Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment

ETA-17/0716 of 11 May 2021

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	Injection System VMH for concrete
Product family to which the construction product belongs	Bonded fastener for use in concrete
Manufacturer	MKT Metall-Kunststoff-Technik GmbH & Co. KG Auf dem Immel 2 67685 Weilerbach DEUTSCHLAND
Manufacturing plant	Werk 1, D Werk 2, D
This European Technical Assessment contains	33 pages including 3 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 330499-01-0601, Edition 04/2020
This version replaces	ETA-17/0716 issued on 22 November 2019

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Specific Part

1 Technical description of the product

The "Injection system VMH for concrete" is a bonded anchor consisting of a cartridge with injection mortar Injection mortar VMH and a steel element according to Annex A3 and A5.

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

The product description is given in Annex A.

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

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

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the anchor of at least 50 and/or 100 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic	Performance
Characteristic resistance to tension load (static and quasi-static loading)	See Annex B 3, C 1, C 3, C4, C 5, C 8, C 9, C 11, C 12
Characteristic resistance to shear load (static and quasi-static loading)	See Annex C 2, C 6, C 10, C 13
Displacements under short-term and long-term loading	See Annex C 15 to C 17
Characteristic resistance and displacements for seismic performance categories C1 and C2	See Annex C 7, C 14, C 15

3.2 Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Content, emission and/or release of dangerous substances	No performance assessed

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

In accordance with the European Assessment Document EAD 330499-01-0601 the applicable European legal act is: [96/582/EC].

The system to be applied is: 1

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable European Assessment Document

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

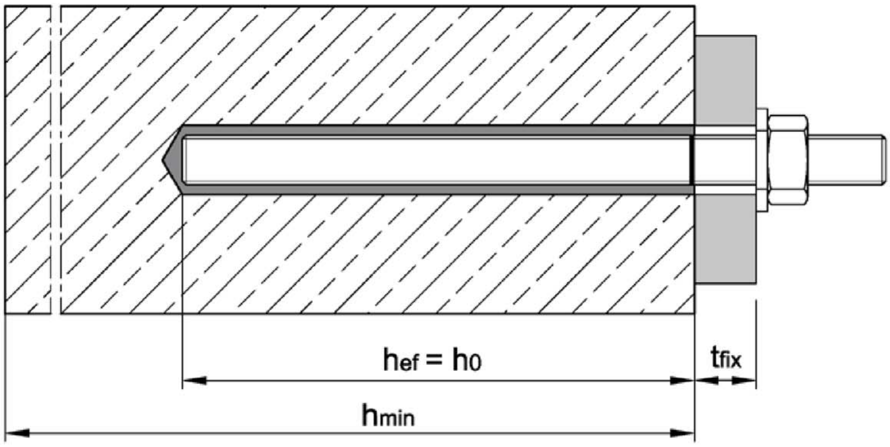
Issued in Berlin on 11 May 2021 by Deutsches Institut für Bautechnik

Dipl.-Ing. Beatrix Wittstock
Head of Section

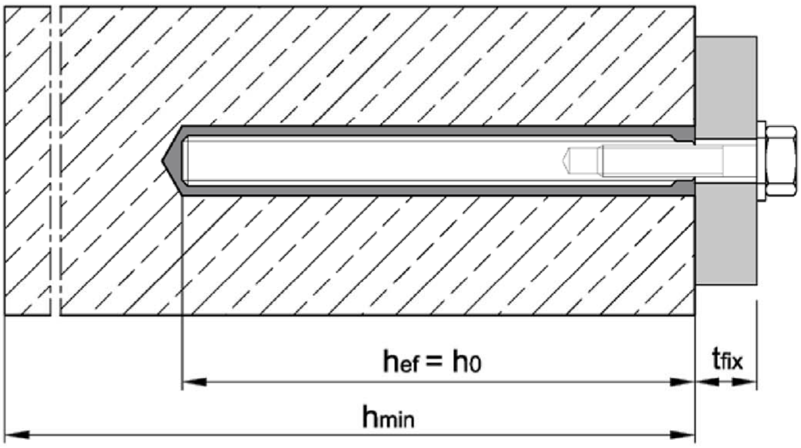
beglaubigt:
Baderschneider

Installation threaded rod M8 to M30

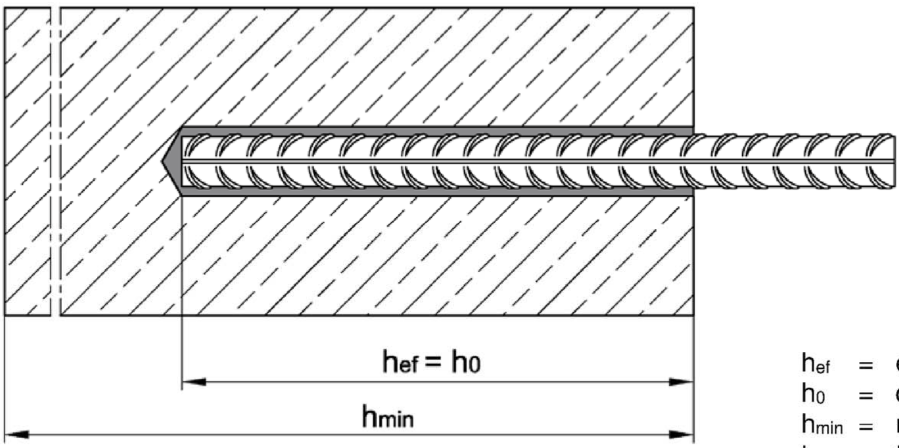
Pre-setting installation or through-setting installation (optional annular gap filled with mortar)



Installation internally threaded anchor rod VMU-IG M6 to VMU-IG M20



Installation reinforcing bar Ø8 to Ø32



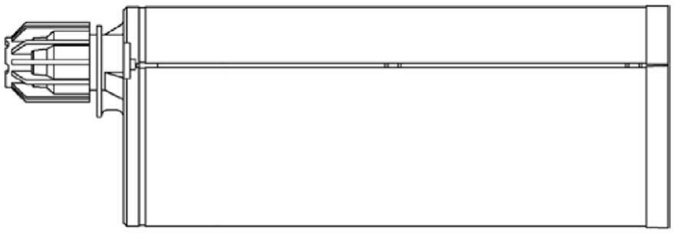
h_{ef} = effective anchorage depth
h_0 = depth of drill hole
h_{min} = minimum thickness of member
t_{fix} = thickness of fixture

Injection System VMH for concrete	**Annex A1**
Product description Installation situation	

Cartridge Injection Mortar VMH

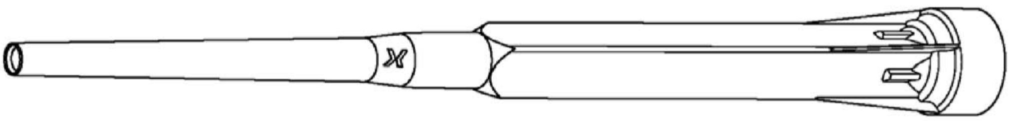
Coaxial cartridge
150 ml, 280 ml,
300 ml to 330 ml,
380 ml to 420 ml

