European Technical Assessment

ETA-17/0716 of 8 December 2017

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	Injection system 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	25 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	ETAG 001 Part 5: "Bonded anchors", April 2013, used as EAD according to Article 66 Paragraph 3 of Regulation (EU) No 305/2011.

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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 VMH and a steel element. The steel element consist 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 for static and quasi-static action and seismic performance categories C1, C2	See Annex C 1 to C 7
Displacements	See Annex C 8 to C 10

3.2 Safety in case of fire (BWR 2)

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

3.3 Hygiene, health and the environment (BWR 3)

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

3.4 Safety in use (BWR 4)

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

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

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

The system to be applied is: 1

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

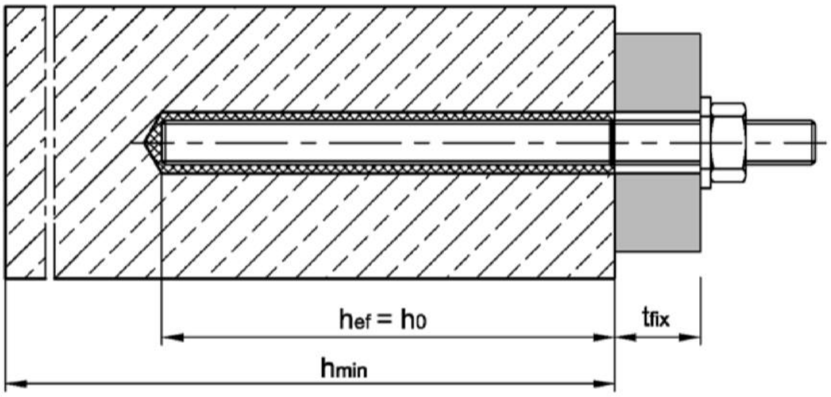
Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 8 December 2017 by Deutsches Institut für Bautechnik

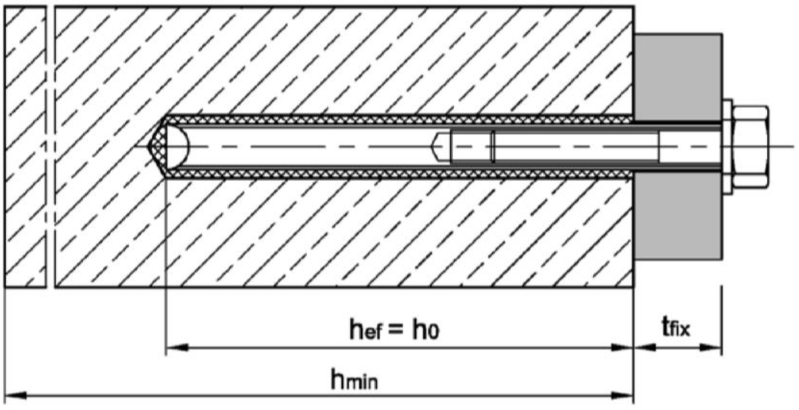
BD Dipl.-Ing. Andreas Kummerow
Head of Department

beglaubigt:
Baderschneider

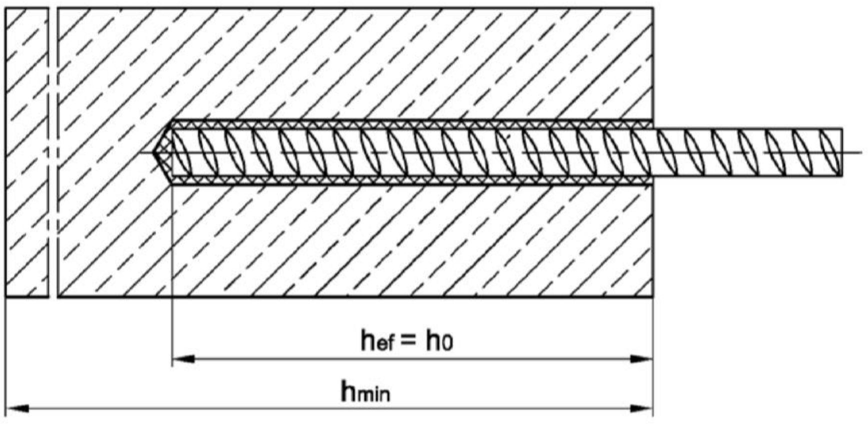
Installation threaded rod M8 to M30



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



Installation reinforcing bar Ø8 to Ø32

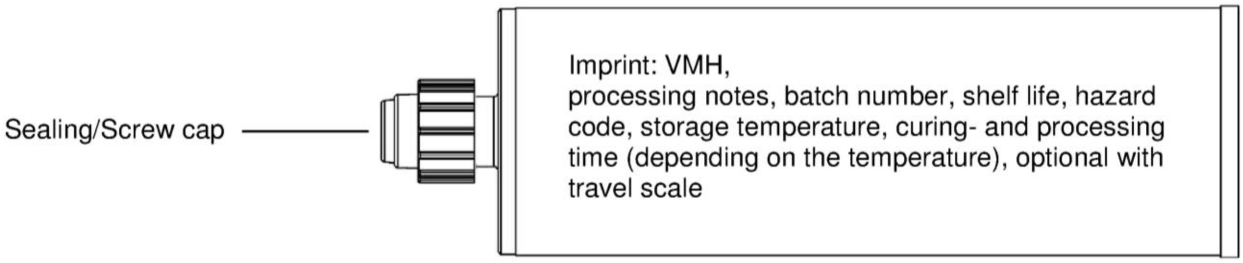


t_{fix} = thickness of fixture
h_{ef} = effective anchorage depth
h_0 = depth of drill hole
h_{min} = minimum thickness of member

