Deutsches Institut für Bautechnik

DIBt

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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-19/0483 of 30 August 2019

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 VME plus
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 und Werk 2,D
This European Technical Assessment contains	29 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

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Specific Part

1 Technical description of the product

The Injection System VME plus is a bonded anchor consisting of a cartridge with injection mortar Injection mortar VME plus and a steel element. The steel element consists of a threaded rod with washer and hexagon nut in the range of M8 to M30, reinforcing bar in the range of diameter ∅8 to ∅32 mm or internal threaded rod VMU-IG-M6 to VMU-IG-M20.

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

The product description is given in Annex A.

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

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

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

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

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic	Performance
Characteristic resistance to tension load (static and quasi-static loading)	See Annex C 1, C 3, C 4, C 7, C 9
Characteristic resistance to shear load (static and quasi-static loading)	See Annex C 2, C 5, C 8, C 10
Displacements (static and quasi-static loading)	See Annex C 12, C 13, C 14
Characteristic resistance for seismic performance category C1 and C2 and displacements	See Annex C 6, C 11, C 12
Durability	See Annex B 1

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.

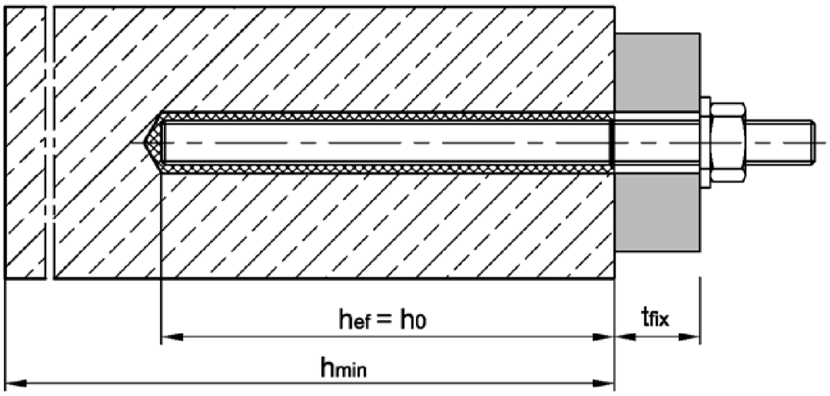
Issued in Berlin on 30 August 2019 by Deutsches Institut für Bautechnik

BD Dipl.-Ing. Andreas Kummerow
Head of Department

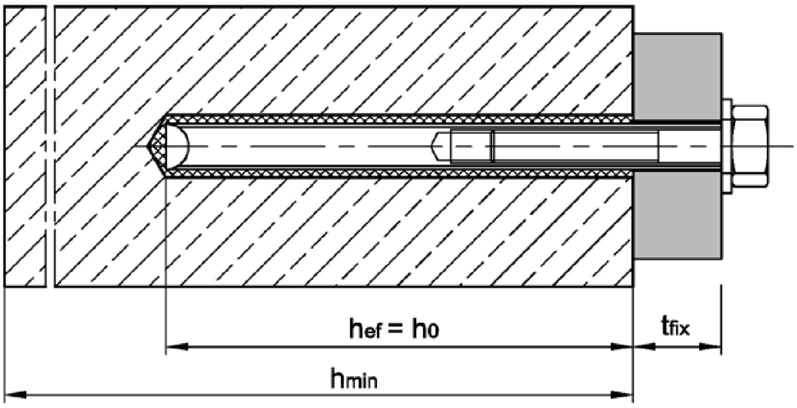
beglaubigt:
Baderschneider

Installation threaded rod M8 to M30

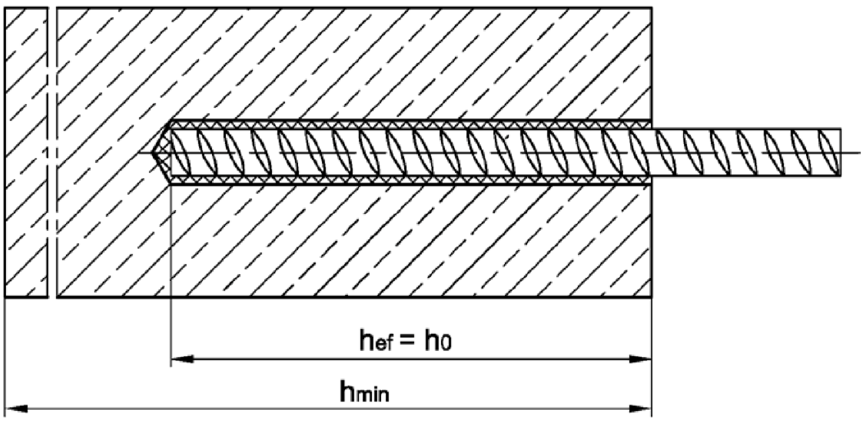
Pre-setting installation or through-setting installation (optional annular gap filled with mortar)