Side-by-side cartridge
235 ml,
345 ml to 360 ml,
825 ml

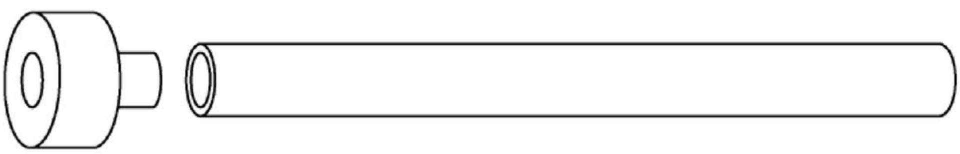


Imprint:
VMH,
processing notes, batch number, shelf life, hazard code, storage temperature, curing- and processing time (depending on the temperature), optional with travel scale

Static mixer



Retaining washer and extension nozzle

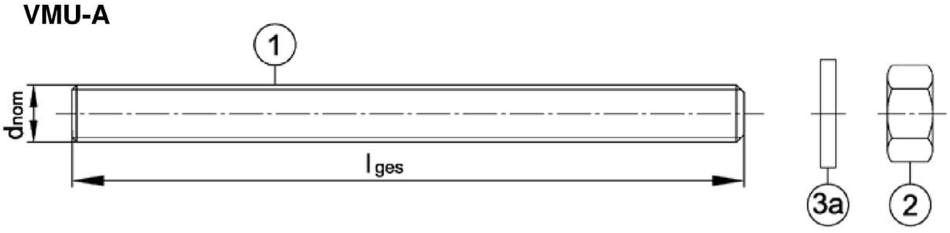


Injection System VMH for concrete	Annex A2
Product description Cartridge, static mixer and retaining washer	

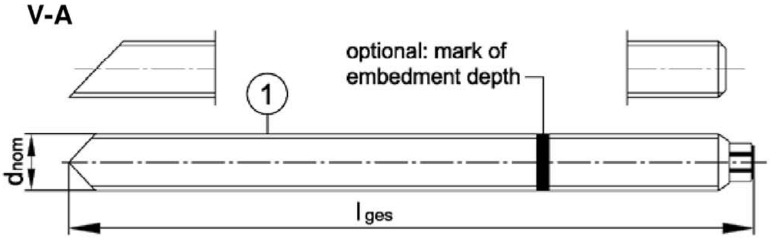
Threaded rod

Threaded rod VMU-A, V-A with washer and hexagon nut
M8, M10, M12, M16, M20, M24, M27, M30 (zinc plated, A4, HCR)

VMU-A



V-A



Marking e.g.: ◇ M10

◇	identifying mark of manufacturing plant
M10	size of thread

additional marking:

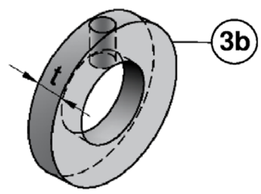
A4	stainless steel
HC	high corrosion resistant steel

Threaded rod VM-A (material sold by the metre, to be cut at the required length)
M8, M10, M12, M16, M20, M24, M27, M30 (zinc plated, A2, A4, HCR)

Commercial standard threaded rod with:
M8, M10, M12, M16, M20, M24, M27, M30 (zinc plated, A2, A4, HCR)

- Materials, dimensions and mechanical properties see Table A1
- Inspection certificate 3.1 acc. to EN 10204:2004

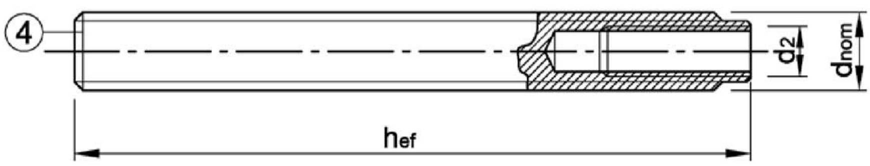
Washer with bore and reducing adapter for filling the gap between threaded rod and fixture



Thickness of washer with bore for diameter
< M24: t = 5 mm
≥ M24: t = 6 mm

Internally threaded anchor rod

VMU-IG M6, VMU-IG M8, VMU-IG M10, VMU-IG M12, VMU-IG M16, VMU-IG M20
(zinc plated, A4, HCR)



Marking e.g.: ◇I M8

◇	identifying mark of manufacturing plant
I	internal thread
M8	size of internal thread

additional marking:

A4	stainless steel
HCR	high corrosion resistant steel

Injection System VMH for concrete	**Annex A3**
Product description Threaded rod and internally threaded anchor rod	

Table A1: Materials - Threaded rod and internally threaded anchor rod

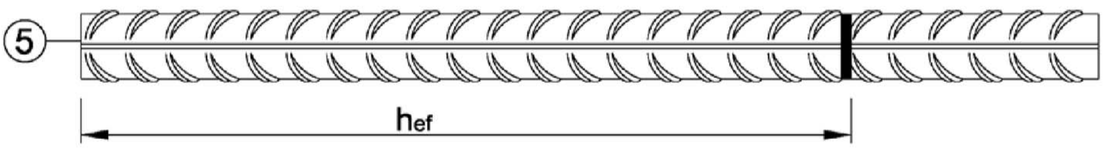
Part	Designation	Property class	Material					
Steel, zinc plated electroplated ≥ 5 µm acc. to EN ISO 4042:2018 or hot-dip galvanized ≥ 40 µm (50 µm in average) acc. to EN ISO 1461:2009, EN ISO 10684:2004+AC:2009 or sherardized ≥ 45 µm acc. to EN ISO 17668:2016								
1	Threaded rod	Property class	characteristic ultimate strength		characteristic yield strength		fracture elongation	EN ISO 683-4:2018, EN 10263:2001; Commercial standard threaded rod: EN ISO 898-1:2013
		4.6	f_{uk} [N/mm²]	400	f_{yk} [N/mm²]	240	A_5 > 8 %	
		4.8		400		320	A_5 > 8 %	
		5.6		500		300	A_5 > 8 %	
		5.8		500		400	A_5 > 8 %	
		8.8		800		640	A_5 ≥ 12%[1]	
2	Hexagon nut	4	for class 4.6 or 4.8 rods					EN ISO 898-2:2012
		5	for class 4.6, 4.8, 5.6 or 5.8 rods					
		8	for class 4.6, 4.8, 5.6, 5.8 or 8.8 rods					
3a	Washer		e.g.: EN ISO 7089:2000, EN ISO 7093:2000, EN ISO 7094:2000, EN ISO 887:2006					
3b	Washer with bore		Steel, zinc plated					
4	Internally threaded anchor rod	5.8	Steel, electroplated or sherardized				A_5 > 8%	EN ISO 683-4:2018
		8.8					A_5 > 8%	
Stainless steel A2 [2] **CRC II** (1.4301 / 1.4307 / 1.4311 / 1.4567 / 1.4541) **Stainless steel A4** **CRC III** (1.4401 / 1.4404 / 1.4571 / 1.4578) **High corrosion resistant steel HCR** **CRC V** (1.4529 / 1.4565)								
1	Threaded rod [3]	Property class	characteristic ultimate strength		characteristic yield strength		fracture elongation	EN 10088-1:2014 EN ISO 3506-1:2020
		50	f_{uk} [N/mm²]	500	f_{yk} [N/mm²]	210	A_5 > 8%	
		70		700		450	A_5 ≥ 12%[1]	
		80		800		600	A_5 ≥ 12%[1]	
2	Hexagon nut [3]	50	for class 50 rods					EN 10088-1:2014 EN ISO 3506-2:2020
		70	for class 50 or 70 rods					
		80	for class 50, 70 or 80 rods					
3a	Washer		e.g.: EN ISO 7089:2000, EN ISO 7093:2000, EN ISO 7094:2000; EN ISO 887:2006					EN 10088-1:2014
3b	Washer with bore		stainless steel A4; high corrosion resistant steel HCR					
4	Internally threaded anchor rod	50	IG-M20				A_5 > 8 %	EN 10088-1:2014
		70	IG-M6 to IG-M16				A_5 > 8 %	