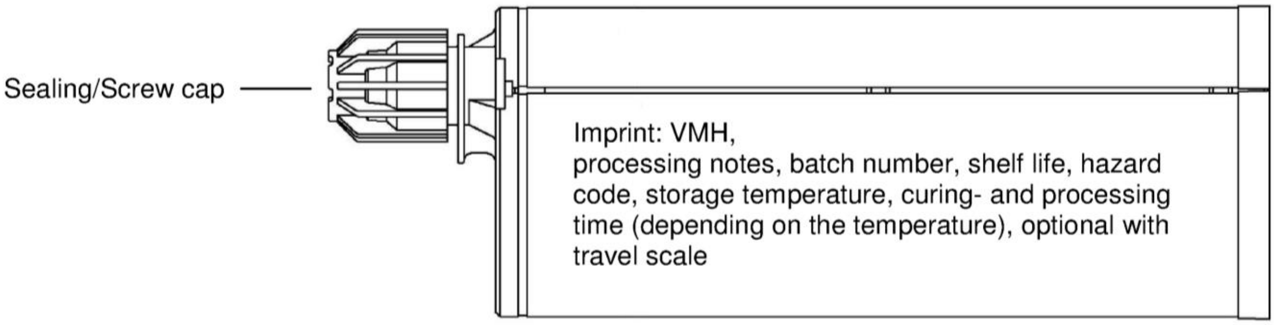
Injection System VMH for concrete	Annex A1
Product description Installation situation	

Cartridge Injection Mortar VMH

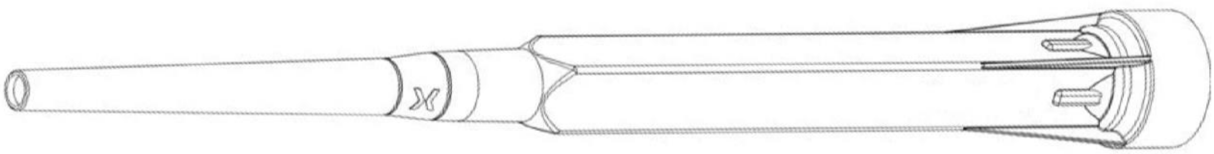
150 ml, 280 ml, 300 ml up to 333 ml and 380 ml up to 420 ml cartridge (Type: coaxial)



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



Static mixer

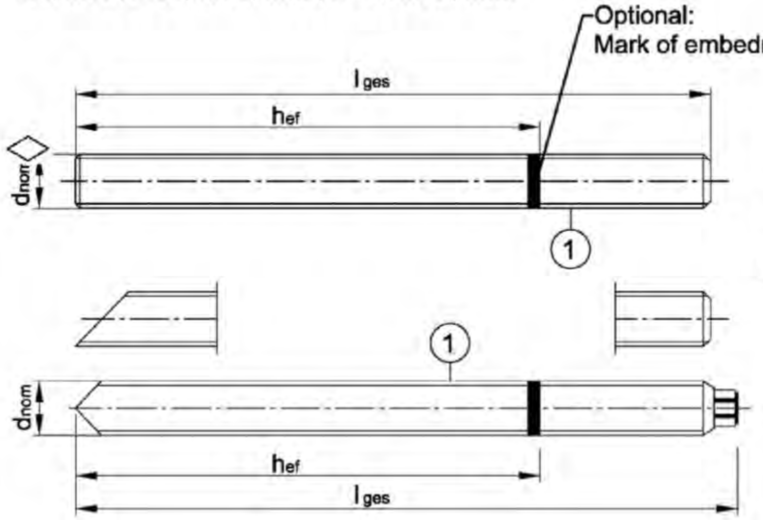


Injection System VMH for concrete	**Annex A2**
Product description Cartridges and static mixer	

Threaded rod

Threaded rod VMU-A, V-A with washer and hexagon nut
M8, M10, M12, M16, M20, M24, M27, M30

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



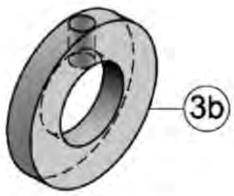
Marking: e.g. M10

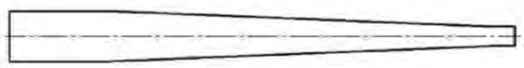
◇	Identifying mark of manufacturing plant
M10	Size of thread
A4	additional marking for stainless steel
HCR	additional marking for High corrosion resistant steel

Commercial standard threaded rod with:

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

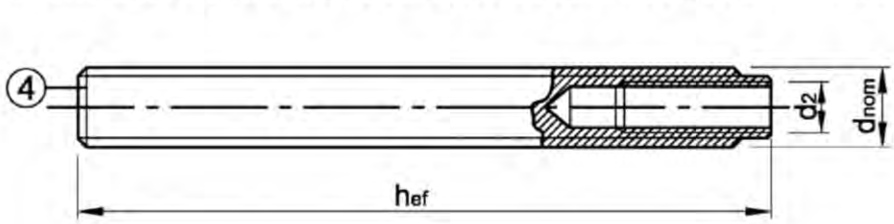
Washer with bore and reducing adapter for filling the gap between threaded rod and fixture





Internally threaded anchor rod

VMU-IG M6, VMU-IG M8, VMU-IG M10, VMU-IG M12, VMU-IG M16, VMU-IG M20



Marking e.g.: ◇I 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 VMH for concrete	Annex A3
Product description Threaded rod and internally threaded anchor rod	

