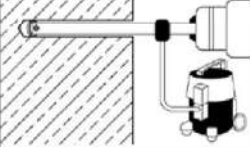
**Injection System VMH for concrete**

**Intended Use**  
 Cleaning and setting tools

**Annex B3**

# Installation Instructions

## Drilling of the hole

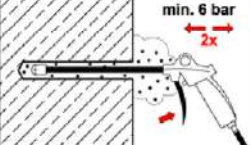
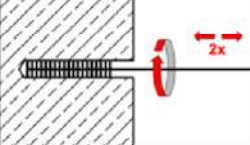
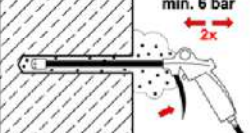
1	1a		<b>Hammer drill oder compressed air drill</b> Drill with hammer drill or compressed air drill a hole into the base material to the size required by the selected anchor (Table B1, B2 or B3). Continue with <u>step 2</u> . In case of aborted drill hole, the drill hole shall be filled with mortar.
	1b		<b>Vacuum drill bit:</b> see Annex B3 Drill hole into the base material to the embedment size and embedment depth required by the selected anchor (table B1, B2 or B3). This drilling system removes dust and cleans the drill hole during drilling. Continue with <u>step 3</u> . In case of aborted hole, the drill hole shall be filled with mortar.

## Cleaning (not applicable when using a vacuum drill)

**Attention! Standing water in the drill hole must be removed before cleaning!**


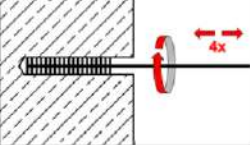

### Cleaning with compressed air

all substrates and diameters according to Annex B1

2	2a		Starting from the bottom or back of the drill hole, blow out the hole with compressed air (min. 6 bar) a minimum of <b>two</b> times until return air stream is free of noticeable dust. If the drill hole ground is not reached, an extension must be used.
	2b		Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush $\geq d_{b,min}$ (Table B4) a minimum of <b>two</b> times. If the drill hole ground is not reached with the brush, an appropriate brush extension must be used.
	2c		Starting from the bottom or back of the drill hole, blow out the hole with compressed air (min. 6 bar) again a minimum of <b>two</b> times until return air stream is free of noticeable dust. If the drill hole ground is not reached, an extension must be used.

### Manual cleaning

uncracked concrete, dry and wet drill holes; drill hole diameter  $d_0 \leq 20\text{mm}$  and drill hole depth  $h_0 \leq 10 d_{nom}$

2	2a		Starting from the bottom or back of the drill hole, blow out the hole with the blow-out pump a minimum of <b>four</b> times.
	2b		Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush $\geq d_{b,min}$ (Table B4) a minimum of <b>four</b> times. If the drill hole ground is not reached with the brush, an appropriate brush extension must be used.
	2c		Starting from the bottom or back of the drill hole blow out the hole again a minimum of <b>four</b> times.

After cleaning, the drill hole has to be protected against re-contamination in an appropriate way, until dispensing the mortar in the drill hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must not contaminate the drill hole again.

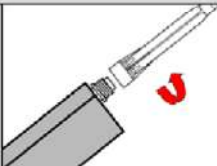
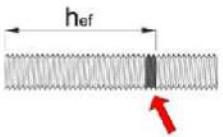
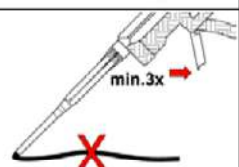
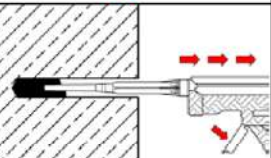
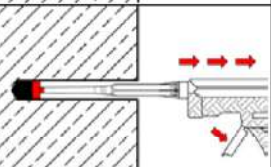
## Injection System VMH for concrete

### Intended Use

Installation instructions

**Annex B4**

## Installation instructions (continuation)

Injection		
3		Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time (Table B6) as well as for new cartridges, a new static-mixer shall be used.
4		Prior to inserting the rod into the filled drill hole, the position of the embedment depth shall be marked on the threaded rod or rebar
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.
6a		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 air pockets. If the drill hole ground is not reached, an appropriate extension nozzle shall be used. Observe working times given in Table B6.
6b		Retaining washer and mixer nozzle extensions shall be used according to Table B5 for the following applications: <ul style="list-style-type: none"> <li>• Horizontal installation (horizontal direction) and ground installation (vertical downwards direction): Drill bit-Ø <math>d_0 \geq 18</math> mm and anchorage depth <math>h_{ef} &gt; 250</math>mm</li> <li>• Overhead installation: Drill bit-Ø <math>d_0 \geq 18</math> mm</li> </ul>

