Deutsches Institut für Bautechnik

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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-05/0202 of 26 August 2016

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	BBV-Internal Bonded Strand Post-tensioning System, type i
Product family to which the construction product belongs	BBV-Internal Bonded Post-Tensioning System for 3 to 31 Strands (140 and 150 mm²)
Manufacturer	BBV Systems GmbH Industriestraße 98 67240 Bobenheim-Roxheim DEUTSCHLAND
Manufacturing plant	BBV Systems GmbH Industriestraße 98 67240 Bobenheim-Roxheim DEUTSCHLAND
This European Technical Assessment contains	35 pages including 30 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	Guideline for European technical approval of "Post-tensioning kits for prestressing of structures", ETAG 013, used as European Assessment Document (EAD) according to Article 66 Paragraph 3 of Regulation (EU) No 305/2011.
This version replaces	ETA-05/0202 issued on 18 December 2015

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Specific Part

1 Technical description of the product

1.1 Definition of the construction product

The present European Technical Approval applies to a kit:

BBV-Internal Bonded Strand Post-Tensioning System, type i

consisting of 3 to 31 strands with a nominal tensile strength 1770 N/mm² or 1860 N/mm² (Y1770 S7 or Y1860 S7 in according with prEN 10138-3, table 4), nominal diameter 15.3 mm (0.6" - 140 mm²) or 15.7 mm (0.62" - 150 mm²) which are used in normal-weight concrete with the following anchors (stressing and fixed anchors and couplers):

1. Stressing (active) anchor type S and fixed (passive) anchor type F and Fe with bearing plate and anchor head for tendons of 3, 4, 5, 7 and 9 strands,
2. Stressing (active) anchor type S and fixed (passive) anchor type F and Fe with cast-iron anchor body and anchor head for tendons of 12, 15, 19, 22, 27 and 31 strands,
3. Coupler ÜK (fixed (FÜK) and movable (BÜK)) for tendons of 3, 4, 5, 7, 9, 12, 15, 19, 22, 27 and 31 strands,

Additional components of the present Post-tensioning system are:

1. Bursting reinforcement (helixes and stirrups),
2. Sheathing (ducts),
3. Corrosion protection.

The anchorage of the strands in anchor heads and couplers is done by means of wedges.

The components and the system setup of the product are given in Annex A.

1.2 Strands

Only 7-wire strands shall be used in accordance with national provisions and with the characteristics given in Table 1:

Table 1: Dimensions and properties of 7-wire strands

Designation	Symbol	Unit	Value	
Tensile strength	R_m	MPa	1770 or 1860	
Strand				
Nominal diameter	D	mm	15.3	15.7
Nominal cross section	A_p	mm²	140	150
Nominal mass	M	g/m	1093	1172
Individual wires				
External wire diameter	d	mm	5.0 ± 0.04	5.2 ± 0.04
Core wire diameter	d'	mm	1.02 to 1.04 d	1.02 to 1.04 d

To avoid confusions only strands with one nominal diameter shall be used on one site. If the use of the strands with R_m = 1860 MPa is intended on site, these shall solely be used there.

Only strands stranded in the same direction shall be used in a tendon. Further characteristic values of the strands see Annex A7.

1.3 Wedges

Wedges type 30, smooth or knurled, (see Annex A3) shall be used. The knurled wedges shall only be used for pre-wedged (pre-locked) ones at fixed anchors. The segments of the wedges for strands Ø 15.7 mm shall be marked with "0.62".

1.4 Anchor heads and couplers

The conical drills of the anchor heads and couplers shall be clean and free of rust and provided with a corrosion protection agent.

1.5 Bearing plates

For tendons of 3 to 9 strands rectangular bearing plates shall be used. The long side of the bearing plates shall be installed parallel to the biggest centre or edge distance (see Annex A2 page 1 and 3 and Annex A4).

1.6 Cast-iron anchor bodies

For tendons 12 to 31 strands multi-surfaced cast-iron anchor bodies shall be used (see Annex A4).