Table A1: Materials

Part	Designation		Material	
Steel, zinc plated electroplated ≥ 5 µm acc. to EN ISO 4042:1999 or hot-dip galvanised ≥ 40 µm acc. to EN ISO 1461:2009 EN ISO 10684:2004+AC:2009 or sherardized ≥ 40µm acc. to EN ISO 17668:2016				
1	Threaded rod	Property class 4.6	f_{uk}≥ 400 N/mm²; f_{yk}≥ 240 N/mm²; A_5 > 8 % fracture elongation	EN 10087:1998, EN 10263:2001; Commercial standard threaded rod: EN ISO 898-1:2013
		Property class 4.8	f_{uk}≥ 400 N/mm²; f_{yk}≥ 320 N/mm²; A_5 > 8 % fracture elongation	
		Property class 5.6	f_{uk}≥ 500 N/mm²; f_{yk}≥ 300 N/mm²; A_5 > 8 % fracture elongation	
		Property class 5.8	f_{uk}≥ 500 N/mm²; f_{yk}≥ 400 N/mm²; A_5 > 8 % fracture elongation	
		Property class 8.8	f_{uk}≥ 800 N/mm²; f_{yk}≥ 640 N/mm²; A_5 > 12% fracture elongation[1)]	
2	Hexagon nut		Steel, zinc plated Property class 4 (for class 4.6 or 4.8 rod) Property class 5 (for class 5.6 or 5.8 rod) Property class 8 (for class 8.8 rod)	EN ISO 898-2:2012
3a	Washer		Steel, zinc plated (e.g..: EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000)	
3b	Washer with bore		Steel, zinc plated	
4	Internally threaded anchor rod		Steel, electroplated, A_5 > 8 % fracture elongation Property class 5.8 and 8.8	EN 10087:1998
Stainless steel A4				
1	Threaded rod		Material 1.4401 / 1.4404 / 1.4571 / 1.4578 / 1.4362 / 1.4062	EN 10088-1:2014
		Property class 50	f_{uk}= 500 N/mm²; f_{yk}= 210 N/mm²; A_5 > 12% fracture elongation[1)]	EN ISO 3506-1:2009
		Property class 70	f_{uk}= 700 N/mm²; f_{yk}= 450 N/mm²; A_5 > 12% fracture elongation[1)] M8 to M24	
2	Hexagon nut		Stainless steel A4 Property class 50 (for class 50 rod) Property class 70 (for class 70 rod; ≤ M24)	EN ISO 3506-2:2009
3a	Washer		Stainless steel A4 (e.g.: EN ISO 7089:2000, EN ISO 7093:2000, EN ISO 7094:2000)	EN 10088-1: 2014
3b	Washer with bore		Material 1.4401 / 1.4404 / 1.4571 / 1.4362	
4	Internally threaded anchor rod		Material 1.4401 / 1.4404 / 1.4571 / 1.4362; Property class 50 (IG-M20) A_5 > 8 % fracture elongation Property class 70 (IG-M8 to IG-M16) A_5 > 8 % fracture elongation	EN 10088-1: 2014
High corrosion resistant steel HCR				
1	Threaded rod		Material 1.4529 / 1.4565	EN 10088-1: 2014
		Property class 50	f_{uk}= 500 N/mm²; f_{yk}= 210 N/mm²; A_5 > 12% fracture elongation[1)]	EN ISO 3506-1: 2009
		Property class 70	f_{uk}= 700 N/mm²; f_{yk}= 450 N/mm²; A_5 > 12% fracture elongation[1)] M8 to M24	
2	Hexagon nut		Material 1.4529 / 1.4565 Property class 50 ((for class 50 rod) Property class 70 (for class 70 rod; ≤ M24)	EN 10088-1: 2014 EN ISO 3506-2:2009
3a	Washer		Material 1.4529 / 1.4565 (e.g.: EN ISO 7089:2000, EN ISO 7093:2000, EN ISO 7094:2000)	EN 10088-1: 2014
3b	Washer with bore		Material 1.4529 / 1.4565	
4	Internally threaded anchor rod		Material 1.4529 / 1.4565, A_5 > 8 % fracture elongation Property class 50 (IG-M20), Property class 70 (IG-M8 to IG-M16)	EN 10088-1: 2014

[1)] Fracture elongation A_5 > 8 % for applications without requirements for seismic performance category C2

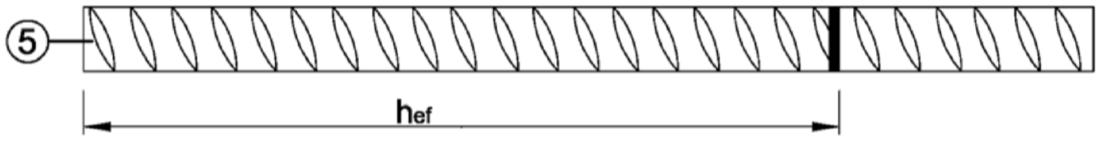
Injection System VMH for concrete

Product description
Materials

Annex A4

Reinforcing bar

Ø 8, Ø 10, Ø 12, Ø 14, Ø 16, Ø 20, Ø 25, Ø 28, Ø 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:2013 $f_{uk} = f_{tk} = k \cdot f_{yk}$

Injection System VMH for concrete

Product description
Product description and material reinforcing bar

Annex A5

Specification of intended use

Injection System VMH	Threaded rod: VMU-A, V-A, VM-A, commercial standard threaded rod	Internally threaded anchor rod: VMU-IG	Rebar
Static or quasi-static action	M8 - M30 zinc plated, A4, HCR	IG-M6 - IG-M20 electroplated, A4, HCR	Ø8 - Ø32
Seismic action, category C1	M8 - M30 zinc plated[1], A4, HCR	-	Ø8 - Ø32
Seismic action, category C2	M12 zinc plated[1] (strength class 8.8) A4, HCR	-	-

Base materials	Reinforced or unreinforced normal weight concrete acc. to EN 206-1:2000
	Strength classes acc. to EN 206-1:2000:C20/25 to C50/60
	Cracked and uncracked concrete
Temperature Range I -40 °C to +80 °C	max long term temperature +50 °C and max short term temperature +80 °C
Temperature Range II -40 °C to +120 °C	max long term temperature +72 °C and max short term temperature +120 °C
Temperature Range III -40 °C to +160 °C	max long term temperature +100 °C and max short term temperature +160 °C

[1] except hot-dip galvanised

Use conditions (Environmental conditions):

- Structures subject to dry internal conditions (zinc plated steel, stainless steel or high corrosion resistant steel)
- Structures subject to external atmospheric exposure (including industrial and marine environment) and to permanently damp internal condition, if no particular aggressive conditions exist (stainless steel or high corrosion resistant steel)
- Structures subject to external atmospheric exposure and to permanently damp internal condition, if other particular aggressive conditions exist (high corrosion resistant steel)
  Note: Particular aggressive conditions are e.g. permanent, alternating immersion in seawater or the splash zone of seawater, chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g. in desulphurization plants or road tunnels where de-icing materials are used)

Design:

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

Installation:

- Dry or wet concrete
- 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 supervision of the person responsible for technical matters of the site
- Fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod

Injection System VMH for concrete

Intended Use
Specifications

Annex B1

Table B1: Installation parameters for threaded rods

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Diameter of threaded rod	d_{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[1]	$d_f \leq$	[mm]	9	12	14	18	22	26	30	33
Installation torque	$T_{inst} \leq$	[Nm]	10	20	40 (35)[2]	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] For larger clearance hole see TR029 section 1.1; for application 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
[2] Installation torque for M12 with steel grade 4.6