Injection System VMH for concrete

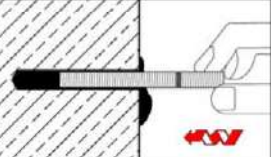
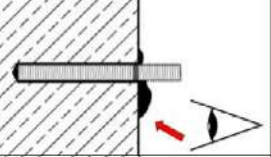
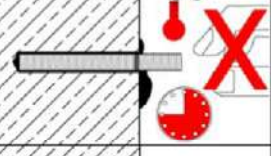
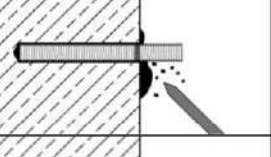
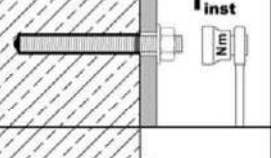
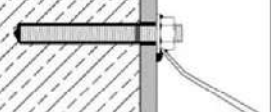
### Intended Use

Installation instructions (continuation)

Annex B5



## Installation instructions (continuation)

Inserting the anchor		
7		<p>Push the fastening element into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached.</p> <p>The anchor shall be free of dirt, grease, oil or other foreign material.</p>
8		<p>After installation, the annular gap between anchor rod and concrete must be completely filled with mortar, in the case of push-through installation also in the fixture. If these requirements are not fulfilled, repeat application before end of working time!</p> <p>For overhead installation, the anchor should be fixed (e.g. by wedges).</p>
9		<p>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 B6).</p>
10		<p>Remove excess mortar.</p>
11		<p>The fixture can be mounted after curing time. Apply installation torque <math>T_{inst}</math> according to Table B1 or B2.</p>
12		<p>In case of pre-setting installation, the annular gap between anchor rod and fixture may optionally be filled with mortar. Therefore, replace regular washer by washer with bore and plug on reducing adapter on static mixer.</p> <p>Annular gap is completely filled, when excess mortar seeps out.</p>

**Table B6: Working time and curing time**

Concrete temperature	Working time	Minimum curing time	
		dry concrete	wet concrete
-5°C to -1°C	50 min	5 h	10 h
0°C to +4°C	25 min	3,5 h	7 h
+5°C to +9°C	15 min	2 h	4 h
+10°C to +14°C	10 min	1 h	2 h
+15°C to +19°C	6 min	40 min	80 min
+20°C to +29°C	3 min	30 min	60 min
+30°C to +40°C	2 min	30 min	60 min
<b>Cartridge temperature</b>	<b>+ 5°C to + 40°C</b>		

### Injection System VMH for concrete

**Intended Use**  
 Installation instructions (continuation)  
 Working and curing time

**Annex B6**



**Table C1: Characteristic steel resistance for threaded rods under tension load**

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Cross sectional area $A_s$ [mm <sup>2</sup> ]				36,6	58,0	84,3	157	245	353	459	561
Characteristic resistance under tension load <sup>1)</sup>											
Steel, zinc plated	Property class 4.6 and 4.8	$N_{Rk,s}$	[kN]	15 (13)	23 (21)	34	63	98	141	184	224
	Property class 5.6 and 5.8	$N_{Rk,s}$	[kN]	18 (17)	29 (27)	42	78	122	176	230	280
	Property class 8.8	$N_{Rk,s}$	[kN]	29 (27)	46 (43)	67	125	196	282	368	449
Stainless steel	A2, A4 and HCR Property class 50	$N_{Rk,s}$	[kN]	18	29	42	79	123	177	230	281
	A2, A4 and HCR Property class 70	$N_{Rk,s}$	[kN]	26	41	59	110	171	247	-	-
	A4 and HCR Property class 80	$N_{Rk,s}$	[kN]	29	46	67	126	196	282	-	-
Partial factor <sup>2)</sup>											
Steel, zinc plated	Property class 4.6	$\gamma_{Ms,N}$	[-]	2,0							
	Property class 4.8	$\gamma_{Ms,N}$	[-]	1,5							
	Property class 5.6	$\gamma_{Ms,N}$	[-]	2,0							
	Property class 5.8	$\gamma_{Ms,N}$	[-]	1,5							
	Property class 8.8	$\gamma_{Ms,N}$	[-]	1,5							
Stainless steel	A2, A4 and HCR Property class 50	$\gamma_{Ms,N}$	[-]	2,86							
	A2, A4 and HCR Property class 70	$\gamma_{Ms,N}$	[-]	1,87						-	-
	A4 and HCR Property class 80	$\gamma_{Ms,N}$	[-]	1,6						-	-

<sup>1)</sup> The characteristic resistances apply for all anchor rods with the cross sectional area  $A_s$  specified here: VMU-A, V-A, VM-A  
For commercial standard threaded rods with a smaller cross sectional area (e.g. hot-dip galvanized threaded rods M8, M10 according to EN ISO 10684:2004 + AC:2009), the values in brackets are valid.