[1] fracture elongation A_5 > 8 % for applications without requirements for seismic performance category C2
[2] property classes 50 and 70
[3] property classes 70 and 80 up to M24

Injection System VMH for concrete	Annex A4
Product description Materials - Threaded rod and internally threaded anchor rod	

Reinforcing bar

∅ 8, ∅ 10, ∅ 12, ∅ 14, ∅ 16, ∅ 20, ∅ 24, ∅ 25, ∅ 28, ∅ 32



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

Table A2: Material reinforcing bar

Part	Designation	Material
Rebar		
5	Rebar EN 1992-1-1:2004+AC:2010, Annex C	Bars and de-coiled rods class B or C f_{yk} and k according to NDP or NCL acc. EN 1992-1-1/NA $f_{uk} = f_{tk} = k \cdot f_{yk}$

Injection System VMH for concrete	**Annex A5**
Product description Product description and material reinforcing bar	

Specification of intended use

Static and quasi-static action	working life 50 years	working life 100 years
Threaded rod **Internally threaded anchor rod** **Rebar**	**M8 - M30** **VMU-IG M6 - VMU-IG M20** **Ø8 - Ø32**	
Base material	cracked or uncracked concrete	
	strength classes C20/25 to C50/60 compacted, reinforced or unreinforced normal weight concrete (without fibers) acc. to EN 206:2013+A1:2016	
Hole drilling	hammer drilling / compressed air drilling / vacuum drilling	
Temperature range [1]	I: -40°C to +40°C II: -40°C to +80°C III: -40°C to +120°C IV: -40°C to +160°C	I: -40°C to +40°C II: -40°C to +80°C

Seismic action	performance category C1	performance category C2
Threaded rod **Rebar**	**M8 - M30** **Ø8 - Ø32**	**M12 - M24** ---
Base material	cracked or uncracked concrete	
	strength classes C20/25 to C50/60 compacted, reinforced or unreinforced normal weight concrete (without fibers) acc. to EN 206:2013+A1:2016	
Hole drilling	hammer drilling / compressed air drilling / vacuum drilling	
Temperature range [1]	I: -40°C to +40°C II: -40°C to +80°C III: -40°C to +120°C IV: -40°C to +160°C	I: -40°C to +40°C II: -40°C to +80°C III: -40°C to +120°C IV: -40°C to +160°C

[1] Temperature Range I: max. long term temperature +24°C and max. short term temperature +40°C
Temperature Range II: max. long term temperature +50°C and max. short term temperature +80°C
Temperature Range III: max. long term temperature +72°C and max. short term temperature +120°C
Temperature Range IV: max. long term temperature +100°C and max. short term temperature +160°C

Specification of intended use

Use conditions (Environmental conditions):

- Structures subject to dry internal conditions: all materials
- For all other conditions:
  Intended use of Materials according to Annex A4, Table A1 corresponding corrosion resistance classes CRC according to EN 1993-1-4:2006+A1:2015

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 and Technical Report TR 055, Edition February 2018

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
- The injection mortar is assessed for installation at minimum concrete temperature of -5°C, where subsequently the temperature in the concrete does not rise at a rapid rate, i.e. from the minimum installation temperature to 24°C within a 12-hour period.
- 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

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 [2)]	Pre-setting installation	$d_f \le$	[mm]	9	12	14	18	22	26	30	33
	Through setting installation	$d_f \le$	[mm]	12	14	16	20	24	30	33	40
Maximum installation torque		$max.T_{inst} \le$	[Nm]	10	20	40 (35)[1)]	60	100	170	250	300
Minimum thickness of member		h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 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

1) max. installation torque for M12 with steel grade 4.6

2) for applications under seismic loading the diameter of clearance hole in the fixture shall be at maximum d_{nom} + 1mm 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[1)]	$d=d_{nom}$	[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	$d_f \le$	[mm]	7	9	12	14	18	22
Maximum installation torque	$max.T_{inst} \le$	[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 mm ≥ 100 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

1) with metric thread acc. to EN 1993-1-8:2005+AC:2009

Table B3: Installation parameters for rebar

Rebar			∅ 8	∅ 10	∅ 12	∅ 14	∅ 16	∅ 20	∅ 24	∅ 25	∅ 28	∅ 32
Diameter of rebar	$d=d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Nominal drill hole diameter[1)]	d_0	[mm]	10 / 12	12 / 14	14 / 16	18	20	25	30 / 32	30 / 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 mm ≥ 100 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

1) for diameter ∅8, ∅10, ∅12, ∅24 and ∅25 both nominal drill hole diameter can be used

Injection System VMH for concrete

Intended use
Installation parameters

Annex B3

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_0 [mm]	d_b [mm]	$d_{b,min}$ [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		24 / 25	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_0 [mm]	[-]	⬇	➡	⬆
10	No retaining washer required			
12				
14				
16				
18	VM-IA 18	h_{ef} > 250mm	h_{ef} > 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_0): 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 (150 m³/h)

Recommended compressed air tool (min 6 bar)
Drill bit diameter (d_0): all diameters

Blow-out pump (volume 750ml)
Drill bit diameter (d_0): 10 mm to 20 mm
Drill hole depth (h_0): ≤ 10 d_{nom}
for uncracked concrete

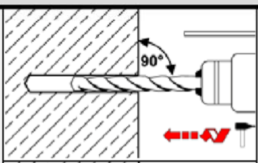
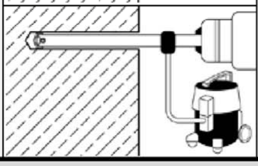
Injection System VMH for concrete

Intended Use
Cleaning and setting tools

Annex B4

Installation Instructions

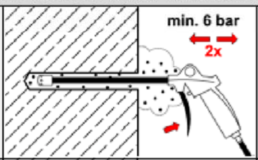
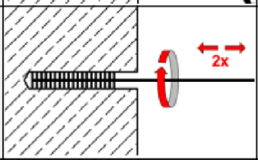
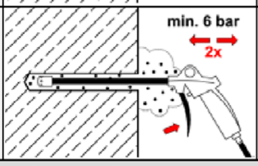
Drilling of the hole

1		**Hammer drill or compressed air drill** 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 step 2. In case of aborted drill hole, the drill hole shall be filled with mortar.
		**Vacuum drill bit**: see Annex B4 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 step 3. In case of aborted hole, the drill hole shall be filled with mortar.