Table B2: Installation parameters for internally threaded anchor rod

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[2]	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[1]	$d_f \leq$	[mm]	7	9	12	14	18	22
Installation torque	$T_{inst} \leq$	[Nm]	10	10	20	40	60	100
Minimum screw-in depth	l_{IG}	[mm]	8	8	10	12	16	20
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 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] For larger clearance hole see TR029 section 1.1
[2] 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 25	Ø 28	Ø 32
Diameter of rebar	$d = d_{nom}$ =	[mm]	8	10	12	14	16	20	25	28	32
Nominal drill hole diameter	d_0 =	[mm]	12	14	16	18	20	25	32	35	40
Effective anchorage depth	$h_{ef,min}$ =	[mm]	60	60	70	75	80	90	100	112	128
	$h_{ef,max}$ =	[mm]	160	200	240	280	320	400	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	130	150
Minimum edge distance	c_{min}	[mm]	35	40	45	50	50	60	70	75	85

Injection System VMH for concrete

Intended use
Installation parameters

Annex B2

Deutsches Institut für Bautechnik DIBt

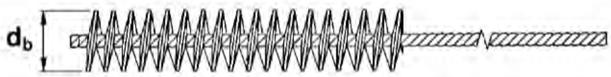
Table B4: Parameter cleaning and setting tools

Threaded rod	Rebar	Internally threaded anchor rod	Drill bit Ø	Brush Ø	min. Brush Ø	Retaining washer			
							Installation direction and use of retaining washer		
[-]	Ø [mm]	[-]	d_0 [mm]	d_b [mm]	$d_{b,min}$ [mm]	[-]	⬇	➡	⬆
M8			10	11,5	10,5	-	No retaining washer required		
M10	8	VMU-IG M 6	12	13,5	12,5	-			
M12	10	VMU-IG M 8	14	15,5	14,5	-			
	12		16	17,5	16,5	-			
M16	14	VMU-IG M10	18	20,0	18,5	VM-IA 18	h_{ef} > 250mm	h_{ef} > 250mm	all
	16		20	22,0	20,5	VM-IA 20			
M20		VMU-IG M12	22	24,0	22,5	VM-IA 22			
	20		25	27,0	25,5	VM-IA 25			
M24		VMU-IG M16	28	30,0	28,5	VM-IA 28			
M27			30	31,8	30,5	VM-IA 30			
	25		32	34,0	32,5	VM-IA 32			
M30	28	VMU-IG M20	35	37,0	35,5	VM-IA 35			
	32		40	43,5	40,5	VM-IA 40			

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

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

Retaining washer for overhead or horizontal installation
Drill bit diameter (d_0):
18 mm to 40 mm

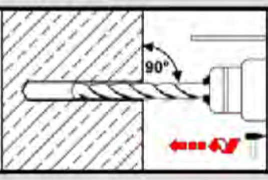


Steel brush
Drill bit diameter (d_0): all diameters

Injection System VMH for concrete	Annex B3
Intended Use Cleaning and setting tools	

Installation Instructions

Drilling of the hole

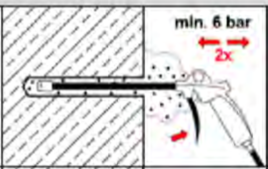
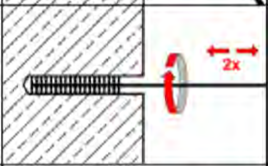
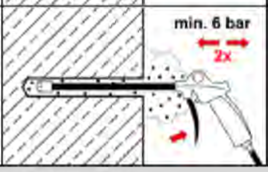
1.		Drill with hammer drill or compressed air drill or vacuum drill a hole into the base material to the size required by the selected anchor (Table B1, B2 or Table B3). In case of aborted drill hole, the drill hole shall be filled with mortar.

Cleaning

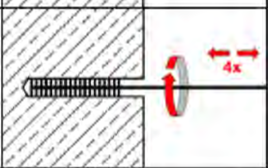
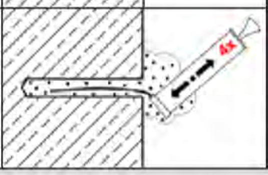
2.

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

<u>Cleaning with compressed air</u>
Cracked and uncracked concrete: all diameters

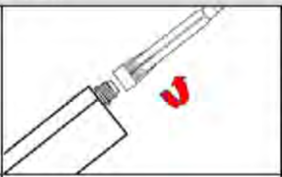
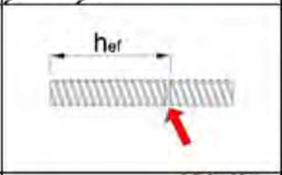
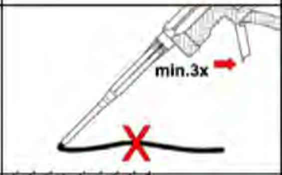
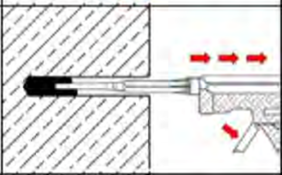
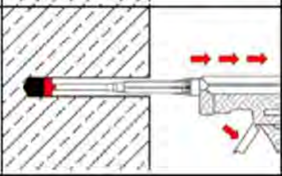
2a.		Starting from the bottom or back of the bore hole, blow out the hole with compressed air (min. 6 bar) a minimum of **two** times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension must be used.
2b.		Check brush diameter (Table B4). Brush the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

<u>Manual cleaning</u>
Drill hole diameter $d_0 \leq 20$mm and drill hole depth $h_0 \leq 10\ d_{nom}$ (uncracked concrete only)

2a.		Starting from the bottom or back of the bore hole, blow out the hole with the blow-out pump a minimum of **four** times.
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 bore hole ground is not reached with the brush, a brush extension must be used.
2c.		Starting from the bottom or back of the bore hole blow out the hole again a minimum of **four** times.