<sup>2)</sup> In absence of other national regulations

### Injection System VMH for concrete

#### Performance

Characteristic values for **threaded rods** under **tension loads**

**Annex C1**

**Table C2: Characteristic steel resistance for threaded rods under shear load**

Threaded rod				M 8	M 10	M 12	M 16	M 20	M 24	M 27	M 30	
Steel failure												
Cross sectional area				A <sub>s</sub> [mm²]	36,5	58,0	84,3	157	245	353	459	561
Characteristic resistances under shear load <sup>1)</sup>												
Steel failure <u>without</u> lever arm												
Steel, zinc plated	Property class 4.6 and 4.8	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	9 (8)	14 (13)	20	38	59	85	110	135	
	Property class 5.6 and 5.8	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	11 (10)	17 (16)	25	47	74	106	138	168	
	Property class 8.8	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	15 (13)	23 (21)	34	63	98	141	184	224	
Stainless steel	A2, A4 and HCR, property class 50	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	9	15	21	39	61	88	115	140	
	A2, A4 and HCR, property class 70	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	13	20	30	55	86	124	-	-	
	A4 and HCR, property class 80	V <sup>0</sup> <sub>Rk,s</sub>	[kN]	15	23	34	63	98	141	-	-	
Steel failure <u>with</u> lever arm												
Steel, zinc plated	Property class 4.6 and 4.8	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	15 (13)	30 (27)	52	133	260	449	666	900	
	Property class 5.6 and 5.8	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	19 (16)	37 (33)	65	166	324	560	833	1123	
	Property class 8.8	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	30 (26)	60 (53)	105	266	519	896	1333	1797	
Stainless steel	A2, A4 and HCR, property class 50	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	19	37	66	167	325	561	832	1125	
	A2, A4 and HCR, property class 70	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	26	52	92	232	454	784	-	-	
	A4 and HCR, property class 80	M <sup>0</sup> <sub>Rk,s</sub>	[Nm]	30	59	105	266	519	896	-	-	
Partial factor <sup>2)</sup>												
Steel, zinc plated	Property class 4.6	γ <sub>Ms,V</sub>	[-]	1,67								
	Property class 4.8	γ <sub>Ms,V</sub>	[-]	1,25								
	Property class 5.6	γ <sub>Ms,V</sub>	[-]	1,67								
	Property class 5.8	γ <sub>Ms,V</sub>	[-]	1,25								
	Property class 8.8	γ <sub>Ms,V</sub>	[-]	1,25								
Stainless steel	A2, A4 and HCR, property class 50	γ <sub>Ms,V</sub>	[-]	2,38								
	A2, A4 and HCR, property class 70	γ <sub>Ms,V</sub>	[-]	1,56						-	-	
	A4 and HCR, property class 80	γ <sub>Ms,V</sub>	[-]	1,33						-	-	

<sup>1)</sup> The characteristic resistances apply for all anchor rods with the cross sectional area  $A_s$  specified here: VMU-A, V-A, VM-A  
For commercial standard threaded rods with a smaller cross sectional area (e.g. hot-dip galvanized threaded rods M8, M10 according to EN ISO 10684:2004 + AC:2009), the values in brackets are valid

<sup>2)</sup> In absence of other national regulations

### Injection System VMH for concrete

#### Performance

Characteristic values for **threaded rods** under **shear loads**

**Annex C2**

**Table C3:** Characteristic values of **tension loads** for **threaded rods**  
under static or quasi-static action

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Characteristic resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$ or see Table C1							
Partial factor		$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure											
Characteristic bond resistance in <u>uncracked</u> concrete C20/25											
Temperature range I:		80°C / 50°C	$\tau_{Rk,ucr}$ [N/mm²]	17	17	16	15	14	13	13	13
Temperature range II:		120°C / 72°C	$\tau_{Rk,ucr}$ [N/mm²]	15	14	14	13	12	12	11	11
Temperature range III:		160°C / 100°C	$\tau_{Rk,ucr}$ [N/mm²]	12	11	11	10	9,5	9,0	9,0	9,0
Characteristic bond resistance in <u>cracked</u> concrete C20/25											
Temperature range I:		80°C / 50°C	$\tau_{Rk,cr}$ [N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
Temperature range II:		120°C / 72°C	$\tau_{Rk,cr}$ [N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
Temperature range III:		160°C / 100°C	$\tau_{Rk,cr}$ [N/mm²]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
Reduction factor $\psi^0_{sus}$ in concrete C20/25											
Temperature range I:		80°C / 50°C	$\psi^0_{sus}$	[-]	0,79						
Temperature range II:		120°C / 72°C	$\psi^0_{sus}$	[-]	0,75						
Temperature range III:		160°C / 100°C	$\psi^0_{sus}$	[-]	0,66						
Increasing factors for concrete			$\psi_c$	C25/30	1,02						
				C30/37	1,04						
				C35/45	1,07						
				C40/50	1,08						
				C45/55	1,09						
				C50/60	1,10						
Concrete cone failure											
Factor $k_1$	uncracked concrete		$k_{ucr,N}$	[-]	11,0						
	cracked concrete		$k_{cr,N}$	[-]	7,7						
Splitting failure											
Edge distance	$h/h_{ef} \geq 2,0$		$c_{cr,sp}$	[mm]	$1,0 h_{ef}$						
	$2,0 > h/h_{ef} > 1,3$				$2 \cdot h_{ef} (2,5 - h / h_{ef})$						
	$h/h_{ef} \leq 1,3$				$2,4 h_{ef}$						
Spacing			$s_{cr,sp}$	[mm]	$2 c_{cr,sp}$						
Installation factor											
dry or wet concrete	Vacuum cleaning		$\gamma_{inst}$	[-]	1,2						
	Manual cleaning		$\gamma_{inst}$	[-]	1,2			NPA			
	Compressed air		$\gamma_{inst}$	[-]	1,0						
water filled drill hole		cleaning	$\gamma_{inst}$	[-]	1,4						