1.7 Helixes and stirrups

The steel grades and dimensions of the helixes and of the stirrups shall comply with the values given in the Annexes. The central position in the structural concrete member on site shall be ensured according to Annex B, section 3.1.3.

1.8 Ducts

Ducts shall be used according to EN 523:2003. For tendons BBV L3 and BBV L4 use may also be made of oval ducts. For these ducts EN 523:2003 applies accordingly. The dimensions of the ducts shall comply with the values given in Annex A2. The trumpets at stressing and fixed anchors (see Annexes A3, A4) are manufactured from 3.5 mm thick PE material (BBV L12 to L31). The other trumpets (see Annexes A3, A4 and A6) are manufactured from steel. In the area of possible contact between strands and steel trumpet (point of deviation) PE pipes of at least 4 mm thickness and a length of 120.0 mm shall be provided for avoiding any contact between strands and steel. The PE pipes shall be fixed in the right position. When using trumpets made of plastic with a minimum thickness of 3.5 mm, it is not necessary to install a PE pipe. It shall be made sure that at anchors and couplers for 3 to 22 and 31 strands (1.part, Annex A6) the maximum deflection angle of the strand is 2.6° (at the end of the wedge and at the deviation point between trumpet and duct). For 27 strands the maximum deflection angle is 2.1°. The deflection at couplers (2.part, Annex A6) is 7° (at the deviation point between trumpet and duct). At the end of the wedge normally there is no deflection.

Also plastic ducts which meet the requirements according to ETAG 013, Annex C.3 and in accordance with regulations valid at the place of use can be used. Plastic ducts or the accompanying boundary conditions are not covered by ETA-05/0202.

1.9 Grout

Grout shall be used according to EN 447:2007

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 PT-System 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 PT-System of at least 100 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

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

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic	**Performance**
Resistance to static load	The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.1-I
Resistance to fatigue	The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.2-I
Load Transfer to structure	The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.3-I
Friction coefficient	The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.4-I See Annex C 1
Deviation/deflection (limits)	The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.5-I

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 013, June 2002, used as European Assessment Document (EAD) according to Article 66 Paragraph 3 of Regulation (EU) No 305/2011, the applicable European legal act is: [98/456/EC].

The system to be applied is: 1+

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

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

Issued in Berlin on 26 August 2016 by Deutsches Institut für Bautechnik

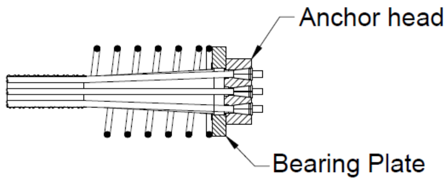
Uwe Bender
Head of Department

beglaubigt:
Sultani

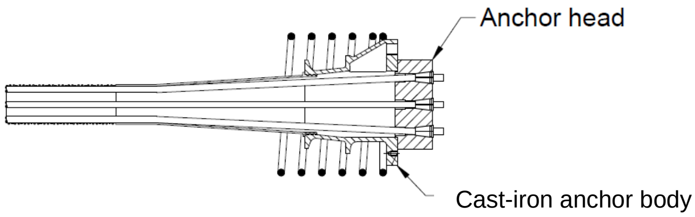
Deutsches Institut für Bautechnik

OVERVIEW ANCHORAGES

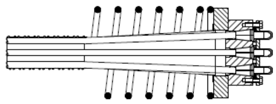
1. Active Anchor (S) and Passive Anchor (F) BBV L3 – BBV L9



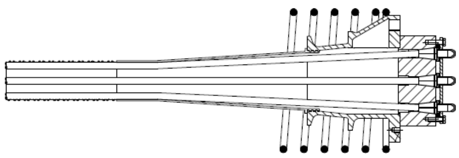
2. Active Anchor (S) and Passive Anchor (F) BBV L12 – BBV L31



3. Embedded Passive Anchor (Fe) BBV L3 – BBV L9

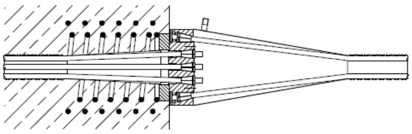


4. Embedded Passive Anchor (Fe) BBV L12 – BBV L31

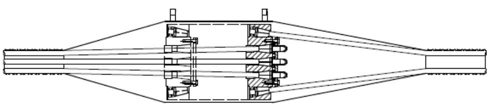


5. Coupler (ÜK) BBV L3 – BBV L9

Fixed Coupler (FÜK)