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



Installation reinforcing bar Ø8 to Ø32



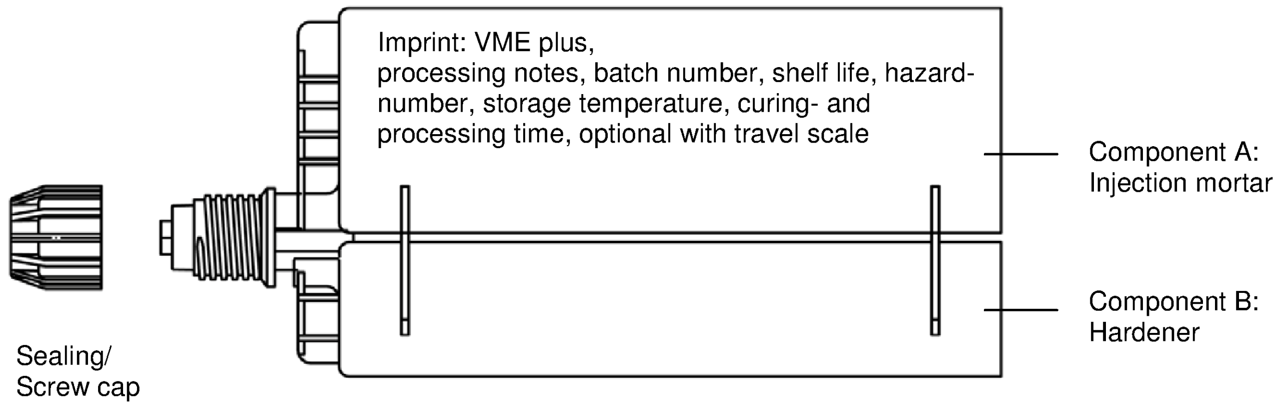
t_{fix} = thickness of fixture
h_{ef} = effective anchorage depth
h_0 = depth of drill hole
h_{min} = minimum thickness of member

Injection System VME plus	**Annex A1**
Product description Installation situation	

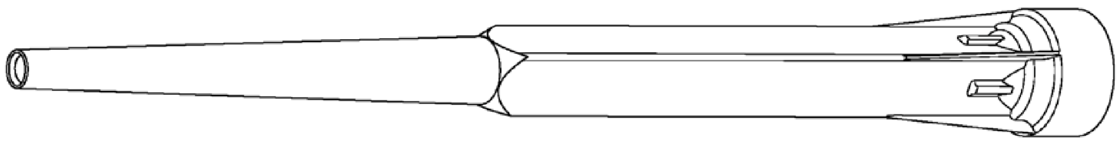
Deutsches Institut für Bautechnik DIBt

Cartridge Injection Mortar VME plus

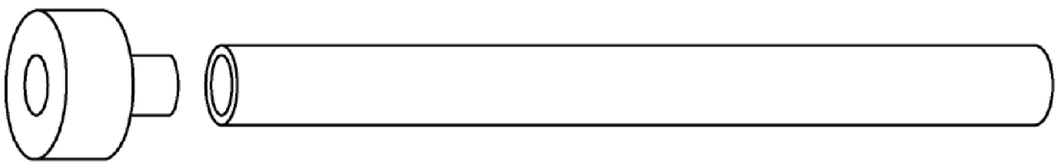
440 ml, 585 ml and 1400 ml cartridge (Type: "side-by-side")



Static Mixer



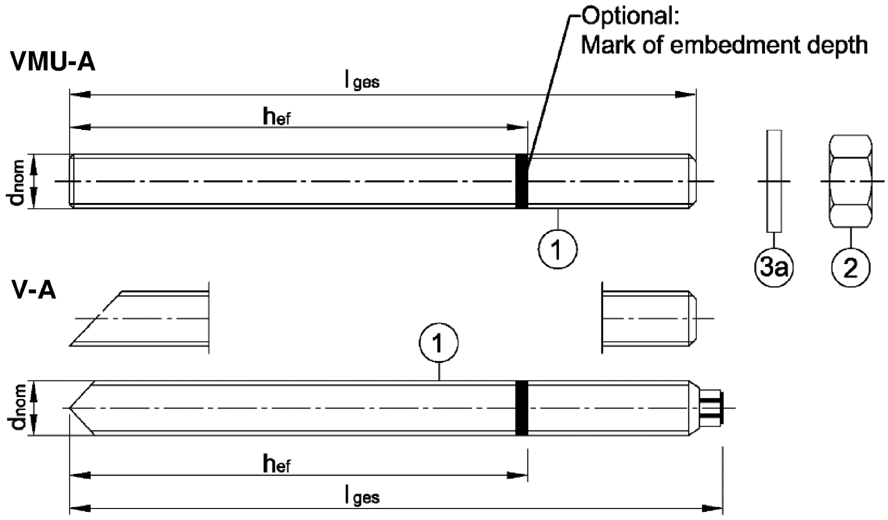
Retaining washer and extension nozzle



Injection System VME plus	Annex A2
Product description Cartridge, static mixer and retaining washer with extension nozzle	