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

Installation instructions (continuation)

<table>
<tr><th colspan="3">Injection</th></tr>
<tr><td>3.</td><td></td><td>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 B5) as well as for new cartridges, a new static-mixer shall be used.</td></tr>
<tr><td>4.</td><td>
</td><td>Prior to inserting the rod into the filled bore hole, the position of the embedment depth shall be marked on the threaded rod or rebar</td></tr>
<tr><td>5.</td><td>
</td><td>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.</td></tr>
<tr><td>6a.</td><td></td><td>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. For embedment larger than 190 mm, an extension nozzle shall be used.
Observe working times given in Table B5.</td></tr>
<tr><td>6b.</td><td></td><td>Retaining washer and mixer nozzle extensions shall be used according to Table B4 for the following applications:
• Horizontal installation (horizontal direction) and ground installation (vertical downwards direction): Drill bit-Ø $d_0 \geq 18$ mm and embedment depth $h_{ef} > 250$mm
• Overhead installation: Drill bit-Ø $d_0 \geq 18$ mm</td></tr>
</table>

Injection System VMH for concrete

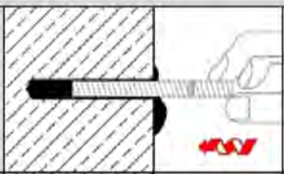
Intended Use
Installation instructions (continuation)

Annex B5

Installation instructions (continuation)

Inserting the anchor

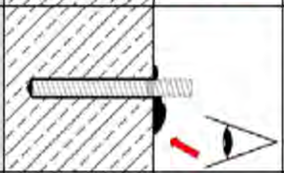
7.



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.

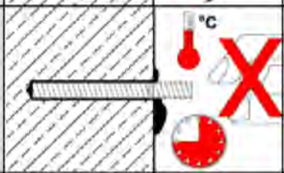
The anchor shall be free of dirt, grease, oil or other foreign material.

8.



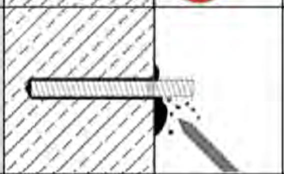
Make sure that the anchor is fully seated up to the full embedment depth and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For overhead installation, the anchor should be fixed (e.g. by wedges).

9.



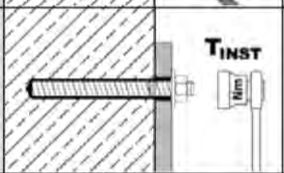
Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured (attend Table B5).

10.



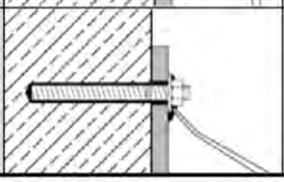
Remove excess mortar.

11.



The fixture can be mounted after curing time. Apply installation torque T_{inst} according to Table B1 or B2 by using a calibrated torque wrench.

12.



Annular gap between anchor rod and attachment 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.

Tabelle B1: Working time and curing time

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

Injection System VMH for concrete

Intended Use
Installation instructions (continuation)
Working and curing time

Annex B6

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

Threaded rod				M 8	M 10	M 12	M 16	M 20	M 24	M 27	M 30
Steel failure											
Tension load											
Characteristic tension resistance	Steel, Property class 4.6 and 4.8	$N_{Rk,s}$	[kN]	15	23	34	63	98	141	184	224
	Steel, Property class 5.6 and 5.8	$N_{Rk,s}$	[kN]	18	29	42	78	122	176	230	280
	Steel, Property class 8.8	$N_{Rk,s}$	[kN]	29	46	67	125	196	282	368	449
	Stainless steel A4 and HCR, Property class 50	$N_{Rk,s}$	[kN]	18	29	42	79	123	177	230	281
	Stainless steel A4 and HCR, Property class 70	$N_{Rk,s}$	[kN]	26	41	59	110	171	247	-	-
Partial factor	Steel, Property class 4.6	$\gamma_{Ms,N}$	[-]	2,0							
	Steel, Property class 4.8	$\gamma_{Ms,N}$	[-]	1,5							
	Steel, Property class 5.6	$\gamma_{Ms,N}$	[-]	2,0							
	Steel, Property class 5.8	$\gamma_{Ms,N}$	[-]	1,5							
	Steel, Property class 8.8	$\gamma_{Ms,N}$	[-]	1,5							
	Stainless steel A4 and HCR, Property class 50	$\gamma_{Ms,N}$	[-]	2,86							
	Stainless steel A4 and HCR, Property class 70	$\gamma_{Ms,N}$	[-]	1,87						-	-
Shear load											
Steel failure without lever arm											
Characteristic shear resistance	Steel, Property class 4.6 and 4.8	$V_{Rk,s}$	[kN]	7	12	17	31	49	71	92	112
	Steel, Property class 5.6 and 5.8	$V_{Rk,s}$	[kN]	9	15	21	39	61	88	115	140
	Steel, Property class 8.8	$V_{Rk,s}$	[kN]	15	23	34	63	98	141	184	224
	Stainless steel A4 and HCR, Property class 50	$V_{Rk,s}$	[kN]	9	15	21	39	61	88	115	140
	Stainless steel A4 and HCR, Property class 70	$V_{Rk,s}$	[kN]	13	20	30	55	86	124	-	-
Steel failure with lever arm											
Characteristic bending moment	Steel, Property class 4.6 and 4.8	$M_{Rk,s}$	[Nm]	15	30	52	133	260	449	666	900
	Steel, Property class 5.6 and 5.8	$M_{Rk,s}$	[Nm]	19	37	65	166	324	560	833	1123
	Steel, Property class 8.8	$M_{Rk,s}$	[Nm]	30	60	105	266	519	896	1333	1797
	Stainless steel A4 and HCR, Property class 50	$M_{Rk,s}$	[Nm]	19	37	66	167	325	561	832	1125
	Stainless steel A4 and HCR, Property class 70	$M_{Rk,s}$	[Nm]	26	52	92	232	454	784	-	-
Partial factor	Steel, Property class 4.6	$\gamma_{Ms,V}$	[-]	1,67							
	Steel, Property class 4.8	$\gamma_{Ms,V}$	[-]	1,25							
	Steel, Property class 5.6	$\gamma_{Ms,V}$	[-]	1,67							
	Steel, Property class 5.8	$\gamma_{Ms,V}$	[-]	1,25							
	Steel, Property class 8.8	$\gamma_{Ms,V}$	[-]	1,25							
	Stainless steel A4 and HCR, Property class 50	$\gamma_{Ms,V}$	[-]	2,38							
	Stainless steel A4 and HCR, Property class 70	$\gamma_{Ms,V}$	[-]	1,56						-	-

Injection System VMH for concrete

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

Annex C1

Table C2: Characteristic values of **tension loads** for **threaded rods** under static, quasi-static action and seismic action C1 + C2