#### Injection System VMH for concrete

**Performance**  
Characteristic values of **tension loads** for **threaded rods**

**Annex C3**

**Table C4:** Characteristic values of **shear loads** for **threaded rods**  
under static or quasi-static action

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Steel failure <u>without</u> lever arm										
Characteristic resistance Steel, zinc plated Class 4.6, 4.8, 5.6 and 5.8	$V_{Rk,s}^0$	[kN]	0,6 · A <sub>s</sub> · f <sub>uk</sub> or see Table C2							
Characteristic resistance Steel, zinc plated, class 8.8, stainless steel A2, A4 and HCR	$V_{Rk,s}^0$	[kN]	0,5 · A <sub>s</sub> · f <sub>uk</sub> or see Table C2							
Ductility factor	k <sub>7</sub>	[-]	1,0							
Partial factor	γ <sub>Ms,V</sub>	[-]	see Table C2							
Steel failure <u>with</u> lever arm										
Characteristic bending resistance	$M_{Rk,s}^0$	[Nm]	1,2 · W <sub>el</sub> · f <sub>uk</sub> or see Table C2							
Elastic section modulus	W <sub>el</sub>	[mm <sup>3</sup> ]	31	62	109	277	541	935	1387	1874
Partial factor	γ <sub>Ms,V</sub>	[-]	see Table C2							
Concrete pry-out failure										
Pry-out factor	k <sub>8</sub>	[-]	2,0							
Concrete edge failure										
Effective length of anchor	l <sub>f</sub>	[mm]	min (h <sub>ef</sub> ; 12 d <sub>nom</sub> )						min (h <sub>ef</sub> ; 300mm)	
Outside diameter of anchor	d <sub>nom</sub>	[mm]	8	10	12	16	20	24	27	30
Installation factor	γ <sub>insl</sub>	[-]	1,0							

**Injection System VMH for concrete**

**Performance**  
Characteristic values of **shear loads** for **threaded rods**

**Annex C4**

**Table C5:** Characteristic values of **tesion loads** for **threaded rods**  
under **seismic action**, performance category **C1 + C2** <sup>1)</sup>

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Characteristic resistance		$N_{Rk,s,eq,C1}$	[kN]	$1,0 \cdot N_{Rk,s}$							
		$N_{Rk,s,eq,C2}$	[kN]	NPA		$1,0 \cdot N_{Rk,s}$				NPA	
Partial factor		$\gamma_{Ms,N}$	[-]	siehe Tabelle C1							
Combined pull-out and concrete failure											
Characteristic bond resistance											
Temperatur- range	I: 80°C / 50°C	$\tau_{Rk,eq,C1}$	[N/mm <sup>2</sup> ]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
		$\tau_{Rk,eq,C2}$	[N/mm <sup>2</sup> ]	NPA		3,6	3,5	3,3	2,3	NPA	
	II: 120°C / 72°C	$\tau_{Rk,eq,C1}$	[N/mm <sup>2</sup> ]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
		$\tau_{Rk,eq,C2}$	[N/mm <sup>2</sup> ]	NPA		3,1	3,0	2,8	2,0	NPA	
	III: 160°C / 100°C	$\tau_{Rk,eq,C1}$	[N/mm <sup>2</sup> ]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
		$\tau_{Rk,eq,C2}$	[N/mm <sup>2</sup> ]	NPA		2,5	2,7	2,5	1,8	NPA	
Installation factor											
Compressed air cleaning	dry or wet concrete	$\gamma_{inst}$	[-]	1,0							
	water filled drill hole			1,4							
Vacuum cleaning	dry or wet concrete	$\gamma_{inst}$	[-]	1,2							

<sup>1)</sup> Materials and property classes according to Annex B1

**Table C6:** Characteristic values of **tesion loads** for **threaded rods**  
under **seismic action**, performance category **C1 + C2** <sup>1)</sup>

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure <u>without</u> lever arm											
Characteristic resistance	$V_{Rk,s,eq,C1}$	[kN]	$0,7 \cdot V^0_{Rk,s}$								
	$V_{Rk,s,eq,C2}$	[kN]	NPA			$0,7 \cdot V^0_{Rk,s}$				NPA	
Partial factor	$\gamma_{Ms,N}$	[-]	siehe Tabelle C2								
Steel failure <u>without</u> lever arm											
Charactersitic bending resistance	$M^0_{Rk,s,eq}$	[Nm]	No Performance Assessed (NPA)								
Installation factor	$\gamma_{inst}$	[-]	1,0								
Factor for anchorage	without hole clearance	$\alpha_{gap}$	[-]	1,0							
	with hole clearance between fastener and fixture	$\alpha_{gap}$	[-]	0,5							