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)



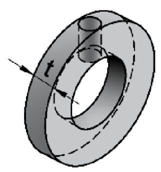
Marking e.g: ◇ M10

◇	identifying mark of manufacturing plant
M10	size of thread
A4	additional marking for stainless steel
HCR	additional marking for high corrosion resistant steel

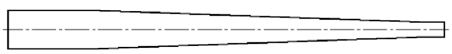
Threaded rod VM-A (material sold by the meter, to be cut at the required length)
M8, M10, M12, M16, M20, M24, M27, M30 (zinc plated, A2, A4, HCR)

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

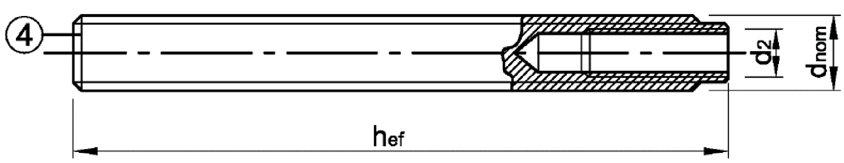


Thickness of washer with bore
for diameter
< M24: t = 5 mm
≥ M24: t = 6 mm



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.: ◇ M8

◇	Identifying mark of manufacturing plant
I	Internal thread
M8	Size of internal thread
A4	additional marking for stainless steel
HCR	additional marking for high corrosion resistant steel

Injection System VME plus

Product description
Threaded rod, internally threaded anchor rod and washer with bore

Annex A3

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 4042:1999 or hot-dip galvanized ≥ 40 µm acc. to EN ISO 1461:2009 and EN ISO 10684:2004+AC:2009 or sherardized ≥ 45 µm acc. to EN ISO 17668:2016								
1	Threaded rod	Property class	characteristic steel ultimate strength		characteristic steel yield strength		fracture elongation	EN 10087:1998, 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	$A_5 \geq 12\%$ [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, 5.8 rods					
		8	for class 4.6, 4.8, 5.6, 5.8, 8.8 rods					
3a	Washer		e.g.: EN ISO 7089:2000, EN ISO 7093:2000, EN ISO 887:2006; EN ISO 7094:2000					
3b	Washer with bore		Steel, zinc plated					
4	Internally threaded anchor rod	5.8	Steel, electroplated or sherardized				$A_5 > 8\%$	EN 10087:1998
		8.8					$A_5 > 8\%$	
Stainless steel A2 [2] (Materials 1.4301 / 1.4307 / 1.4567 / 1.4541) **Stainless steel A4** (Materials 1.4401 / 1.4404 / 1.4571 / 1.4578 / 1.4362 / 1.4062) **High corrosion resistant steel HCR** (Materials 1.4529 / 1.4565)								
1	Threaded rod [3]	Property class	characteristic steel ultimate strength		characteristic steel yield strength		fracture elongation	EN 10088-1:2014 EN ISO 3506-1:2009
		50	f_{uk} [N/mm²]	500	f_{yk} [N/mm²]	210	$A_5 > 8\%$	
		70		700		450	$A_5 \geq 12\%$ [1]	
		80		800		600	$A_5 \geq 12\%$ [1]	
2	Hexagon nut [3]	50	for class 50 rods					EN 10088-1:2014 EN ISO 3506-2:2009
		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					
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

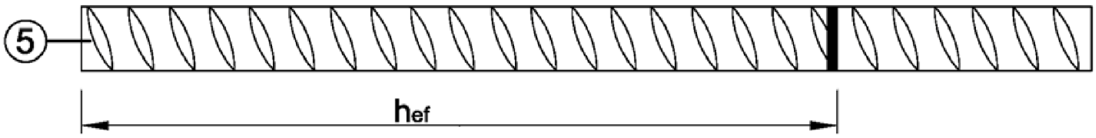
Injection System VME plus

Product description
Materials - Threaded rod and internally threaded anchor rod

Annex A4

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 of EN 1992-1-1/NA $f_{uk} = f_{tk} = k \cdot f_{yk}$