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Characteristic tension resistance		$N_{Rk,s}$	[kN]	see Table C1							
		$N_{Rk,s,C1}$	[kN]	$1{,}0 \cdot N_{Rk,s}$							
		$N_{Rk,s,C2}$	[kN]	NPD		$1{,}0 \cdot N_{Rk,s}$	No Performance Determined (NPD)				
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: 80°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	17	17	16	15	14	13	13	13
Temperature range II: 120°C / 72°C		$\tau_{Rk,ucr}$	[N/mm²]	15	14	14	13	12	12	11	11
Temperature range III: 160°C / 100°C		$\tau_{Rk,ucr}$	[N/mm²]	12	12	11	10	9,5	9,0	9,0	9,0
Characteristic bond resistance in cracked concrete C20/25											
Temperature range I: 80°C / 50°C		$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	6,5	7,0	7,5	8,5	8,5	8,5	8,5	8,5
		$\tau_{Rk,C2}$	[N/mm²]	NPD		3,6	No Performance Determined (NPD)				
Temperature range II: 120°C / 72°C		$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	5,5	6,0	6,5	7,5	7,5	7,5	7,5	7,5
		$\tau_{Rk,C2}$	[N/mm²]	NPD		3,1	No Performance Determined (NPD)				
Temperature range III: 160°C / 100°C		$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	5,0	5,5	6,0	6,5	6,5	6,5	6,5	6,5
		$\tau_{Rk,C2}$	[N/mm²]	NPD		2,5	No Performance Determined (NPD)				
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							
Factor according to CEN/TS1992-4-5	uncracked concrete	k_8	[-]	10,1							
	cracked concrete			7,2							
Concrete cone failure											
Factor according to CEN/TS1992-4-5	uncracked concrete	k_{ucr}	[-]	10,1							
	cracked concrete	k_{cr}	[-]	7,2							
Splitting failure											
Edge distance	$h/h_{ef} \geq 2{,}0$	$c_{cr,sp}$	[mm]	$1{,}0\ h_{ef}$							
	$2{,}0 > h/h_{ef} > 1{,}3$			$2 * h_{ef}\ (2{,}5 - h / h_{ef})$							
	$h/h_{ef} \leq 1{,}3$			$2{,}4\ h_{ef}$							
Spacing		$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$							
Installation factor **Compressed air cleaning**		$\gamma_2 = \gamma_{inst}$	[-]	1,0 (1,2)[1]				1,2			
Installation factor **Manual cleaning**		$\gamma_2 = \gamma_{inst}$	[-]	1,2				-			

[1] Value in brackets for cracked concrete

Injection System VMH for concrete

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

Annex C2

Table C3: Characteristic values of **shear loads** for **threaded rods** under static, quasi-static action and seismic action C1 + C2

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure without lever arm										
Characteristic shear resistance	$V_{Rk,s}$	[kN]	see Table C1							
	$V_{Rk,s,C1}$	[kN]	$0{,}70 \cdot V_{Rk,s}$							
	$V_{Rk,s,C2}$	[kN]	NPD		$0{,}80 \cdot V_{Rk,s}$	No Performance Determined (NPD)				
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C1							
Steel failure with lever arm										
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	see Table C1							
	$M^0_{Rk,s,C1}$	[Nm]	No Performance Determined (NPD)							
	$M^0_{Rk,s,C2}$	[Nm]								
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C1							
Concrete pry-out failure										
Factor k acc. to TR 029 Factor k_3 acc. to CEN/TS 1992-4-5	$k_{(3)}$	[-]	2,0							
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0							
Concrete edge failure										
Effective length of anchor	l_f	[mm]	$l_f = \min(h_{ef}; 8\ d_{nom})$							
Outside diameter of anchor	d_{nom}	[mm]	8	10	12	16	20	24	27	30
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0							

Injection System VMH for concrete

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

Annex C3

Table C4: Characteristic values of **tension loads** for **internally threaded anchor rod** under static, quasi-static action

Internally threaded anchor rod				**IG-M 6**	**IG-M 8**	**IG-M 10**	**IG-M 12**	**IG-M 16**	**IG-M 20**
Steel failure [1)]									
Characteristic tension resistance, Steel, strength class 5.8		$N_{Rk,s}$	[kN]	10	18	29	42	79	123
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic tension resistance, Steel, strength class 8.8		$N_{Rk,s}$	[kN]	16	27	46	67	121	196
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic tension resistance, Stainless steel A4 / HCR, strength class 70		$N_{Rk,s}$	[kN]	14	26	41	59	110	124 [3)]
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: 80°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	17	16	15	14	13	13
Temperature range II: 120°C / 72°C		$\tau_{Rk,ucr}$	[N/mm²]	14	14	13	12	12	11
Temperature range III: 160°C / 100°C		$\tau_{Rk,ucr}$	[N/mm²]	12	11	10	9,5	9,0	9,0
Characteristic bond resistance in cracked concrete C20/25									
Temperature range I: 80°C / 50°C		$\tau_{Rk,cr}$	[N/mm²]	7,0	7,5	8,5	8,5	8,5	8,5
Temperature range II: 120°C / 72°C		$\tau_{Rk,cr}$	[N/mm²]	6,0	6,5	7,5	7,5	7,5	7,5
Temperature range III: 160°C / 100°C		$\tau_{Rk,cr}$	[N/mm²]	5,5	6,0	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					
Factor according to CEN/TS1992-4-5	uncracked concrete	k_8	[-]	10,1					
	cracked concrete			7,2					
Concrete cone failure									
Factor according to CEN/TS1992-4-5	uncracked concrete	k_{ucr}	[-]	10,1					
	cracked concrete	k_{cr}	[-]	7,2					
Splitting failure									
Edge distance	$h/h_{ef} \geq 2{,}0$	$c_{cr,sp}$	[mm]	$1{,}0\ h_{ef}$					
	$2{,}0 > h/h_{ef} > 1{,}3$			$2 * h_{ef}\ (2{,}5 - h / h_{ef})$					
	$h/h_{ef} \leq 1{,}3$			$2{,}4\ h_{ef}$					
Spacing		$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$					
Installation factor **Compressed air cleaning**		$\gamma_2 = \gamma_{inst}$	[-]	1,0 (1,2)[2)]			1,2		
Installation factor **Manual cleaning**		$\gamma_2 = \gamma_{inst}$	[-]	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) Value in brackets for cracked concrete
3) For VMU-IG M20: Internally threaded rod: strength class 50; Fastening screws or threaded rods (incl. nut and washer): strength class 70