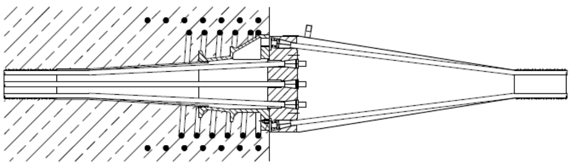


Movable Coupler (BÜK)

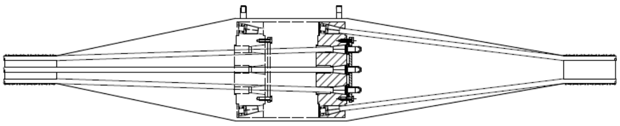


6. Coupler (ÜK) BBV L12 – BBV L31

Fixed Coupler (FÜK)

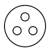
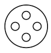
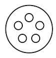
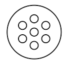
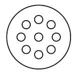


Movable Coupler (BÜK)



BBV-Internal Bonded Strand Post-tensioning System, type i	Annex A1
Description of the product Overview Anchorages	

TECHNICAL DETAILS BBV L 3 – BBV L 9
Steel Grade Y1770
Anchors (S), (F), (Fe), Coupler (FÜK),(BÜK)

Tendon Type		**BBV L 3**	**BBV L 4**	**BBV L 5**	**BBV L 7**	**BBV L 9**
Strand Pattern						
Number of strands	n	3	4	5	7	9
150mm² : Nominal Cross Section A_p	mm²	450	600	750	1050	1350
150mm² : Nominal mass M	kg/m	3.52	4.69	5.86	8.20	10.55
150mm² : Ultimate Force F_{pk}	kN	797	1062	1328	1859	2390
150mm² : $P_{0max} = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	616	821	1026	1436	1847
150mm² : $P_{m0}(x) = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	581	775	969	1357	1744
140mm² : Nominal Cross Section A_p	mm²	420	560	700	980	1260
140mm² : Nominal mass M	kg/m	3.28	4.37	5.47	7.65	9.84
140mm² : Ultimate Force F_{pk}	kN	743	991	1239	1735	2230
140mm² : $P_{0max} = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	575	766	958	1341	1724
140mm² : $P_{m0}(x) = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	543	724	904	1266	1628
Wobble Coefficient k	°/m	0.4	0.3	0.3	0.3	0.3
at max. Support Distance	m	1.80	1.80	1.80	1.80	1.80
Friction Coefficient μ	-	0.21	0.20 / 0.19 / 0.19	0.20 / 0.19 / 0.20	0.20 / 0.20 / 0.19	0.20 / 0.20 / 0.19
Friction Losses						
Active Anchor $\Delta P_\mu S$	%	1.2	1.2	1.2	1.1	1.0
Coupling $\Delta P_\mu ÜK$	%	1.2	1.2	1.2	1.1	1.2
Ducts						
Inner Diameter	mm	40****	45/50/55****	50/55/60	55/60/65	65/70/75
Outer Diameter	mm	46	51/56/62	56/61/67	61/67/72	72/77/82
Eccentricity, 150mm²	mm	5.4	6.3/9.7/12.6	7.5/10.7/13.8	5.7/9.0/12.1	8.4/12.1/15.4
Eccentricity, 140mm²	mm	6.1	6.9/10.1/13.1	8.8/11.9/15.0	7.2/10.4/14.2	10.5/13.9/17.1
Strand Protrusion **	cm	21.5	21.5	70	71	82
Anchors (S), (F), (Fe), Couplers (FÜK),(BÜK)						
Min. Centre Distance *, *****						
$f_{cmj,cube}$ = 30 N/mm²	mm	215 x 190	245 x 220	275 x 245	325 x 285	370 x 325
$f_{cmj,cube}$ = 34 N/mm²	mm	200 x 175	230 x 205	260 x 230	305 x 270	345 x 305
$f_{cmj,cube}$ = 40 N/mm²	mm	185 x 160	215 x 185	235 x 210	280 x 245	320 x 275
$f_{cmj,cube}$ = 45 N/mm²	mm	170 x 150	200 x 175	225 x 195	260 x 230	295 x 265