Injection System VME plus

Product description
Product description and material reinforcing bar

Annex A5

Specification of intended use

Injection System VME plus	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, A4, HCR	Ø8 - Ø32
Seismic action, category C1	M8 - M30 zinc plated [1], A4, HCR	-	Ø8 - Ø32
Seismic action, category C2	M12 – M24 zinc plated [1] (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 +40 °C	max. long term temperature +24 °C and max. short term temperature +40 °C		
Temperature Range II -40 °C to +72 °C	max. long term temperature +50 °C and max. short term temperature +72 °C		

[1] except hot-dip galvanized

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 A 4, Table A1: CRC II
  - Stainless steel A4 according to Annex A 4, Table A1: CRC III
  - High corrosion resistant steel HCR according to Annex A 4, 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, February 2018

Installation:
- Dry or wet concrete or waterfilled boreholes (not seawater)
- Hole drilling by hammer drill, 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 responsible for technical matters of the 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 VME plus

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	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)[1]	60	100	170	250	300
Minimum thickness of member		h_{min}	[mm]	h_{ef} + 30mm ≥100mm			$h_{ef} + 2d_0$				
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] Installation torque for property class 4.6

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	$d_f \leq$	[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} + 30mm ≥ 100mm		$h_{ef} + 2d_0$			
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			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[1]	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 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 ∅8, ∅10 and ∅12 both nominal drill hole diameter can be used

Injection System VME plus

Intended use
Installation parameters

Annex B2

Table B4: Parameter for 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 M6	8 / 10	12	13,5	12,5
M12	VMU-IG M8	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_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
Vacuum drill bit (MKT Hollow drill bit SB, Würth Hammer drill bit with suction or Heller Duster Expert hollow drill bit system) and a vacuum cleaner with minimum negative pressure of 253 hPa and flow rate of minimum 42 l/s

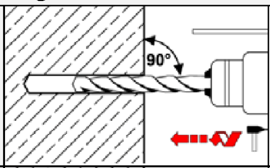
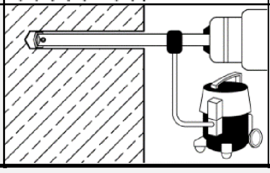
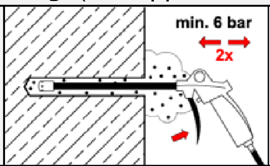
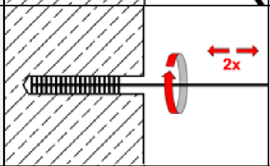
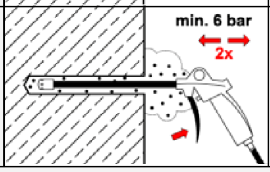
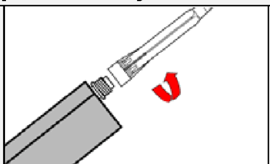
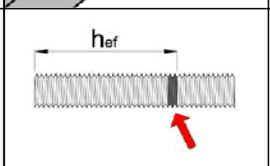
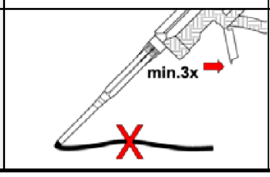
Recommended compressed air tool (min 6 bar)
Drill bit diameter (d_0): all diameters

Injection System VME plus	Annex B3
Intended use Cleaning and setting tools	

Table B6: Working time and curing time

Concrete temperature			Working time	Minimum curing time	
				dry concrete	wet concrete
+5°C	to	+9°C	80 min	48 h	96 h
+10°C	to	+14°C	60 min	28 h	56 h
+15°C	to	+19°C	40 min	18 h	36 h
+20°C	to	+24°C	30 min	12 h	24 h
+25°C	to	+34°C	12 min	9 h	18 h
+35°C	to	+39°C	8 min	6 h	12 h
+40°C			8 min	4 h	8 h
Cartridge temperature			+5°C to +40°C		