<sup>1)</sup> Materials and property classes according to Annex B1

## Injection System VMH for concrete

**Performance**  
Characteristic values under **seismic action** for **threaded rods**

**Annex C5**

**Table C7: Characteristic values of tension loads for internally threaded anchor rod under static or quasi-static action**

Internally threaded anchor rod				VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20	
Steel failure <sup>1)</sup>										
Characteristic resistance, steel, zinc plated, property class	5.8	N <sub>Rk,s</sub>	[kN]	10	17	29	42	76	123	
	8.8	N <sub>Rk,s</sub>	[kN]	16	27	46	67	121	196	
Partial factor		γ <sub>Ms,N</sub>	[-]	1,5						
Characteristic resistance, stainless steel A4 / HCR, property class	70	N <sub>Rk,s</sub>	[kN]	14	26	41	59	110	124 <sup>2)</sup>	
Partial factor		γ <sub>Ms,N</sub>	[-]	1,87						2,86
Combined pull-out and concrete failure										
Characteristic bond resistance in <u>uncracked</u> concrete C20/25										
Temperature range	I: 80°C / 50°C	τ <sub>Rk,ucr</sub>	[N/mm²]	17	16	15	14	13	13	
	II: 120°C / 72°C	τ <sub>Rk,ucr</sub>	[N/mm²]	14	14	13	12	12	11	
	III: 160°C / 100°C	τ <sub>Rk,ucr</sub>	[N/mm²]	11	11	10	9,5	9,0	9,0	
Characteristic bond resistance in <u>cracked</u> concrete C20/25										
Temperature range	I: 80°C / 50°C	τ <sub>Rk,cr</sub>	[N/mm²]	7,5	8,0	9,0	8,5	7,0	7,0	
	II: 120°C / 72°C	τ <sub>Rk,cr</sub>	[N/mm²]	6,5	7,0	7,5	7,0	6,0	6,0	
	III: 160°C / 100°C	τ <sub>Rk,cr</sub>	[N/mm²]	5,5	6,0	6,5	6,0	5,5	5,5	
Reduction factor ψ <sup>0</sup> <sub>sus</sub> in concrete C20/25										
Temperature range	I: 80°C / 50°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,79						
	II: 120°C / 72°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,75						
	III: 160°C / 100°C	ψ <sup>0</sup> <sub>sus</sub>	[-]	0,66						
Increasing factors for concrete		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						
Concrete cone failure										
Factor k <sub>1</sub>	uncracked concrete	k <sub>ucr,N</sub>	[-]	11,0						
	cracked concrete	k <sub>cr,N</sub>	[-]	7,7						
Splitting failure										
Edge distance	h/h <sub>ef</sub> ≥ 2,0	c <sub>cr,sp</sub>	[mm]	1,0 h <sub>ef</sub>						
	2,0 > h/h <sub>ef</sub> > 1,3			2 · h <sub>ef</sub> (2,5 – h / h <sub>ef</sub> )						
	h/h <sub>ef</sub> ≤ 1,3			2,4 h <sub>ef</sub>						
Spacing		s <sub>cr,sp</sub>	[mm]	2 c <sub>cr,sp</sub>						
Installation factor										
dry or wet concrete	vaccum cleaning	γ <sub>inst</sub>	[-]	1,2						
	manual cleaning	γ <sub>inst</sub>	[-]	1,2			NPA			
waterfilled drill hole	compressed air	γ <sub>inst</sub>	[-]	1,0						
	cleaning	γ <sub>inst</sub>	[-]	1,2						

<sup>1)</sup> Fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod. The characteristic tension resistance for steel failure of the given strength class are valid for the internally threaded anchor rod and the fastening element

<sup>2)</sup> For VMU-IG M20: property class 50

#### Injection System VMH for concrete

#### Performance

Characteristic values of tension loads for internally threaded anchor rod

#### Annex C6

**Table C8:** Characteristic values of **shear loads** for **internally threaded anchor rod** under static or quasi-static action

Internally threaded anchor rod					VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20
Steel failure <u>without</u> lever arm <sup>1)</sup>										
Steel, zinc plated	Characteristic resistance	property class 5.8	$V_{Rk,s}^0$	[kN]	5	9	15	21	38	61
	Characteristic resistance	property class 8.8	$V_{Rk,s}^0$	[kN]	8	14	23	34	60	98
	Partial factor		$\gamma_{Ms,V}$	[-]	1,25					
Stainless steel	Characteristic resistance A4 / HCR	property class 70	$V_{Rk,s}^0$	[kN]	7	13	20	30	55	62 <sup>2)</sup>
	Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38
Ductility factor			$K_7$	[-]	1,0					
Steel failure <u>with</u> lever arm <sup>1)</sup>										
Steel, zinc plated	Characteristic bending resistance	property class 5.8	$M_{Rk,s}^0$	[Nm]	8	19	37	66	167	325
	Characteristic bending resistance	property class 8.8	$M_{Rk,s}^0$	[Nm]	12	30	60	105	267	519
	Partial factor		$\gamma_{Ms,V}$	[-]	1,25					
Stainless steel	Characteristic bending resistance A4 / HCR	property class 70	$M_{Rk,s}^0$	[Nm]	11	26	53	92	234	643 <sup>2)</sup>
	Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38
Concrete pry-out failure										
Pry-out factor			$k_8$	[-]	2,0					
Concrete edge failure										
Effective length of anchor			$l_f$	[mm]	min ( $h_{ef}$ ; 12 $d_{nom}$ )					min ( $h_{ef}$ ; 300mm)
Outside diameter of anchor			$d_{nom}$	[mm]	10	12	16	20	24	30
Installation factor			$\gamma_{inst}$	[-]	1,0					