* Distances can be reduced to 85 % of the given values in one direction, if increased correspondingly in the other direction

** Distance from anchor head for placing of jack

*** Based on $f_{p0,1k}$ = 1500 N/mm² (Grade Y1770S7)

**** Oval ducts allowed to use for: BBV L 3 (60 x 21mm)
(inner dimensions) BBV L 4 (80 x 21mm)

Wobble coefficient k to be considered for oval ducts is: k = 0.8 °/m

Friction coefficient μ to be considered is:	BBV L 3	BBV L 4
Bending round the stiff axis:	μ = 0.23	μ = 0.26
Bending round the weak axis:	μ = 0.15	μ = 0.15

***** Min. edge distance : min. centre distance/2+20 mm

BBV-Internal Bonded Strand Post-tensioning System, type i

Description of the product
Technical Details BBV L3 – BBV L9
Steel Grade Y1770S7

Annex A2
Page 1 of 4

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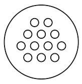
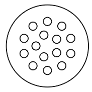
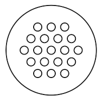
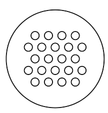
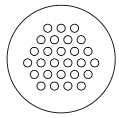
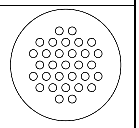
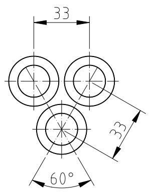
TECHNICAL DETAILS BBV L 12 – BBV L 31
Grade Y1770
Anchors (S), (F), (Fe), Coupler (FÜK),(BÜK)

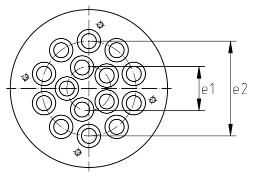
Tendon type		**BBV L 12**	**BBV L 15**	**BBV L 19**	**BBV L 22**	**BBV L 27**	**BBV L 31**
Strand Pattern							
Number of strands	n	12	15	19	22	27	31
150mm² : Nominal Cross Section A_p	mm²	1800	2250	2850	3300	4050	4650
150mm² : Nominal Mass M	kg/m	14.06	17.58	22.27	25.78	31.64	36.58
150mm² : Ultimate Force F_{pk}	kN	3186	3983	5045	5841	7169	8231
150mm² : $P_{max} = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2462	3078	3899	4514	5540	6361
150mm² : $P_{m0}(x) = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2326	2907	3682	4264	5233	6008
140mm² : Nominal Cross Section Ap	mm²	1680	2100	2660	3080	3780	4340
140mm² : Nominal Mass M	kg/m	13,12	16,40	20,77	24,05	29,51	34,07
140mm² : Ultimate Force F_{pk}	kN	2974	3717	4708	5452	6691	7682
140mm² : $P_{max} = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2298	2873	3639	4213	5171	5937
140mm² : $P_{m0}(x) = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2171	2713	3437	3979	4884	5607
Wobble Coefficient k	°/m	0.3	0.3	0.3	0.3	0.3	0.3
at max. Support Distance	m	1.80	1.80	1.80	1.80	1.80	1.80
Friction Coefficient μ	-	0.19/0.19/0.19	0.20/0.20 / 0.19	0.21 / 0.20	0.21/0.20 / 0.19	0.20 / 0.20	0.20 / 0.20
Friction Losses							
Active Anchor $\Delta P_{\mu}S$	%	0.8	0.8	0.8	0.6	0.8	0.8
Coupler $\Delta P_{\mu}ÜK$	%	1.2	1.1	1.0	1.2	1.2	1.2
Ducts							
Inner Diameter	mm	75/80/90	80/85/90	90/95	95/100/110	110/115	115/125
Outer Diameter	mm	82/87/97	87/92/97	97/102	102/107/117	117/125	122/135
Eccentricity, 150mm²	mm	10.3/13.9/20,2	9.0/12.4/15.8	9.9/13.1	9,7/13.3/20.1	14.1/17.3	12.1/19.6
Eccentricity, 140mm²	mm	11.7/14.9/21.1	10.1/14.0/17.7	10.2/15.8	11.9/15.9/22.1	15.7/19.0	14.2/21.5
Strand Protrusion **	cm	80	80	110	110	120	120
Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK)							
Min. Centre / Edge Distance *							
$f_{cmj,cube}$ = 28 N/mm²	mm	405/225	450/245	505/275	545/295	605/325	645/345
$f_{cmj,cube}$ = 34 N/mm²	mm	370/205	415/230	465/255	500/270	550/295	595/320
$f_{cmj,cube}$ = 40 N/mm²	mm	340/190	380/210	430/235	460/250	510/275	545/295
$f_{cmj,cube}$ = 45 N/mm²	mm	325/185	360/200	405/225	435/240	485/265	520/280