Installation Instructions

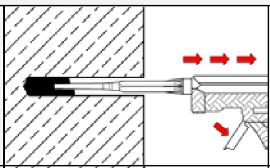
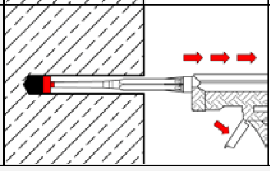
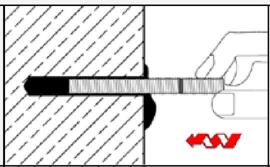
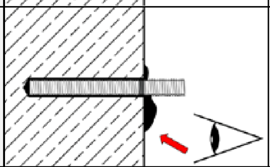
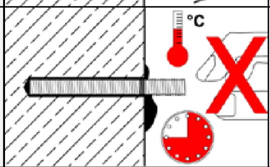
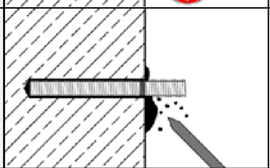
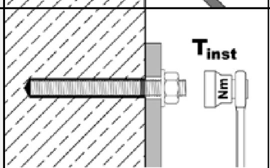
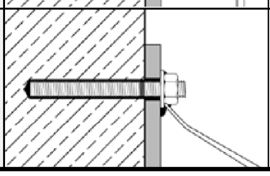
Drilling of the hole		
1a		**Hammer drilling or compressed air drilling** Drill with hammer drill or compressed air drill a hole into the base material with prescribed nominal drill hole diameter (Table B1, B2 or B3) and selected borehole depth. Continue with step 2. In case of aborted drill hole, the drill hole shall be filled with mortar.
1b		**Vacuum drilling:** see Annex B3 Drill borehole with prescribed nominal drill hole diameter (Table B1, B2 or B3) and selected borehole depth. This drilling method removes dust and cleans the borehole during drilling. Continue with step 3. In case of aborted drill hole, the drill hole shall be filled with mortar.
Attention! Standing water in the bore hole must be removed before cleaning!		
Cleaning (Not applicable when using vacuum drilling – see step 1b and Annex B3)		
2a		Starting from the bottom or back of the bore 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 borehole 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 borehole ground is not reached with the brush, an appropriate brush extension must be used.
2c		Starting from the bottom or back of the bore 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 borehole ground is not reached, an extension must be used.
After cleaning, the borehole has to be protected against re-contamination in an appropriate way, until dispensing the mortar in the borehole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must not contaminate the borehole again.		
Preparation 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 borehole, 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 or red colour.

Injection System VME plus

Intended Use
Installation instructions

Annex B5

Installation instructions (continue)

Injection		
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 bore hole ground is not reached, an appropriate extension nozzle shall be used. Observe temperature dependent 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
Inserting the anchor		
7		Push the threaded rod or reinforcing bar into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached. The anchor shall be free of dirt, grease, oil or other foreign material.
8		Make sure that excess mortar is visible at the top of the hole and in case of through-setting installation also in the fixture. If these requirements are not maintained, 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 T_{inst} according to Table B1 or B2.
12		In case of pre-setting installation the annular gap between anchor rod and fixture can 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.

Injection System VME plus	**Annex B6**
Intended Use Installation instructions (continuation)	

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	-	-
	A4 and HCR Property class 80	$N_{Rk,s}$	[kN]	29	46	67	126	196	282	-	-
Partial factors [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						-	-
	A4 and HCR Property class 80	$\gamma_{Ms,N}$	[-]	1,6						-	-

[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 national regulation

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 resistance under shear load [1]											
Steel failure without 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	-	-
	A4 and HCR, property class 80	$V^0_{Rk,s}$	[kN]	15	23	34	63	98	141	-	-
Steel failure with 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	-	-
	A4 and HCR, property class 80	$M^0_{Rk,s}$	[Nm]	30	59	105	266	519	896	-	-
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						-	-
	A4 and HCR, property class 80	$\gamma_{Ms,V}$	[-]	1,33						-	-

[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 national regulation

Injection System VME plus	
Performance Characteristic **steel resistance** for **threaded rods** under **shear load**	**Annex C2**

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

Threaded rods / Internally threaded anchor rods / Rebar				**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]	$2 \cdot c_{cr,N}$
Splitting failure				
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]	$2 \cdot c_{cr,sp}$

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Table C4: Characteristic values of **tension load** for **threaded rods** under **static** and **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: 40°C / 24°C	Hammer- or compressed air drilling	$\tau_{Rk,ucr}$	[N/mm²]	20	20	19	19	18	17	16	16
Temperature range II: 72°C / 50°C	Hammer- or compressed air drilling	$\tau_{Rk,ucr}$	[N/mm²]	15	15	15	14	13	13	12	12
Temperature range I: 40°C / 24°C	Vacuum drilling	$\tau_{Rk,ucr}$	[N/mm²]	17 (16)[1)]	16	16	16 (15)[1)]	15	14	14	13
Temperature range II: 72°C / 50°C	Vacuum drilling	$\tau_{Rk,ucr}$	[N/mm²]	14	14	14	13	13	12	12	11
Characteristic bond resistance in <u>cracked</u> concrete C20/25											
Temperature range I: 40°C / 24°C	all drilling methods	$\tau_{Rk,cr}$	[N/mm²]	7,0	7,0	8,5	8,5	8,5	8,5	8,5	8,5
Temperature range II: 72°C / 50°C	all drilling methods	$\tau_{Rk,cr}$	[N/mm²]	6,0	6,0	7,0	7,0	7,0	7,0	7,0	7,0
Reductionfactor ψ^0_{sus} in concrete C20/25											
Temperature range I: 40°C / 24°C	all drilling methods	ψ^0_{sus}	[-]	0,75							
Temperature range II: 72°C / 50°C	all drilling methods	ψ^0_{sus}	[-]	0,68							
Increasing factors for concrete	C25/30	ψ_c	[-]	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		γ_{inst}	[-]	1,0							
Waterfilled bore hole		γ_{inst}	[-]	1,2							