<sup>1)</sup> Fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod (exception: VMU-IG M20). The characteristic shear resistance for steel failure of the given strength class are valid for the internally threaded anchor rod and the fastening element

<sup>2)</sup> For VMU-IG M20: Internally threaded rod: property class 50;  
Fastening screws or threaded rods (incl. nut and washer): property class 70

#### Injection System VMH for concrete

#### Performance

Characteristic values of **shear loads** for **internally threaded anchor rod**

**Annex C7**

**Table C9:** Characteristic values of **tension loads** for **rebar** under static or quasi-static action

Reinforcing bar				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure													
Characteristic resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}^{1)}$									
Cross sectional area		$A_s$	[mm <sup>2</sup> ]	50	79	113	154	201	314	452	491	616	804
Partial factor		$\gamma_{Ms,N}$	[-]	1,4 <sup>2)</sup>									
Combined pull-out and concrete failure													
Characteristic bond resistance in <u>uncracked</u> concrete C20/25													
Temperature range	I: 80°C / 50°C	$\tau_{Rk,ucr}$	[N/mm <sup>2</sup> ]	14	14	14	14	13	13	13	13	13	13
	II: 120°C / 72°C	$\tau_{Rk,ucr}$	[N/mm <sup>2</sup> ]	13	12	12	12	12	11	11	11	11	11
	III: 160°C / 100°C	$\tau_{Rk,ucr}$	[N/mm <sup>2</sup> ]	9,5	9,5	9,5	9,0	9,0	9,0	9,0	9,0	8,5	8,5
Characteristic bond resistance in <u>cracked</u> concrete C20/25													
Temperature range	I: 80°C / 50°C	$\tau_{Rk,cr}$	[N/mm <sup>2</sup> ]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
	II: 120°C / 72°C	$\tau_{Rk,cr}$	[N/mm <sup>2</sup> ]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
	III: 160°C / 100°C	$\tau_{Rk,cr}$	[N/mm <sup>2</sup> ]	4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Reduction factor $\psi_{sus}^0$ in concrete C20/25													
Temperature range	I: 80°C / 50°C	$\psi_{sus}^0$	[-]	0,79									
	II: 120°C / 72°C	$\psi_{sus}^0$	[-]	0,75									
	III: 160°C / 100°C	$\psi_{sus}^0$	[-]	0,66									
Increasing factor for concrete		$\psi_c$	C25/30	1,02									
			C30/37	1,04									
			C35/45	1,07									
			C40/50	1,08									
			C45/55	1,09									
			C50/60	1,10									
Concrete cone failure													
Factor $k_1$	uncracked concrete	$k_{ucr,N}$	[-]	11,0									
	cracked concrete	$k_{cr,N}$	[-]	7,7									
Splitting failure													
Edge distance	$h/h_{ef} \geq 2,0$	$c_{cr,sp}$	[mm]	$1,0 h_{ef}$									
	$2,0 > h/h_{ef} > 1,3$			$2 \cdot h_{ef} (2,5 - h / h_{ef})$									
	$h/h_{ef} \leq 1,3$			$2,4 h_{ef}$									
Spacing		$s_{cr,sp}$	[mm]	$2 c_{cr,sp}$									
Installation factor													
dry or wet concrete	vacuum cleaning	$\gamma_{inst}$	[-]	1,2									
	manual cleaning	$\gamma_{inst}$	[-]	1,2					NPA				
	compressed air	$\gamma_{inst}$	[-]	1,0									
waterfilled drill hole		cleaning	$\gamma_{inst}$	[-]	1,4								

<sup>1)</sup>  $f_{uk}$  shall be taken from the specifications of reinforcing bars<sup>2)</sup> in absence of national regulation**Injection System VMH for concrete****Performance**Characteristic values of **tension loads** for **rebar****Annex C8**