* and ** see Annex A2 page 1 of 4
*** based on $f_{p0,1k}$ = 1520 N/mm² (Grade Y1770S7)

Strand Pattern BBV L 12; 19; 22; 27; 31
Conical borings are in line,
lines result in a grid



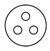
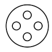
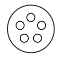
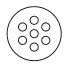
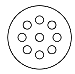
BBV L 3; 4; 5; 7; 9; 15
All conical borings are aligned on one or two circles
e1 and e 2). See Annex A4



Example: BBV L15

BBV-Internal Bonded Strand Post-tensioning System, type i	Annex A2 Page 2 of 4
Description of the product Technical Details BBV L12 – BBV L31 Steel Grade Y1770S7	

TECHNICAL DETAILS BBV L 3 – BBV L 9
Steel Grade Y1860
Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK)

Tendon Type	Unit	**BBV L 3**	**BBV L 4**	**BBV L 5**	**BBV L 7**	**BBV L 9**
Strand Pattern						
Number of Strands	n	3	4	5	7	9
150mm² : Nominal Cross Section Ap	mm²	450	600	750	1050	1350
150mm² : Nominal Mass M	kg/m	3.52	4.69	5.86	8.20	10.55
150mm² : Ultimate Force F_{pk}	kN	837	1116	1395	1953	2511
150mm² : $P_{0max} = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	648	864	1080	1512	1944
150mm² : $P_{m0}(x) = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	612	816	1020	1428	1836
140mm² : Nominal Cross Section Ap	mm²	420	560	700	980	1260
140mm² : Nominal Mass M	kg/m	3.28	4.37	5.47	7.65	9.84
140mm² : Ultimate Force F_{pk}	kN	781	1042	1302	1823	2344
140mm² : $P_{0max} = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	605	806	1008	1411	1814
140mm² : $P_{m0}(x) = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	571	762	952	1333	1714
Wobble Coefficient k	°/m	0.4	0.3	0.3	0.3	0.3
at max. Support Distance	m	1.80	1.80	1.80	1.80	1.80
Friction Coefficient μ	-	0.21	0.20 / 0.19 / 0.19	0.20 / 0.19 / 0.20	0.20 / 0.20 / 0.19	0.20 / 0.20 / 0.19
Friction Losses						
Active Anchor $\Delta P_{\mu}S$	%	1.2	1.2	1.2	1.1	1.0
Coupler $\Delta P_{\mu}ÜK$	%	1.2	1.2	1.2	1.1	1.2
Ducts		****	****			
Inner Diameter	mm	40	45/50/55	50/55/60	55/60/65	65/70/75
Outer Diameter	mm	46	51/56/61	56/61/67	61/67/72	72/77/82
Eccentricity, 150mm²	mm	5.4	6.3/9.7/12.6	7.5/10.7/13.8	5.7/9.0/12.1	8.4/12.1/15.4
Eccentricity, 140mm²	mm	6.1	6.9/10.1/13.1	8.8/11.9/15.0	7.2/10.4/14.2	10.5/13.9/17.1
Strand Protrusion **	cm	21,5	21,5	70	71	82
Anchors (S), (F), (Fe), Couplers (FÜK),(BÜK)						
Min. Centre Distance *, *****						
$f_{cmj,cube}$ = 30 N/mm²	mm	215 x 190	245 x 220	275 x 245	325 x 285	370 x 325
$f_{cmj,cube}$ = 34 N/mm²	mm	200 x 175	230 x 205	260 x 230	305 x 270	345 x 305
$f_{cmj,cube}$ = 40 N/mm²	mm	185 x 160	215 x 185	235 x 210	280 x 245	320 x 275
$f_{cmj,cube}$ = 45 N/mm²	mm	170 x 150	200 x 175	225 x 195	260 x 230	295 x 265