Injection System VMH for concrete	**Annex C4**
Performance Characteristic values of **tension loads** for **internally threaded anchor rod**	

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

Internally threaded anchor rod			**IG-M 6**	**IG-M 8**	**IG-M 10**	**IG-M 12**	**IG-M 16**	**IG-M 20**
Steel failure without lever arm[1]								
Characteristic shear resistance Steel, strength class 5.8	$V_{Rk,s}$	[kN]	5	9	15	21	39	61
Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Characteristic shear resistance Steel, strength class 8.8	$V_{Rk,s}$	[kN]	8	14	23	34	60	98
Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Characteristic shear resistance Stainless steel A4 / HCR, strength class 70	$V_{Rk,s}$	[kN]	7	13	20	30	55	62 [2]
Partial factor	$\gamma_{Ms,V}$	[-]	1,56					2,38
Steel failure with lever arm[1]								
Characteristic bending moment, Steel, strength class 5.8	$M^0_{Rk,s}$	[Nm]	8	19	37	66	167	325
Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Characteristic bending moment, Steel, strength class 8.8	$M^0_{Rk,s}$	[Nm]	12	30	60	105	267	519
Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Characteristic bending moment, Stainless steel A4 / HCR, strength 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								
Factor k acc. to TR 029 Factor k_3 acc. to CEN/TS 1992-4-5	$k_{(3)}$	[-]	2,0					
Concrete edge failure								
Effective length of anchor	l_f	[mm]	$l_f = \min(h_{ef}; 8\ d_{nom})$					
Outside diameter of anchor	d_{nom}	[mm]	10	12	16	20	24	30
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	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. 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: strength class 50; Fastening screws or threaded rods (incl. nut and washer): strength class 70

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Table C6: Characteristic values of **tension loads** for **rebar** under static, quasi-static action and seismic action C1

Reinforcing bar			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Steel failure											
Characteristic tension resistance	$N_{Rk,s} = N_{Rk,s,C1}$	[kN]	$A_s \cdot f_{uk}$ [1]								
Cross section area	A_s	[mm²]	50	79	113	154	201	314	491	616	804
Partial factor	$\gamma_{Ms,N}$	[-]	1,4 [2]								
Combined pull-out and concrete failure											
Characteristic bond resistance in <u>uncracked</u> concrete C20/25											
Temperature range I: 80°C / 50°C	$\tau_{Rk,ucr}$	[N/mm²]	14	14	14	14	13	13	13	13	13
Temperature range II: 120°C / 72°C	$\tau_{Rk,ucr}$	[N/mm²]	13	12	12	12	12	11	11	11	11
Temperature range III: 160°C / 100°C	$\tau_{Rk,ucr}$	[N/mm²]	10	10	9,5	9,5	9,5	9,0	9,0	9,0	9,0
Characteristic bond resistance in <u>cracked</u> concrete C20/25											
Temperature range I: 80°C / 50°C	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	5,0	5,5	6,0	6,0	7,5	7,5	7,5	7,5	8,0
Temperature range II: 120°C / 72°C	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	4,5	5,0	5,0	5,5	6,5	6,5	6,5	6,5	7,0
Temperature range III: 160°C / 100°C	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	4,0	4,5	4,5	5,0	5,5	6,0	6,0	5,5	6,5
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								
Factor according to CEN/TS1992-4-5 – uncracked concrete	k_8	[-]	10,1								
Factor according to CEN/TS1992-4-5 – cracked concrete	k_8	[-]	7,2								
Concrete cone failure											
Factor according to CEN/TS1992-4-5 – uncracked concrete	k_{ucr}	[-]	10,1								
Factor according to CEN/TS1992-4-5 – cracked concrete	k_{cr}	[-]	7,2								
Splitting failure											
Edge distance – $h/h_{ef} \geq 2,0$	$c_{cr,sp}$	[mm]	$1,0\ h_{ef}$								
Edge distance – $2,0 > h/h_{ef} > 1,3$	$c_{cr,sp}$	[mm]	$2 * h_{ef}\ (2,5 – h / h_{ef})$								
Edge distance – $h/h_{ef} \leq 1,3$	$c_{cr,sp}$	[mm]	$2,4\ h_{ef}$								
Spacing	$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$								
Installation factor **Compressed air cleaning**	$\gamma_2 = \gamma_{inst}$	[-]	1,0 (1,2) [3]					1,2			
Installation factor **Manual cleaning**	$\gamma_2 = \gamma_{inst}$	[-]	1,2					-			

[1] f_{uk} shall be taken from the specifications of reinforcing bars
[2] in absence of nation regulation
[3] Value in brackets for cracked concrete

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Table C7: Characteristic values of **shear loads** for **rebar** under static, quasi-static action and seismic action C1

Reinforcing bar			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Steel failure without lever arm											
Characteristic shear resistance	$V_{Rk,s}$	[kN]	$0{,}50 \cdot A_s \cdot f_{uk}$ 1)								
	$V_{Rk,s,C1}$	[kN]	$0{,}37 \cdot A_s \cdot f_{uk}$ 1)								
Cross section area	A_s	[mm²]	50	79	113	154	201	314	491	616	804
Partial factor	$\gamma_{Ms,V}$	[-]	1,5 2)								
Ductility factor according to CEN/TS 1992-4-5	k_2	[-]	0,8								
Steel failure with lever arm											
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	$1{,}2 \cdot W_{el} \cdot f_{uk}$ 1)								
	$M^0_{Rk,s,C1}$	[Nm]	No Performance Determined (NPD)								
Elastic section modulus	W_{el}	[mm³]	50	98	170	269	402	785	1534	2155	3217
Partial factor	$\gamma_{Ms,V}$	[-]	1,5 2)								
Concrete pry-out failure											
Factor k acc. to TR 029 Factor k_3 acc. to CEN/TS 1992-4-5	$k_{(3)}$	[-]	2,0								
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0								
Concrete edge failure											
Effective length of rebar	l_f	[mm]	$l_f = \min(h_{ef};\, 8\, d_{nom})$								
Outside diameter of rebar	d_{nom}	[mm]	8	10	12	14	16	20	25	28	32
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0								

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

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Table C8: **Displacements** under **tension loads**[1)] (threaded rod)