1) Value in brackets: characteristic bond resistance for waterfilled bore holes

Injection System VME plus

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

Annex C4

Table C5: Characteristic values of **shear loads** for **threaded rods** under **static** and **quasi-static action**

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Steel failure without lever arm										
Characteristic shear resistance Steel, property 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 shear resistance Steel, property class 8.8 Stainless steel A2, A4 and HCR (all property classes)	$V^0_{Rk,s}$	[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							

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Table C6: Characteristic values of **tension load** for **threaded rods** under **seismic action** (performance category **C1 + C2**)

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Tension loads											
Steel failure											
Characteristic resistance **C1**		$N_{Rk,s,eq,C1}$	[kN]	$1,0 \cdot N_{Rk,s}$							
Characteristic resistance **C2** steel, zinc plated, property class 8.8 stainless steel A4 and HCR, property class ≥ 70		$N_{Rk,s,eq,C2}$	[kN]	NPA		$1,0 \cdot N_{Rk,s}$				NPA	
Partial factor		$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure											
Characteristic bond resistance in concrete C20/25											
Temperature range I: 40°C / 24°C	all drilling methods	$\tau_{Rk,eq,C1}$	[N/mm²]	7,0	7,0	8,5	8,5	8,5	8,5	8,5	8,5
		$\tau_{Rk,eq,C2}$	[N/mm²]	NPA		5,8	4,8	5,0	5,1	NPA	
Temperature range II: 72°C / 50°C		$\tau_{Rk,eq,C1}$	[N/mm²]	6,0	6,0	7,0	7,0	7,0	7,0	7,0	7,0
		$\tau_{Rk,eq,C2}$	[N/mm²]	NPA		5,0	4,1	4,3	4,4	NPA	
Installation factor											
Dry or wet concrete		γ_{inst}	[-]	1,0							
Waterfilled bore hole		γ_{inst}	[-]	1,2							

Table C7: Characteristic values of **shear loads** for **threaded rods** under **seismic action** (performance category **C1 + C2**)

Shear loads					
Steel failure without lever arm					
Characteristic resistance **C1**	$V_{Rk,s,eq,C1}$	[kN]	$0,7 \cdot V^0_{Rk,s}$		
Characteristic resistance **C2** steel, zinc plated, property class 8.8 stainless steel A4 and HCR, property class ≥ 70	$V_{Rk,s,eq,C2}$	[kN]	No Performance Assessed (NPA)	$0,7 \cdot V^0_{Rk,s}$	No Performance Assessed (NPA)
Steel failure with lever arm					
Characteristic bending resistance	$M^0_{Rk,s,eq,C1}$	[Nm]	No Performance Assessed (NPA)		
	$M^0_{Rk,s,eq,C2}$	[Nm]	No Performance Assessed (NPA)		
Installation factor	γ_{inst}	[-]	1,0		
Factor for annular gap	α_{gap}	[-]	1,0 (0,5)[1)]		

[1)] Value in bracket is valid for fastenings with annular gap between threaded rod and fixture

Injection System VME plus	**Annex C6**
Performance Characteristic values for **threaded rods** under **seismic action**	

Table C8: Characteristic values of **tension loads** for **internally threaded anchor rod** under **static** and **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 [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 5.8 and 8.8		$\gamma_{Ms,N}$	[-]	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 uncracked concrete C20/25									
Temperature range I: 40°C / 24°C	Hammer- or compressed air drilling	$\tau_{Rk,ucr}$	[N/mm²]	20	19	19	18	17	16
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	15	15	14	13	13	12
Temperature range I: 40°C / 24°C	Vacuum drilling	$\tau_{Rk,ucr}$	[N/mm²]	16	16	16 (15)[3]	15	14	13
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	14	14	13	13	12	11
Characteristic bond resistance in cracked concrete C20/25									
Temperature range I: 40°C / 24°C	all drilling methods	$\tau_{Rk,cr}$	[N/mm²]	7,0	8,5	8,5	8,5	8,5	8,5
Temperature range II: 72°C / 50°C		$\tau_{Rk,cr}$	[N/mm²]	6,0	7,0	7,0	7,0	7,0	7,0
Reductionfactor ψ^0_{sus}									
Temperature range I: 40°C / 24°C	all drilling methods	ψ^0_{sus}	[-]	0,75					
Temperature range II: 72°C / 50°C		ψ^0_{sus}	[-]	0,68					
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		γ_{inst}	[-]	1,0					
Waterfilled bore hole		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
[3] Value in bracket is valid for waterfilled bore hole