Cleaning (not applicable when using a vacuum drill)

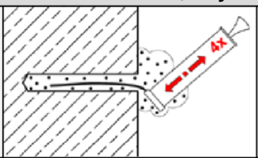
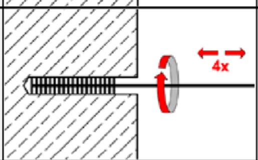
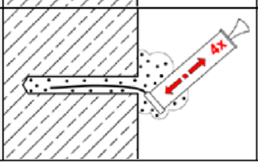
Attention! Standing water in the drill hole must be removed before cleaning!

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 **two** 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 ≥ $d_{b,min}$ (Table B4) a minimum of **two** 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 **two** times until return air stream is free of noticeable dust. If the drill hole ground is not reached, an extension must be used.

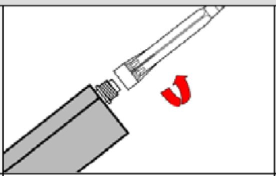
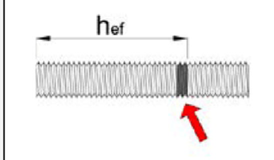
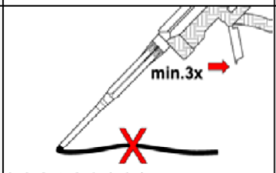
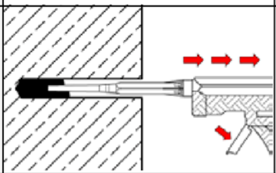
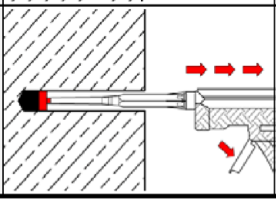
2

Manual cleaning
uncracked concrete, dry and wet drill holes; drill hole diameter d_0 ≤ 20mm and drill hole depth h_0 ≤ 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 **four** times until return air stream is free of noticeable dust.
2b		Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush ≥ $d_{b,min}$ (Table B4) a minimum of **four** 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 **four** times until return air stream is free of noticeable dust.

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.

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: • Horizontal installation (horizontal direction) and ground installation (vertical downwards direction): Drill bit-Ø $d_0 \geq 18$ mm and anchorage depth $h_{ef} > 250$mm • Overhead installation: Drill bit-Ø $d_0 \geq 18$ mm

Injection System VMH for concrete	**Annex B6**
Intended Use Installation instructions (continuation)	

Installation instructions (continuation)

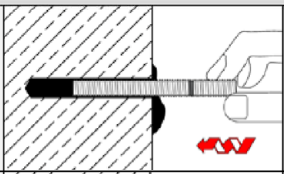
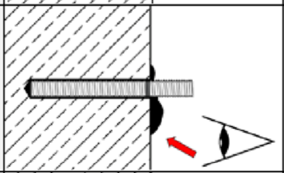
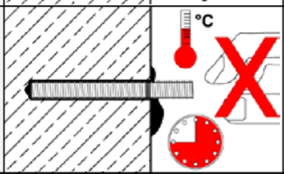
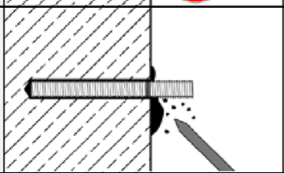
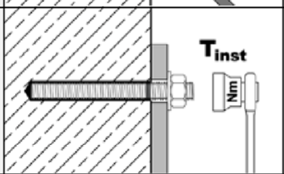
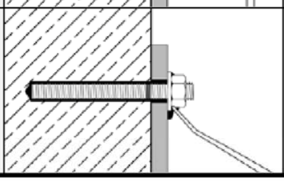
Setting the fastening element		
7		Push the fastening element into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached. The anchor shall be free of dirt, grease, oil or other foreign material.
8		After installation, the annular gap between 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! For overhead installation, the anchor should be fixed (e.g. by wedges).
9		Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured (attend Table B6).
10		Remove excess mortar.
11		The fixture can be mounted after curing time. Apply installation torque $\leq T_{inst}$ according to Table B1 or B2.
12		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. Annular gap is completely filled, when excess mortar seeps out.

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 B7

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	[mm²]	36,6	58,0	84,3	157	245	353	459	561
Characteristic resistance under tension load [1]											
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	-[3]	-[3]
	A4 and HCR Property class 80	$N_{Rk,s}$	[kN]	29	46	67	126	196	282	-[3]	-[3]
Partial factor [2]											
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						-[3]	-[3]
	A4 and HCR Property class 80	$\gamma_{Ms,N}$	[-]	1,6						-[3]	-[3]

[1] 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.
[2] in absence of other national regulations
[3] Anchor type not part of the ETA

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				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Cross sectional area		A_s	[mm²]	36,6	58,0	84,3	157	245	353	459	561
Characteristic resistances under shear load[1)]											
Steel failure <u>without</u> lever arm											
Steel, zinc plated	Property class 4.6 and 4.8	$V^0_{Rk,s}$	[kN]	9 (8)	14 (13)	20	38	59	85	110	135
	Property class 5.6 and 5.8	$V^0_{Rk,s}$	[kN]	11 (10)	17 (16)	25	47	74	106	138	168
	Property class 8.8	$V^0_{Rk,s}$	[kN]	15 (13)	23 (21)	34	63	98	141	184	224
Stainless steel	A2, A4 and HCR, property class 50	$V^0_{Rk,s}$	[kN]	9	15	21	39	61	88	115	140
	A2, A4 and HCR, property class 70	$V^0_{Rk,s}$	[kN]	13	20	30	55	86	124	-[3)]	-[3)]
	A4 and HCR, property class 80	$V^0_{Rk,s}$	[kN]	15	23	34	63	98	141	-[3)]	-[3)]
Steel failure <u>with</u> lever arm											
Steel, zinc plated	Property class 4.6 and 4.8	$M^0_{Rk,s}$	[Nm]	15 (13)	30 (27)	52	133	260	449	666	900
	Property class 5.6 and 5.8	$M^0_{Rk,s}$	[Nm]	19 (16)	37 (33)	65	166	324	560	833	1123
	Property class 8.8	$M^0_{Rk,s}$	[Nm]	30 (26)	60 (53)	105	266	519	896	1333	1797
Stainless steel	A2, A4 and HCR, property class 50	$M^0_{Rk,s}$	[Nm]	19	37	66	167	325	561	832	1125
	A2, A4 and HCR, property class 70	$M^0_{Rk,s}$	[Nm]	26	52	92	232	454	784	-[3)]	-[3)]
	A4 and HCR, property class 80	$M^0_{Rk,s}$	[Nm]	30	59	105	266	519	896	-[3)]	-[3)]
Partial factor [2)]											
Steel, zinc plated	Property class 4.6	$\gamma_{Ms,V}$	[-]	1,67							
	Property class 4.8	$\gamma_{Ms,V}$	[-]	1,25							
	Property class 5.6	$\gamma_{Ms,V}$	[-]	1,67							
	Property class 5.8	$\gamma_{Ms,V}$	[-]	1,25							
	Property class 8.8	$\gamma_{Ms,V}$	[-]	1,25							
Stainless steel	A2, A4 and HCR, property class 50	$\gamma_{Ms,V}$	[-]	2,38							
	A2, A4 and HCR, property class 70	$\gamma_{Ms,V}$	[-]	1,56						-[3)]	-[3)]
	A4 and HCR, property class 80	$\gamma_{Ms,V}$	[-]	1,33						-[3)]	-[3)]