**Table C10:** Characteristic values of **shear loads** for **rebar** under static or quasi-static action

Reinforcing bar		Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32	
Steel failure <u>without</u> lever arm												
Characteristic shear resistance	$V_{Rk,s}^0$	[kN]	$0,50 \cdot A_s \cdot f_{uk}^{1)}$									
Gross sectional area	$A_s$	[mm <sup>2</sup> ]	50	79	113	154	201	314	452	491	616	804
Partial factor	$\gamma_{Ms,V}$	[-]	$1,5^{2)}$									
Ductility factor	$k_7$	[-]	1,0									
Steel failure <u>with</u> lever arm												
Characteristic bending resistance	$M_{Rk,s}^0$	[Nm]	$1,2 \cdot W_{el} \cdot f_{uk}^{1)}$									
Elastic section modulus	$W_{el}$	[mm <sup>3</sup> ]	50	98	170	269	402	785	1357	1534	2155	3217
Partial factor	$\gamma_{Ms,V}$	[-]	$1,5^{2)}$									
Concrete pry-out failure												
Pry-out Factor	$k_8$	[-]	2,0									
Concrete edge failure												
Effective length of rebar	$l_f$	[mm]	$\min(h_{ef}; 12 d_{nom})$							$\min(h_{ef}; 300mm)$		
Outside diameter of rebar	$d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Installation factor	$\gamma_{inst}$	[-]	1,0									

<sup>1)</sup>  $f_{uk}$  shall be taken from the specifications of reinforcing bars

<sup>2)</sup> in absence of national regulation

**Injection System VMH for concrete**

**Performance**  
Characteristic values of **shear loads** for **rebar**

**Annex C9**

**Table C11:** Characteristic values of **tension loads** for **rebar** under **seismic action**, performance category **C1**

Reinforcing bar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32	
Steel failure													
Characteristic resistance		N <sub>Rk,s,eq,C1</sub>	[kN]	A <sub>s</sub> • f <sub>uk</sub> <sup>1)</sup>									
Cross sectional area		A <sub>s</sub>	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor		γ <sub>MS,N</sub>	[-]	1,4 <sup>2)</sup>									
Combined pull-out and concrete failure													
Characteristic bond resistance in concrete C20/25													
Temperature range	I: 80°C / 50°C	τ <sub>Rk,eq,C1</sub>	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
	II: 120°C / 72°C	τ <sub>Rk,eq,C1</sub>	[N/mm²]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
	III: 160°C / 100°C	τ <sub>Rk,eq,C1</sub>	[N/mm²]	4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Installation factor													
dry or wet concrete	vacuum cleaning	γ <sub>inst</sub>	[-]	1,2									
	compressed air cleaning	γ <sub>inst</sub>	[-]	1,0									
waterfilled drill hole			γ <sub>inst</sub>	[-]	1,4								

<sup>1)</sup>  $f_{uk}$  shall be taken from the specifications of reinforcing bars

<sup>2)</sup> in absence of national regulation

**Table C12:** Characteristic values of **shear loads** for **rebar** under **seismic action**, performance category **C1**

Reinforcing bar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure <u>without</u> lever arm												
Characteristic resistance	$V_{Rk,s,eq,C1}^0$	[kN]	$0,35 \cdot A_s \cdot f_{uk}^{1)}$									
Cross sectional area	$A_s$	[mm <sup>2</sup> ]	50	79	113	154	201	314	452	491	616	804
Partial factor	$\gamma_{Ms,V}$	[-]	$1,5^{2)}$									
Ductility factor	$k_7$	[-]	1,0									
Steel failure <u>with</u> lever arm												
Characteristic bending resistance	$M_{Rk,s,eq,C1}^0$	[Nm]	No Performance Assessed (NPA)									
Installation factor	$\gamma_{inst}$	[-]	1,0									

<sup>1)</sup>  $f_{uk}$  shall be taken from the specifications of reinforcing bars

<sup>2)</sup> in absence of national regulation

#### Injection System VMH for concrete

#### Performance

Characteristic values under **seismic action** for **rebar**

**Annex C10**

**Table C13: Displacements under tension load (threaded rod)**

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
<b>Displacement factor<sup>1)</sup> for uncracked concrete under static and quasi-static action</b>										
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,031	0,032	0,034	0,037	0,039	0,042	0,044	0,046
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,040	0,042	0,044	0,047	0,051	0,054	0,057	0,060
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,032	0,034	0,035	0,038	0,041	0,044	0,046	0,048
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,042	0,044	0,045	0,049	0,053	0,056	0,059	0,062
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,121	0,126	0,131	0,142	0,153	0,163	0,171	0,179
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,124	0,129	0,135	0,146	0,157	0,168	0,176	0,184
<b>Displacement factor<sup>1)</sup> for cracked concrete under static and quasi-static action</b>										
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,081	0,083	0,085	0,090	0,095	0,099	0,103	0,106
	$\delta_{Ncr}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,104	0,107	0,110	0,116	0,122	0,128	0,133	0,137
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,084	0,086	0,088	0,093	0,098	0,103	0,107	0,110
	$\delta_{Ncr}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,108	0,111	0,114	0,121	0,127	0,133	0,138	0,143
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,312	0,321	0,330	0,349	0,367	0,385	0,399	0,412
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,321	0,330	0,340	0,358	0,377	0,396	0,410	0,424
<b>Cracked concrete under seismic action (C2)</b>										
All temperature ranges	$\delta_{N,eq}$ (DLS)	[mm]	NPA			0,24	0,27	0,29	0,27	NPA
	$\delta_{N,eq}$ (ULS)	[mm]								