Injection System VME plus

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

Annex C7

Table C9: Characteristic values of **shear loads** for **internally threaded anchor rod** under **static** and **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 without lever arm [1)]										
Steel, zinc plated	Characteristic resistance, property class	5.8	$V^0_{Rk,s}$	[kN]	5	9	15	21	38	61
		8.8	$V^0_{Rk,s}$	[kN]	8	14	23	34	60	98
	Partial factor 5.8 and 8.8		$\gamma_{Ms,V}$	[-]	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 with lever arm [1)]										
Steel, zinc plated	Characteristic bending resistance, property class	5.8	$M^0_{Rk,s}$	[Nm]	8	19	37	66	167	325
		8.8	$M^0_{Rk,s}$	[Nm]	12	30	60	105	267	519
	Partial factor 5.8 and 8.8		$\gamma_{Ms,V}$	[-]	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

Table C10: Characteristic values of **tension loads** for **rebar** under **static** and **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 tension 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	Hammer- or compressed air drilling	$\tau_{Rk,ucr}$	[N/mm²]	16	16	16	16	16	16	15	15	15	15
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	12	12	12	12	12	12	12	12	11	11
Temperature range I: 40°C / 24°C	Vacuum drilling	$\tau_{Rk,ucr}$	[N/mm²]	14 (13)[3]	14 (13)[3]	13	13	13	13	13	13	13	13
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	12 (11)[3]	12 (11)[3]	12 (11)[3]	11	11	11	11	11	11	11
Characteristic bond resistance in cracked concrete C20/25													
Temperature range I: 40°C / 24°C	all drilling methods	$\tau_{Rk,cr}$	[N/mm²]	7,0	7,0	8,5	8,5	8,5	8,5	8,5	8,5	8,5	8,5
Temperature range II: 72°C / 50°C		$\tau_{Rk,cr}$	[N/mm²]	6,0	6,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Reductionfactor ψ^0_{sus}													
Temperature range I: 40°C / 24°C	all drilling methods	ψ^0_{sus}	[-]	0,75									
Temperature range II: 72°C / 50°C		ψ^0_{sus}	[-]	0,68									
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		γ_{inst}	[-]	1,0									
Waterfilled bore hole		γ_{inst}	[-]	1,2									

[1] f_{uk} shall be taken from the specifications of reinforcing bars
[2] in absence of national regulation
[3] Value in brackets: characteristic bond resistance for waterfilled bore holes

Injection System VME plus

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

Annex C9

Table C11: Characteristic values of **shear loads** for **rebar** under **static** and **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 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	896	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 C12: Characteristic values of **tension load** 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: 40°C / 24°C	all drilling methods	$\tau_{Rk,eq,C1}$	[N/mm²]	7,0	7,0	8,5	8,5	8,5	8,5	8,5	8,5	8,5	8,5
Temperature range II: 72°C / 50°C		$\tau_{Rk,eq,C1}$	[N/mm²]	6,0	6,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Installation factor													
Dry or wet concrete		γ_{inst}	[-]	1,0									
Waterfilled bore hole		γ_{inst}	[-]	1,2									

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

Table C13: 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 without lever arm												
Characteristic resistance	$V_{Rk,s,eq,C1}$	[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 with lever arm												
Characteristic bending resistance	$M^0_{Rk,s,eq,C1}$	[Nm]	No Performance Assessed (NPA)									
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 C14: **Displacements** under **tension load**[1)] (threaded rod)