* Distances can be reduced to 85 % of the given values in one direction, if increased correspondingly in the other direction

** Distance from anchor head for placing of jack

*** Based on $f_{p0,1k} \approx 1600$ N/mm² (Grade Y1860S7)

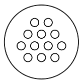
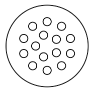
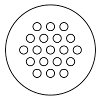
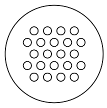
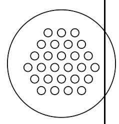
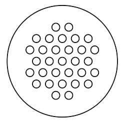
**** Oval ducts allowed to use for: (inner dimensions) — BBV L 3 (60 x 21mm); BBV L 4 (80 x 21mm)

Wobble coefficient k to be considered for oval ducts is: k = 0.8 °/m

Friction coefficient μ to be considered is:	BBV L 3	BBV L 4
Bending round the stiff axis:	μ = 0.23	μ = 0.26
Bending round the weak axis:	μ = 0.15	μ = 0.15

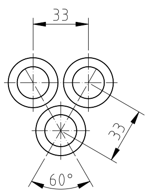
***** Min. edge distance : min. centre distance/2+20 mm

TECHNICAL DETAILS BBV L 12 – BBV L 31
Steel Grade Y1860
Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK)

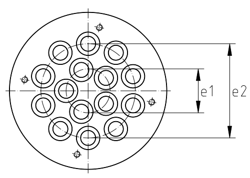
Tendon Type		**BBV L 12**	**BBV L 15**	**BBV L 19**	**BBV L 22**	**BBV L 27**	**BBV L 31**
Strand Pattern							
Number of Strands	n	12	15	19	22	27	31
150mm² : Nominal Cross Section A_p	mm²	1800	2250	2850	3300	4050	4650
150mm² : Nominal Mass M	kg/m	14.06	17.58	22.27	25.78	31.64	36.58
150mm² : Ultimate Force F_{pk}	kN	3348	4185	5301	6138	7533	8649
150mm² : $P_{max} = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2592	3240	4104	4752	5832	6696
150mm² : $P_{m0}(x) = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2448	3060	3876	4488	5508	6324
140mm² : Nominal Cross Section A_p	mm²	1680	2100	2660	3080	3780	4340
140mm² : Nominal Mass M	kg/m	13.12	16.40	20.77	24.05	29.51	34.07
140mm² : Ultimate Force F_{pk}	kN	3125	3906	4948	5729	7031	8072
140mm² : $P_{max} = 0.90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2419	3024	3830	4435	5443	6250
140mm² : $P_{m0}(x) = 0.85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2285	2856	3618	4189	5141	5902
Wobble Coefficient k	°/m	0.3	0.3	0.3	0.3	0.3	0.3
at max. Support Distance	m	1.80	1.80	1.80	1.80	1.80	1.80
Friction Coefficient μ	-	0.19/ 0.19 / 0.19	0.20/0.20 / 0.19	0.21 / 0.20	0.21/0.20 / 0.19	0.20 / 0.20	0.20 / 0.20
Friction Losses							
Active Anchor $\Delta P_{\mu}S$	%	0.8	0.8	0.8	0.6	0.8	0.8
Coupler $\Delta P_{\mu}ÜK$	%	1.2	1.1	1.0	1.2	1.2	1.2
Ducts							
Inner Diameter	mm	75/80/90	80/85/90	90/95	95/100/110	110/115	115/125
Outer Diameter	mm	82/87/97	87/92/97	97/102	102/107/117	117/125	122/135
Eccentricity, 150mm²	mm	10.3/13.9/20,2	9,0/12.4/15.8	9.9/13.1	9.7/13.3/20.1	14.1/17.3	12.1/19.6
Eccentricity, 140mm²	mm	11.7/14.9/21,1	10,1/14.0/17.7	10.2/15.8	11.9/15.9/22.1	15.7/19.0	14.2/21.5
Strand Protrusion **	cm	80	80	110	110	120	120
Anchors (S), (F), (Fe), Couplers (FÜK), (BÜK)							
Min. Centre/Edge Distance*							
$f_{cmj,cube}$ = 28 N/mm²	mm	405/225	450/245	505/275	545/295	605/325	645/345
$f_{cmj,cube}$ = 34 N/mm²	mm	370/205	415 /230	465/255	500/270	550/295	595/320
$f_{cmj,cube}$ = 40 N/mm²	mm	340/190	380/210	430/235	460/250	510/275	545/295
$f_{cmj,cube}$ = 45 N/mm²	mm	325/185	360/200	405/225	435/240	485/265	520/280