[1)] 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
[2)] in absence of other national regulations
[3)] Anchor type not part of the ETA

Injection System VMH for concrete

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

Annex C2

Table C3: Characteristic values of **concrete cone failure and splitting failure**

Threaded rods / Internally threaded anchor rods / Rebars				**all sizes**
Concrete cone failure				
Factor k_1	uncracked concrete	$k_{ucr,N}$	[-]	11,0
	cracked concrete	$k_{cr,N}$	[-]	7,7
Edge distance		$c_{cr,N}$	[mm]	$1{,}5 \cdot h_{ef}$
Spacing		$s_{cr,N}$	[mm]	$2{,}0 \cdot c_{cr,N}$
Splitting failure				
Characteristic resistance		$N^0_{Rk,sp}$	[kN]	$\min (N_{Rk,p} ; N^0_{Rk,c})$
Edge distance	$h/h_{ef} \geq 2{,}0$	$c_{cr,sp}$	[mm]	$1{,}0 \cdot h_{ef}$
	$2{,}0 > h/h_{ef} > 1{,}3$			$2 \cdot h_{ef} (2{,}5 - h / h_{ef})$
	$h/h_{ef} \leq 1{,}3$			$2{,}4 \cdot h_{ef}$
Spacing		$s_{cr,sp}$	[mm]	$2{,}0 \cdot c_{cr,sp}$

Table C4: Characteristic values of **tension loads** for **threaded rods, static** and **quasi-static action**, working life **50 years**

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	40°C / 24°C	$\tau_{Rk,ucr}$	[N/mm²]	17	17	16	15	14	13	13	13
	II	80°C / 50°C			17	17	16	15	14	13	13	13
	III	120°C / 72°C			15	14	14	13	12	12	11	11
	VI	160°C / 100°C			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	40°C / 24°C	$\tau_{Rk,cr}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
	II	80°C / 50°C			7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
	III	120°C / 72°C			6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
	VI	160°C / 100°C			5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
Reduction factor ψ^0_{sus} in concrete C20/25												
Temperature range	I	40°C / 24°C	ψ^0_{sus}	[-]	0,90							
	II	80°C / 50°C			0,87							
	III	120°C / 72°C			0,75							
	VI	160°C / 100°C			0,66							
Increasing factors for concrete			ψ_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												
Relevant parameter					see Table C3							
Splitting failure												
Relevant parameter					see Table C3							
Installation factor												
dry or wet concrete	vacuum cleaning		γ_{inst}	[-]	1,2							
	manual cleaning				1,2				No performance assessed			
	compressed air cleaning				1,0							
water filled drill hole	compressed air cleaning		γ_{inst}	[-]	1,4							

Injection System VMH for concrete

Performance
Characteristic values of **tension loads** for **threaded rods,** working life **50 years**

Annex C4

Table C5: Characteristic values of **tension loads** for **threaded rods, static** and **quasi-static action**, working life **100 years**

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 uncracked concrete C20/25												
Temperature range	I	40°C / 24°C	$\tau_{Rk,ucr,100}$	[N/mm²]	17	17	16	15	14	13	13	13
	II	80°C / 50°C			17	17	16	15	14	13	13	13
Characteristic bond resistance in cracked concrete C20/25												
Temperature range	I	40°C / 24°C	$\tau_{Rk,cr,100}$	[N/mm²]	5,5	6,0	6,5	6,5	6,5	6,5	6,5	6,5
	II	80°C / 50°C			5,5	6,0	6,5	6,5	6,5	6,5	6,5	6,5
Increasing factors for concrete			ψ_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												
Relevant parameter					see Table C3							
Splitting failure												
Relevant parameter					see Table C3							
Installation factor												
dry or wet concrete	vacuum cleaning		γ_{inst}	[-]	1,2							
	manual cleaning				1,2				No performance assessed			
	compressed air cleaning				1,0							
water filled drill hole	compressed air cleaning		γ_{inst}	[-]	1,4							

Injection System VMH for concrete	Annex C5
Performance Characteristic values of **tension loads** for **threaded rods,** working life **100 years**	

Table C6: Characteristic values of **shear loads** for **threaded rods**, **static** and **quasi-static action**

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure without lever arm										
Characteristic resistance Steel, zinc plated Class 4.6, 4.8, 5.6 and 5.8	$V^0_{Rk,s}$	[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	$V^0_{Rk,s}$	[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 with lever arm										
Characteristic bending resistance	$M^0_{Rk,s}$	[Nm]	$1{,}2 \cdot W_{el} \cdot f_{uk}$ or see Table C2							
Elastic section modulus	W_{el}	[mm³]	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};300mm)	
Outside diameter of anchor	d_{nom}	[mm]	8	10	12	16	20	24	27	30
Installation factor	γ_{inst}	[-]	1,0							

Injection System VMH for concrete

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

Annex C6

Table C7: Characteristic values of **tension loads** for **threaded rods, seismic action** (performance category **C1 + C2**), working life **50** and **100 years**

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Characteristic resistance		$N_{Rk,s,C1}$	[kN]	$1{,}0 \cdot N_{Rk,s}$							
		$N_{Rk,s,C2}$	[kN]	-[1]		$1{,}0 \cdot N_{Rk,s}$				-[1]	
Partial factor		$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure											
Characteristic bond resistance in concrete C20/25 to C50/60											
Temperature range	I: 40°C / 24°C	$\tau_{Rk,C1}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
		$\tau_{Rk,C2}$	[N/mm²]	-[1]		3,6	3,5	3,3	2,3	-[1]	
	II: 80°C / 50°C	$\tau_{Rk,C1}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
		$\tau_{Rk,C2}$	[N/mm²]	-[1]		3,6	3,5	3,3	2,3	-[1]	
	III: 120°C / 72°C	$\tau_{Rk,C1}$	[N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
		$\tau_{Rk,C2}$	[N/mm²]	-[1]		3,1	3,0	2,8	2,0	-[1]	
	VI: 160°C / 100°C	$\tau_{Rk,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
		$\tau_{Rk,C2}$	[N/mm²]	-[1]		2,5	2,7	2,5	1,8	-[1]	
Installation factor											
Compressed air cleaning	dry or wet concrete	γ_{inst}	[-]	1,0							
	water filled drill hole			1,4							
Vacuum cleaning	dry or wet concrete	γ_{inst}	[-]	1,2							