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Uncracked concrete under static and quasi-static action										
Temperature range I: 40°C / 24°C	δ_{N0}- factor	[mm/(N/mm²)]	0,028	0,029	0,030	0,033	0,035	0,038	0,039	0,041
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,028	0,029	0,030	0,033	0,035	0,038	0,039	0,041
Temperature range II: 72°C / 50°C	δ_{N0}- factor	[mm/(N/mm²)]	0,038	0,039	0,040	0,044	0,047	0,051	0,052	0,055
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,047	0,049	0,051	0,055	0,059	0,064	0,067	0,070
Cracked concrete under static and quasi-static action										
Temperature range I: 40°C / 24°C	δ_{N0}- factor	[mm/(N/mm²)]	0,069	0,071	0,072	0,074	0,076	0,079	0,081	0,082
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,193	0,115	0,122	0,128	0,135	0,142	0,155	0,171
Temperature range II: 72°C / 50°C	δ_{N0}- factor	[mm/(N/mm²)]	0,092	0,095	0,096	0,099	0,102	0,106	0,109	0,110
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,259	0,154	0,163	0,172	0,181	0,189	0,207	0,229
Uncracked and cracked concrete under seismic action (C2)										
All temperature ranges	$\delta_{N,eq\,(DLS)}$	[mm]	NPA		0,21	0,24	0,27	0,36	NPA	
	$\delta_{N,eq\,(ULS)}$	[mm]			0,54	0,51	0,54	0,63		

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

Table C15: **Displacements** under **shear load** [1)] (threaded rod)

Threaded rod			**M 8**	**M 10**	**M 12**	**M 16**	**M 20**	**M24**	**M 27**	**M 30**
Uncracked and cracked concrete under 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	[mm/(kN)]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05
Uncracked and cracked concrete under seismic action (C2)										
All temperature ranges	$\delta_{V,eq(DLS)}$	[mm]	NPA		3,1	3,4	3,5	4,2	NPA	
	$\delta_{V,eq(ULS)}$	[mm]			6,0	7,6	7,3	10,9		

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

Table C16: **Displacements** under **tension load**[1)] (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**
Uncracked concrete under static and quasi-static action								
Temperature range I: 40°C / 24°C	δ_{N0}- factor	[mm/(N/mm²)]	0,029	0,030	0,033	0,035	0,038	0,041
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,029	0,030	0,033	0,035	0,038	0,041
Temperature range II: 72°C / 50°C	δ_{N0}- factor	[mm/(N/mm²)]	0,039	0,040	0,044	0,047	0,051	0,055
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,049	0,051	0,055	0,059	0,064	0,070
Cracked concrete under static and quasi-static action								
Temperature range I: 40°C / 24°C	δ_{N0}- factor	[mm/(N/mm²)]	0,071	0,072	0,074	0,076	0,079	0,082
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,115	0,122	0,128	0,135	0,142	0,171
Temperature range II: 72°C / 50°C	δ_{N0}- factor	[mm/(N/mm²)]	0,095	0,096	0,099	0,102	0,106	0,110
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,154	0,163	0,172	0,181	0,189	0,229

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

Table C17: **Displacements** under **shear load**[1)] (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**
Uncracked and cracked concrete under 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	[mm/(kN)]	0,10	0,09	0,08	0,08	0,06	0,06

[1)] 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 VME plus

Performance
Displacements (internally threaded anchor rod)

Annex C13

Table C18: **Displacements** under **tension load**[1] (rebar)

Reinforcing bar			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Uncracked concrete under static and quasi-static action												
Temperature range I: 40°C / 24°C	δ_{N0}- factor	[mm/(N/mm²)]	0,028	0,029	0,030	0,031	0,033	0,035	0,038	0,038	0,040	0,043
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,015	0,015	0,016	0,017	0,017	0,019	0,020	0,020	0,021	0,023
Temperature range II: 72°C / 50°C	δ_{N0}- factor	[mm/(N/mm²)]	0,038	0,039	0,040	0,042	0,044	0,047	0,051	0,051	0,054	0,058
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,047	0,049	0,051	0,053	0,055	0,059	0,065	0,065	0,068	0,072
Cracked concrete under static and quasi-static action												
Temperature range I: 40°C / 24°C	δ_{N0}- factor	[mm/(N/mm²)]	0,069	0,071	0,072	0,073	0,074	0,076	0,079	0,079	0,081	0,084
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,115	0,122	0,128	0,135	0,142	0,155	0,171	0,171	0,181	0,194
Temperature range II: 72°C / 50°C	δ_{N0}- factor	[mm/(N/mm²)]	0,092	0,095	0,096	0,098	0,099	0,102	0,106	0,106	0,109	0,113
	$\delta_{N\infty}$- factor	[mm/(N/mm²)]	0,154	0,163	0,172	0,181	0,189	0,207	0,229	0,229	0,242	0,260

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

Table C19: **Displacements** under **shear load**[1] (rebar)

Reinforcing bar			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Uncracked and cracked concrete under 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	[mm/(kN)]	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
$\delta_{V0} = \delta_{V0}$- factor $\cdot$ V;　　V: acting shear load
$\delta_{V\infty} = \delta_{V\infty}$- factor $\cdot$ V;

Injection System VME plus

Performance
Displacements (rebar)

Annex C14