* and ** see Annex A2 page 1 of 4
*** based on $f_{p0,1k}$ = 1600 N/mm² (Grade Y1860S7)

Strand Pattern BBV L 12; 19; 22; 27; 31
Conical borings are in line, lines result in a grid.



BBV L 3; 4; 5; 7; 9; 15
All conical borings are aligned on one or two circles (e1 and e2). See Annex A4



Example: BBV L15

BBV-Internal Bonded Strand Post-tensioning System, type i	Annex A2 Page 4 of 4
Description of the product Technical Details BBV L12 – BBV L31 Steel Grade Y 1860S7	

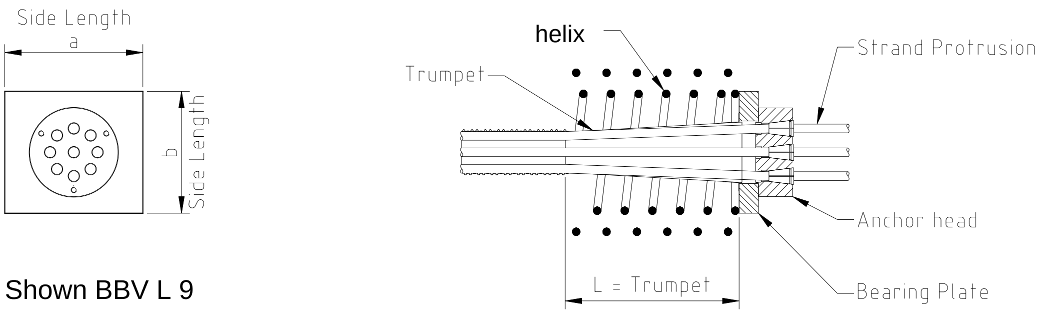
Description of Wedge Anchorages

Active Anchors (S)
Passive Anchors (F), (Fe)

Active anchors (S) with bearing plate and anchor head
Accessible passive anchor (F) with bearing plate and anchor head

For embedded Passive Anchor (Fe) the anchor head is installed to the bearing plate, the wedges are sealed and secured in their cones by a retainer plate. The area around the wedges of embedded passive anchors is to be filled with corrosion protection mass and filled sealing caps are to be applied.