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Uncracked concrete C20/25 under static and quasi-static action										
Temperature range I: 80°C / 50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,031	0,032	0,034	0,037	0,039	0,042	0,044	0,046
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,040	0,042	0,044	0,047	0,051	0,054	0,057	0,060
Temperature range II: 120°C / 72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,032	0,034	0,035	0,038	0,041	0,044	0,046	0,048
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,042	0,044	0,045	0,049	0,053	0,056	0,059	0,062
Temperature range III: 160°C / 100°C	δ_{N0}-factor	[mm/(N/mm²)]	0,121	0,126	0,131	0,142	0,153	0,163	0,171	0,179
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,124	0,129	0,135	0,146	0,157	0,168	0,176	0,184
Cracked concrete C20/25 under static and quasi-static action										
Temperature range I: 80°C / 50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,081	0,083	0,085	0,090	0,095	0,099	0,103	0,106
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,104	0,107	0,110	0,116	0,122	0,128	0,133	0,137
Temperature range II: 120°C / 72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,084	0,086	0,088	0,093	0,098	0,103	0,107	0,110
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,108	0,111	0,114	0,121	0,127	0,133	0,138	0,143
Temperature range III: 160°C / 100°C	δ_{N0}-factor	[mm/(N/mm²)]	0,312	0,321	0,330	0,349	0,367	0,385	0,399	0,412
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,321	0,330	0,340	0,358	0,377	0,396	0,410	0,424
Cracked concrete C20/25 under seismic action (C2)										
All temperature ranges	$\delta_{N,seis\,(DLS)}$-factor	[mm/(N/mm²)]	(NPD)		0,120	No Performance Determined (NPD)				
	$\delta_{N,seis\,(ULS)}$-factor	[mm/(N/mm²)]			0,140					

[1)] Calculation of the displacement

$\delta_{N0} = \delta_{N0}$- factor $\cdot\ \tau$; $\delta_{N,seis(DLS)} = \delta_{N,seis(DLS)}$-factor $\cdot\ \tau$; τ: acting bond stress for tension

$\delta_{N\infty} = \delta_{N\infty}$- factor $\cdot\ \tau$; $\delta_{N,seis(ULS)} = \delta_{N,seis(ULS)}$-factor $\cdot\ \tau$;

Table C9: **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 C20/25 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
Cracked concrete C20/25 under seismic action (C2)										
All temperature ranges	$\delta_{V,seis(DLS)}$-factor	[mm/(kN)]	(NPD)		0,27	No Performance Determined (NPD)				
	$\delta_{V,seis(ULS)}$-factor	[mm/(kN)]			0,27					

[1)] Calculation of the displacement

$\delta_{V0} = \delta_{V0}$-factor $\cdot$ V; $\delta_{V,seis(DLS)} = \delta_{V,seis(DLS)}$- factor $\cdot$ V; V: acting shear load

$\delta_{V\infty} = \delta_{V\infty}$-factor $\cdot$ V; $\delta_{V,seis(ULS)} = \delta_{V,seis(ULS)}$- factor $\cdot$ V;

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Table C10: Displacements under tension load[1] (internally threaded anchor rod)

Internally threaded anchor rod			IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Uncracked concrete C20/25 under static and quasi-static action								
Temperature range I: 80°C / 50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,032	0,034	0,037	0,039	0,042	0,046
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,042	0,044	0,047	0,051	0,054	0,060
Temperature range II: 120°C / 72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,034	0,035	0,038	0,041	0,044	0,048
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,044	0,045	0,049	0,053	0,056	0,062
Temperature range III: 160°C / 100°C	δ_{N0}-factor	[mm/(N/mm²)]	0,126	0,131	0,142	0,153	0,163	0,179
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,129	0,135	0,146	0,157	0,168	0,184
Cracked concrete C20/25 under static and quasi-static action								
Temperature range I: 80°C / 50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,083	0,085	0,090	0,095	0,099	0,106
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,107	0,110	0,116	0,122	0,128	0,137
Temperature range II: 120°C / 72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,086	0,088	0,093	0,098	0,103	0,110
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,111	0,114	0,121	0,127	0,133	0,143
Temperature range III: 160°C / 100°C	δ_{N0}-factor	[mm/(N/mm²)]	0,321	0,330	0,349	0,367	0,385	0,412
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	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 C11: Displacements under shear load[1] (internally threaded anchor rod)

Internally threaded anchor rod			IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Uncracked and cracked concrete C20/25 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
$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V$; V: acting shear load
$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V$;

Table C12: Displacements under tension load[1] (rebar)

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Uncracked concrete C20/25 under static and quasi-static action											
Temperature range I: 80°C / 50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,031	0,032	0,034	0,035	0,037	0,039	0,043	0,045	0,048
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,040	0,042	0,044	0,045	0,047	0,051	0,055	0,058	0,063
Temperature range II: 120°C / 72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,032	0,034	0,035	0,036	0,038	0,041	0,045	0,047	0,050
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,042	0,044	0,045	0,047	0,049	0,053	0,057	0,060	0,065
Temperature range III: 160°C / 100°C	δ_{N0}-factor	[mm/(N/mm²)]	0,121	0,126	0,131	0,137	0,142	0,153	0,164	0,172	0,186
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,124	0,129	0,135	0,141	0,146	0,157	0,169	0,177	0,192
Cracked concrete C20/25 under static and quasi-static action											
Temperature range I: 80°C / 50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,081	0,083	0,085	0,087	0,090	0,095	0,099	0,103	0,108
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,104	0,107	0,110	0,113	0,116	0,122	0,128	0,133	0,141
Temperature range II: 120°C / 72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,084	0,086	0,088	0,090	0,093	0,098	0,103	0,107	0,113
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,108	0,111	0,114	0,118	0,121	0,127	0,133	0,138	0,148
Temperature range III: 160°C / 100°C	δ_{N0}-factor	[mm/(N/mm²)]	0,312	0,321	0,330	0,340	0,349	0,367	0,385	0,399	0,425
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,321	0,330	0,340	0,349	0,358	0,377	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 C13: Displacements under shear load[1] (rebar)

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Cracked and uncracked concrete C20/25 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
	$\delta_{V\infty}$-factor	[mm/(kN)]	0,09	0,08	0,08	0,06	0,06	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
$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V$;

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Performance
Displacements (rebar)

Annex C10