[1] No performance assessed

Table C8: Characteristic values of **shear loads** for **threaded rods, seismic action** (performance category **C1 + C2**)

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure <u>without</u> lever arm											
Characteristic resistance		$V_{Rk,s,C1}$	[kN]	$0{,}7 \cdot V^0_{Rk,s}$							
		$V_{Rk,s,C2}$	[kN]	-[1]		$0{,}7 \cdot V^0_{Rk,s}$				-[1]	
Partial factor		$\gamma_{Ms,N}$	[-]	see Table C2							
Factor for anchorages	without hole clearance	α_{gap}	[-]	1,0							
	with hole clearance between fastener and fixture	α_{gap}	[-]	0,5							

[1] No performance assessed

Injection System VMH for concrete	**Annex C7**
Performance Characteristic values for **threaded rods** under **seismic action**	

Table C9: Characteristic values of **tension loads** for **internally threaded anchor rod, static** and **quasi-static action**, working life **50 years**

Internally threaded anchor rod				**VMU-IG M6**	**VMU-IG M8**	**VMU-IG M10**	**VMU-IG M12**	**VMU-IG M16**	**VMU-IG M20**
Steel failure [1)]									
Characteristic resistance, steel, zinc plated, property class	5.8	$N_{Rk,s}$	[kN]	10	17	29	42	76	123
	8.8	$N_{Rk,s}$	[kN]	16	27	46	67	121	196
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic resistance, stainless steel A4 / HCR, property class	70	$N_{Rk,s}$	[kN]	14	26	41	59	110	124 [2)]
Partial factor		$\gamma_{Ms,N}$	[-]	1,87					2,86
Combined pull-out and concrete failure									
Characteristic bond resistance in <u>uncracked</u> concrete C20/25									
Temperature range	I: 40°C / 24°C	$\tau_{Rk,ucr}$	[N/mm²]	17	16	15	14	13	13
	II: 80°C / 50°C			17	16	15	14	13	13
	III: 120°C / 72°C			14	14	13	12	12	11
	VI: 160°C / 100°C			11	11	10	9,5	9,0	9,0
Characteristic bond resistance in <u>cracked</u> concrete C20/25									
Temperature range	I: 40°C / 24°C	$\tau_{Rk,cr}$	[N/mm²]	7,5	8,0	9,0	8,5	7,0	7,0
	II: 80°C / 50°C			7,5	8,0	9,0	8,5	7,0	7,0
	III: 120°C / 72°C			6,5	7,0	7,5	7,0	6,0	6,0
	VI: 160°C / 100°C			5,5	6,0	6,5	6,0	5,5	5,5
Reduction factor ψ^0_{sus} in concrete C20/25									
Temperature range	I: 40°C / 24°C	ψ^0_{sus}	[-]	0,90					
	II: 80°C / 50°C			0,87					
	III: 120°C / 72°C			0,75					
	VI: 160°C / 100°C			0,66					
Increasing factors for concrete		ψ_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									
Relevant parameter				see Table C3					
Splitting failure									
Relevant parameter				see Table C3					
Installation factor									
dry or wet concrete	vacuum cleaning	γ_{inst}	[-]	1,2					
	manual cleaning			1,2			No performance assessed		
	compressed air cleaning			1,0					
waterfilled drill hole	compressed air cleaning	γ_{inst}	[-]	1,2					

[1)] 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

[2)] for VMU-IG M20: property class 50

Injection System VMH for concrete	**Annex C8**
Performance Characteristic values of **tension loads** for **internally threaded anchor rod,** working life **50 years**	

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Table C10: Characteristic values of **tension loads** for **internally threaded anchor rod, static** and **quasi-static action**, working life **100 years**

Internally threaded anchor rod				VMU-IG M6	VMU-IG M8	VMU-IG M10	VMU-IG M12	VMU-IG M16	VMU-IG M20
Steel failure [1]									
Characteristic resistance, steel, zinc plated, property class	5.8	$N_{Rk,s}$	[kN]	10	17	29	42	76	123
	8.8	$N_{Rk,s}$	[kN]	16	27	46	67	121	196
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic resistance, stainless steel A4 / HCR, property class	70	$N_{Rk,s}$	[kN]	14	26	41	59	110	124 [2]
Partial factor		$\gamma_{Ms,N}$	[-]	1,87					2,86
Combined pull-out and concrete failure									
Characteristic bond resistance in <u>uncracked</u> concrete C20/25									
Temperature range	I: 40°C / 24°C	$\tau_{Rk,ucr,100}$	[N/mm²]	17	16	15	14	13	13
	II: 80°C / 50°C			17	16	15	14	13	13
Characteristic bond resistance in <u>cracked</u> concrete C20/25									
Temperature range	I: 40°C / 24°C	$\tau_{Rk,cr,100}$	[N/mm²]	6,0	6,5	6,5	6,5	6,5	6,5
	II: 80°C / 50°C			6,0	6,5	6,5	6,5	6,5	6,5
Increasing factors for concrete		ψ_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									
Relevant parameter				see Table C3					
Splitting failure									
Relevant parameter				see Table C3					
Installation factor									
dry or wet concrete	vacuum cleaning	γ_{inst}	[-]	1,2					
	manual cleaning			1,2			No performance assessed		
	compressed air cleaning			1,0					
waterfilled drill hole	compressed air cleaning	γ_{inst}	[-]	1,2					

[1] 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

[2] for VMU-IG M20: property class 50

Injection System VMH for concrete

Performance
Characteristic values of **tension loads** for **internally threaded anchor rod,** working life **100 years**

Annex C9

Table C11: Characteristic values of **shear loads** for **internally threaded anchor rod, static** and **quasi-static action**

Internally threaded anchor rod					**VMU-IG M6**	**VMU-IG M8**	**VMU-IG M10**	**VMU-IG M12**	**VMU-IG M16**	**VMU-IG M20**
Steel failure <u>without</u> lever arm [1]										
Steel, zinc plated	Characteristic resistance	property class 5.8	$V^0_{Rk,s}$	[kN]	6	10	17	25	45	74
	Characteristic resistance	property class 8.8	$V^0_{Rk,s}$	[kN]	8	14	23	34	60	98
	Partial factor		$\gamma_{Ms,V}$	[-]	1,25					
Stainless steel	Characteristic resistance A4 / HCR	property class 70	$V^0_{Rk,s}$	[kN]	7	13	20	30	55	62 [2]
	Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38
Ductility factor			k_7	[-]	1,0					
Steel failure <u>with</u> lever arm [1]										
Steel, zinc plated	Characteristic bending resistance	property class 5.8	$M^0_{Rk,s}$	[Nm]	8	19	37	66	167	325
	Characteristic bending resistance	property class 8.8	$M^0_{Rk,s}$	[Nm]	12	30	60	105	267	519
	Partial factor		$\gamma_{Ms,V}$	[-]	1,25					
Stainless steel	Characteristic bending resistance A4 / HCR	property class 70	$M^0_{Rk,s}$	[Nm]	11	26	53	92	234	643 [2]
	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			γ_{inst}	[-]	1,0					