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

$\delta_{N0} = \delta_{N0}$ -factor  $\cdot \tau$ ;  $\tau$ : acting bond stress for tension

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

**Table C14: Displacements under shear load (threaded rod)**

Threaded rod			M 8	M 10	M 12	M 16	M 20	M24	M 27	M 30
<b>Displacement factor<sup>1)</sup> for concrete under static and quasi-static action</b>										
All temperature ranges	$\delta_{V0}$ -Faktor	[mm/(kN)]	0,06	0,06	0,05	0,04	0,04	0,03	0,03	0,03
	$\delta_{V\infty}$ -Faktor	[mm/(kN)]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05
<b>Cracked concrete under seismic action (C2)</b>										
All temperature ranges	$\delta_{V,eq}$ (DLS)	[mm]	NPA			3,6	3,0	3,1	3,5	NPA
	$\delta_{V,eq}$ (ULS)	[mm]								

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

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

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

### Injection System VMH for concrete

**Performance**  
Displacements (threaded rod)

**Annex C11**

**Table C15: Displacements under tension load** (internally threaded anchor rod)

Internally threaded anchor rod			VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20
<b>Displacement factor<sup>1)</sup> for uncracked concrete under static and quasi-static action</b>								
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,032	0,034	0,037	0,039	0,042	0,046
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,042	0,044	0,047	0,051	0,054	0,060
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,034	0,035	0,038	0,041	0,044	0,048
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,044	0,045	0,049	0,053	0,056	0,062
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,126	0,131	0,142	0,153	0,163	0,179
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,129	0,135	0,146	0,157	0,168	0,184
<b>Displacement factor<sup>1)</sup> for cracked concrete under static and quasi-static action</b>								
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,083	0,085	0,090	0,095	0,099	0,106
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,107	0,110	0,116	0,122	0,128	0,137
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,086	0,088	0,093	0,098	0,103	0,110
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,111	0,114	0,121	0,127	0,133	0,143
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,321	0,330	0,349	0,367	0,385	0,412
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,330	0,340	0,358	0,377	0,396	0,424

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

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

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

**Table C16: Displacements under shear load** (internally threaded anchor rod)

Internally threaded anchor rod			VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20
<b>Displacement factor<sup>1)</sup> under static and quasi-static action</b>								
All temperature ranges	$\delta_{V0}$ -factor	[mm/(kN)]	0,07	0,06	0,06	0,05	0,04	0,04
	$\delta_{V\infty}$ -factor	[mm/(kN)]	0,10	0,09	0,08	0,08	0,06	0,06

<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 System VMH for concrete**

**Performance**  
Displacements (internally threaded anchor rod)

**Annex C12**

**Table C17: Displacements under tension load (rebar)**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
<b>Displacement factor<sup>1)</sup> for uncracked concrete under static and quasi-static action</b>												
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,031	0,032	0,034	0,035	0,037	0,039	0,042	0,043	0,045	0,048
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,040	0,042	0,044	0,045	0,047	0,051	0,054	0,055	0,058	0,063
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,032	0,034	0,035	0,036	0,038	0,041	0,044	0,045	0,047	0,050
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,042	0,044	0,045	0,047	0,049	0,053	0,056	0,057	0,060	0,065
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,121	0,126	0,131	0,137	0,142	0,153	0,163	0,164	0,172	0,186
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,124	0,129	0,135	0,141	0,146	0,157	0,168	0,169	0,177	0,192
<b>Displacement factor<sup>1)</sup> for cracked concrete under static and quasi-static action</b>												
Temperature range I: 80°C / 50°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,081	0,083	0,085	0,087	0,090	0,095	0,099	0,099	0,103	0,108
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,104	0,107	0,110	0,113	0,116	0,122	0,128	0,128	0,133	0,141
Temperature range II: 120°C / 72°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,084	0,086	0,088	0,090	0,093	0,098	0,103	0,103	0,107	0,113
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,108	0,111	0,114	0,118	0,121	0,127	0,133	0,133	0,138	0,148
Temperature range III: 160°C / 100°C	$\delta_{N0}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,312	0,321	0,330	0,340	0,349	0,367	0,385	0,385	0,399	0,425
	$\delta_{N\infty}$ -factor	[mm/(N/mm <sup>2</sup> )]	0,321	0,330	0,340	0,349	0,358	0,377	0,396	0,396	0,410	0,449

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

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

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

**Table C18: Displacements under shear load (rebar)**

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
<b>Displacement factor<sup>1)</sup> under static and quasi-static action</b>												
All temperature ranges	$\delta_{V0}$ -factor	[mm/(kN)]	0,06	0,05	0,05	0,04	0,04	0,04	0,03	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	0,04	0,04

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

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

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

**Injection System VMH for concrete**

**Performance**  
Displacements (rebar)

**Annex C13**