[1] 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

[2] 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 C10

Table C12: Characteristic values of **tension loads** for **rebar, static** and **quasi-static action**, **50 years** working life

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	[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 uncracked concrete C20/25												
Temperature range I: 40°C / 24°C	$\tau_{Rk,ucr}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
Temperature range II: 80°C / 50°C	$\tau_{Rk,ucr}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
Temperature range III: 120°C / 72°C	$\tau_{Rk,ucr}$	[N/mm²]	13	12	12	12	12	11	11	11	11	11
Temperature range VI: 160°C / 100°C	$\tau_{Rk,ucr}$	[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 cracked concrete C20/25												
Temperature range I: 40°C / 24°C	$\tau_{Rk,cr}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
Temperature range II: 80°C / 50°C	$\tau_{Rk,cr}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
Temperature range III: 120°C / 72°C	$\tau_{Rk,cr}$	[N/mm²]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
Temperature range VI: 160°C / 100°C	$\tau_{Rk,cr}$	[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^0_{sus} in concrete C20/25												
Temperature range I: 40°C / 24°C	ψ^0_{sus}	[-]	0,90									
Temperature range II: 80°C / 50°C	ψ^0_{sus}	[-]	0,87									
Temperature range III: 120°C / 72°C	ψ^0_{sus}	[-]	0,75									
Temperature range VI: 160°C / 100°C	ψ^0_{sus}	[-]	0,66									
Increasing factor for concrete	ψ_c	C25/30	1,02									
Increasing factor for concrete	ψ_c	C30/37	1,04									
Increasing factor for concrete	ψ_c	C35/45	1,07									
Increasing factor for concrete	ψ_c	C40/50	1,08									
Increasing factor for concrete	ψ_c	C45/55	1,09									
Increasing factor for concrete	ψ_c	C50/60	1,10									
Concrete cone failure												
Relevant parameter			see Table C3									
Splitting failure												
Relevant parameter			see Table C3									
Installation factor												
dry or wet concrete – vacuum cleaning	γ_{inst}	[-]	1,2									
dry or wet concrete – manual cleaning	γ_{inst}	[-]	1,2					No performance assessed				
dry or wet concrete – compressed air cleaning	γ_{inst}	[-]	1,0									
waterfilled drill hole – compressed air cleaning	γ_{inst}	[-]	1,4									

1) f_{uk} shall be taken from the specifications of reinforcing bars
2) in absence of national regulation

Table C13: Characteristic values of **tension loads** for **rebar, static** and **quasi-static action**, **100 years** working life

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	[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 uncracked concrete C20/25														
Temperature range	I:	40°C / 24°C	$\tau_{Rk,ucr,100}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
Temperature range	II:	80°C / 50°C	$\tau_{Rk,ucr,100}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
Characteristic bond resistance in cracked concrete C20/25														
Temperature range	I:	40°C / 24°C	$\tau_{Rk,cr,100}$	[N/mm²]	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
Temperature range	II:	80°C / 50°C	$\tau_{Rk,cr,100}$	[N/mm²]	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
Increasing factor for concrete			ψ_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														
Relevant parameter					see Table C3									
Splitting failure														
Relevant parameter					see Table C3									
Installation factor														
dry or wet concrete	vacuum cleaning		γ_{inst}	[-]	1,2									
dry or wet concrete	manual cleaning		γ_{inst}	[-]	1,2					No performance assessed				
dry or wet concrete	compressed air cleaning		γ_{inst}	[-]	1,0									
waterfilled drill hole	compressed air cleaning		γ_{inst}	[-]	1,4									

[1)] f_{uk} shall be taken from the specifications of reinforcing bars
[2)] in absence of national regulation

Table C14: Characteristic values of **shear loads** for **rebar, static** and **quasi-static action**

Reinforcing bar			∅ 8	∅ 10	∅ 12	∅ 14	∅ 16	∅ 20	∅ 24	∅ 25	∅ 28	∅ 32
Steel failure without lever arm												
Characteristic shear resistance	$V^0_{Rk,s}$	[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 with lever arm												
Characteristic bending resistance	$M^0_{Rk,s}$	[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	γ_{inst}	[-]	1,0									

1) f_{uk} shall be taken from the specifications of reinforcing bars
2) in absence of national regulation

Table C15: Characteristic values of **tension loads** for **rebar, seismic action** (performance category **C1**), **50** and **100 years** working life

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		$N_{Rk,s,C1}$	[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 to C50/60													
Temperature range	I: 40°C / 24°C	$\tau_{Rk,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
	II: 80°C / 50°C			5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
	III: 120°C / 72°C			4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
	VI: 160°C / 100°C			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_{inst}	[-]	1,2									
	compressed air cleaning	γ_{inst}	[-]	1,0									
waterfilled drill hole	compressed air cleaning	γ_{inst}	[-]	1,4									

[1] f_{uk} shall be taken from the specifications of reinforcing bars
[2] in absence of national regulation

Table C16: Characteristic values of **shear loads** for **rebar, 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	$V^0_{Rk,s,C1}$	[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									

[1] f_{uk} shall be taken from the specifications of reinforcing bars
[2] in absence of national regulation

Table C17: Displacements under **tension load** (threaded rod)

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Displacement factor [1)] uncracked concrete, static and quasi-static action, working life 50 and 100 years										
Temperature range I: 40°C / 24°C II: 80°C / 50°C	δ_{N0}-factor	$[\frac{mm}{N/mm^2}]$	0,031	0,032	0,034	0,037	0,039	0,042	0,044	0,046
	$\delta_{N\infty}$-factor		0,040	0,042	0,044	0,047	0,051	0,054	0,057	0,060
Temperature range III: 120°C / 72°C	δ_{N0}-factor		0,032	0,034	0,035	0,038	0,041	0,044	0,046	0,048
	$\delta_{N\infty}$-factor		0,042	0,044	0,045	0,049	0,053	0,056	0,059	0,062
Temperature range VI: 160°C / 100°C	δ_{N0}-factor		0,121	0,126	0,131	0,142	0,153	0,163	0,171	0,179
	$\delta_{N\infty}$-factor		0,124	0,129	0,135	0,146	0,157	0,168	0,176	0,184
Displacement factor [1)] cracked concrete, static and quasi-static action, working life 50 and 100 years										
Temperature range I: 40°C / 24°C II: 80°C / 50°C	δ_{N0}-factor	$[\frac{mm}{N/mm^2}]$	0,081	0,083	0,085	0,090	0,095	0,099	0,103	0,106
	$\delta_{N\infty}$-factor		0,104	0,107	0,110	0,116	0,122	0,128	0,133	0,137
Temperature range III: 120°C / 72°C	δ_{N0}-factor		0,084	0,086	0,088	0,093	0,098	0,103	0,107	0,110
	$\delta_{N\infty}$-factor		0,108	0,111	0,114	0,121	0,127	0,133	0,138	0,143
Temperature range VI: 160°C / 100°C	δ_{N0}-factor		0,312	0,321	0,330	0,349	0,367	0,385	0,399	0,412
	$\delta_{N\infty}$-factor		0,321	0,330	0,340	0,358	0,377	0,396	0,410	0,424
Displacement, seismic action (C2)										
All temperature ranges	$\delta_{N,C2\ (DLS)}$	[mm]	-[2)]		0,24	0,27	0,29	0,27	-[2)]	
	$\delta_{N,C2\ (ULS)}$				0,55	0,51	0,50	0,58		

[1)] Calculation of the displacement
$\delta_{N0} = \delta_{N0}\text{- factor} \cdot \tau$; τ: acting bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}\text{- factor} \cdot \tau$;
[2)] No performance assessed

Table C18: Displacements under **shear load** (threaded rod)

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Displacement factor[1)] cracked and uncracked concrete, static and quasi-static action										
All temperature ranges	δ_{V0}-factor	[mm/(kN)]	0,06	0,06	0,05	0,04	0,04	0,03	0,03	0,03
	$\delta_{V\infty}$-factor		0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05
Displacement, seismic action (C2)										
All temperature ranges	$\delta_{V,C2(DLS)}$	[mm]	-[2)]		3,6	3,0	3,1	3,5	-[2)]	
	$\delta_{V,C2(ULS)}$				7,0	6,6	7,0	9,3		

[1)] Calculation of the displacement
$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V$; V: acting shear load
$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V$;
[2)] No performance assessed

Injection System VMH for concrete	**Annex C15**
Performance Displacements (threaded rod)	

Table C19: 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
Displacement factor[1)] uncracked concrete, static and quasi-static action, working life 50 and 100 years								
Temperature range I: 40°C / 24°C II: 80°C / 50°C	δ_{N0}-factor	$[\frac{mm}{N/mm^2}]$	0,032	0,034	0,037	0,039	0,042	0,046
	$\delta_{N\infty}$-factor		0,042	0,044	0,047	0,051	0,054	0,060
Temperature range III: 120°C / 72°C	δ_{N0}-factor		0,034	0,035	0,038	0,041	0,044	0,048
	$\delta_{N\infty}$-factor		0,044	0,045	0,049	0,053	0,056	0,062
Temperature range VI: 160°C / 100°C	δ_{N0}-factor		0,126	0,131	0,142	0,153	0,163	0,179
	$\delta_{N\infty}$-factor		0,129	0,135	0,146	0,157	0,168	0,184
Displacement factor[1)] cracked concrete, static and quasi-static action, working life 50 and 100 years								
Temperature range I: 40°C / 24°C II: 80°C / 50°C	δ_{N0}-factor	$[\frac{mm}{N/mm^2}]$	0,083	0,085	0,090	0,095	0,099	0,106
	$\delta_{N\infty}$-factor		0,107	0,110	0,116	0,122	0,128	0,137
Temperature range III: 120°C / 72°C	δ_{N0}-factor		0,086	0,088	0,093	0,098	0,103	0,110
	$\delta_{N\infty}$-factor		0,111	0,114	0,121	0,127	0,133	0,143
Temperature range VI: 160°C / 100°C	δ_{N0}-factor		0,321	0,330	0,349	0,367	0,385	0,412
	$\delta_{N\infty}$-factor		0,330	0,340	0,358	0,377	0,396	0,424

[1)] Calculation of the displacement
$\delta_{N0} = \delta_{N0}\text{-factor} \cdot \tau$; τ: acting bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}\text{-factor} \cdot \tau$;

Table C20: 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
Displacement factor[1)] cracked and uncracked concrete, static and quasi-static action								
All temperature ranges	δ_{V0}-factor	[mm/(kN)]	0,07	0,06	0,06	0,05	0,04	0,04
	$\delta_{V\infty}$-factor		0,10	0,09	0,08	0,08	0,06	0,06

[1)] Calculation of the displacement
$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V$; V: acting shear load
$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V$;

Table C21: 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
Displacement factor[1)] uncracked concrete, static and quasi-static action, working life 50 and 100 years												
Temperature range I: 40°C / 24°C II: 80°C / 50°C	δ_{N0}-factor	$[\frac{mm}{N/mm^2}]$	0,031	0,032	0,034	0,035	0,037	0,039	0,042	0,043	0,045	0,048
	$\delta_{N\infty}$-factor		0,040	0,042	0,044	0,045	0,047	0,051	0,054	0,055	0,058	0,063
Temperature range III: 120°C / 72°C	δ_{N0}-factor		0,032	0,034	0,035	0,036	0,038	0,041	0,044	0,045	0,047	0,050
	$\delta_{N\infty}$-factor		0,042	0,044	0,045	0,047	0,049	0,053	0,056	0,057	0,060	0,065
Temperature range VI: 160°C / 100°C	δ_{N0}-factor		0,121	0,126	0,131	0,137	0,142	0,153	0,163	0,164	0,172	0,186
	$\delta_{N\infty}$-factor		0,124	0,129	0,135	0,141	0,146	0,157	0,168	0,169	0,177	0,192
Displacement factor[1)] cracked concrete, static and quasi-static action, working life 50 and 100 years												
Temperature range I: 40°C / 24°C II: 80°C / 50°C	δ_{N0}-factor	$[\frac{mm}{N/mm^2}]$	0,081	0,083	0,085	0,087	0,090	0,095	0,099	0,099	0,103	0,108
	$\delta_{N\infty}$-factor		0,104	0,107	0,110	0,113	0,116	0,122	0,128	0,128	0,133	0,141
Temperature range III: 120°C / 72°C	δ_{N0}-factor		0,084	0,086	0,088	0,090	0,093	0,098	0,103	0,103	0,107	0,113
	$\delta_{N\infty}$-factor		0,108	0,111	0,114	0,118	0,121	0,127	0,133	0,133	0,138	0,148
Temperature range VI: 160°C / 100°C	δ_{N0}-factor		0,312	0,321	0,330	0,340	0,349	0,367	0,385	0,385	0,399	0,425
	$\delta_{N\infty}$-factor		0,321	0,330	0,340	0,349	0,358	0,377	0,396	0,396	0,410	0,449

1) Calculation of the displacement
$\delta_{N0} = \delta_{N0}\text{-factor} \cdot \tau$; τ: acting bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}\text{- factor} \cdot \tau$;

Table C22: 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
Displacement factor[1)] cracked and uncracked concrete, static and quasi-static action												
All temperature ranges	δ_{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		0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05	0,04	0,04

1) 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 C17