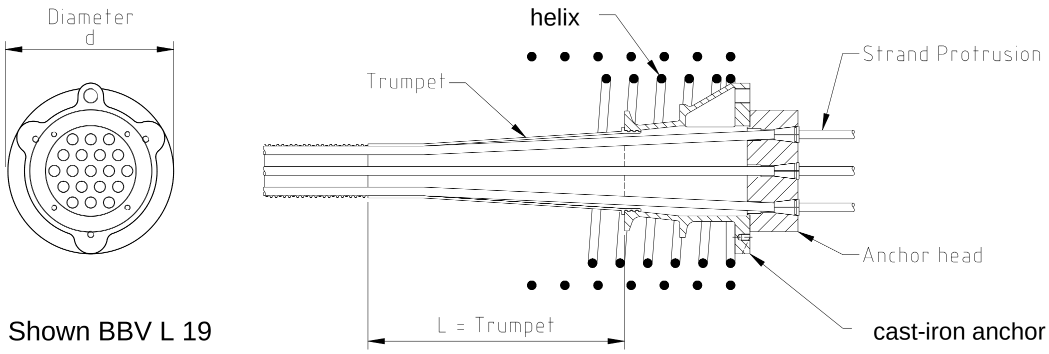
L 3 – L 9



Shown BBV L 9

Tendon Type BBV L 3 – L9: active anchor and passive anchor with rectangular bearing plate *a x b* and anchor head.

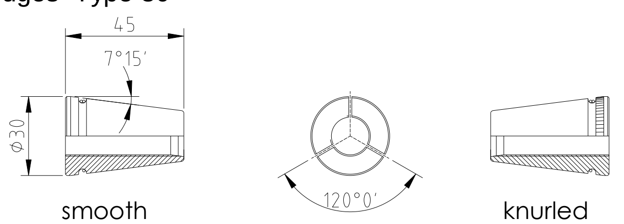
L 12 – L 31



Shown BBV L 19

Tendon Type BBV L 12 – L 31: active anchor with cast-iron anchor body of diameter *d* and anchor head.

Wedges Type 30



Optional knurled wedges for pre-wedged passive anchors

Wedges for 150 mm² strands are marked with "0.62" on the front face.

BBV-Internal Bonded Strand Post-tensioning System, type i	Annex A3
Description of the product Wedge Anchorages	

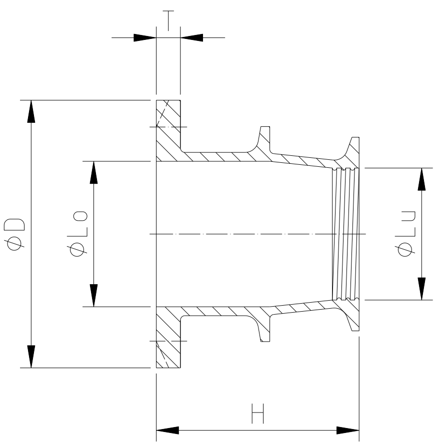
Dimension of Anchor Components

Tendon Type		L3	L4	L5	L7	L9	L12	L15	L19	L22	L27	L31
Bearing Plate												
Side length a	mm	160	180	195	215	250						
Side length b	mm	140	160	170	190	220						
Thickness	mm	25	25	30	35	35						
Hole diameter	mm	72	81	83	93	113						
Cast-iron Anchor												
Diameter D	mm						240	270	300	327	360	382
Height H	mm						182	203	227	248	272	294
Thickness 1st plane T	mm						22	23	27	28	32	34
Hole - dia. top Lo	mm						131	150	163	183	199	208
Hole - dia. bottom Lu	mm						123	139	148	165	176	182
Anchor Head												
Diameter D	mm	104	104	115	132	160	180	200	220	245	265	280
Thickness T	mm	65	65	70	75	75	80	82	92	105	120	125
Diameter A	mm	68	77	79	89	109	127	146	159	179	195	204
Diameter circle e1	mm	45	54	56	66	86	*grid	56	*grid	*grid	*grid	*grid
Diameter circle e2	mm							120				
Trumpet												
Max. outer diameter	mm	70	79	81	91	111	131	147	156	173	184	190
Length	mm	≥200	≥244	≥201	≥247	≥417	≥500	≥553	≥595	≥620	≥544	≥509

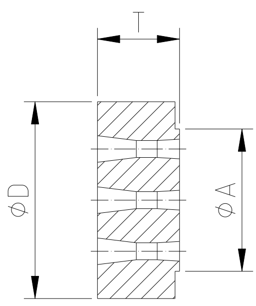
* Grid according to Annex A2 page 2 of 4

Bearing Plate see Annex A3

Cast-iron Anchor Body



Anchor Head

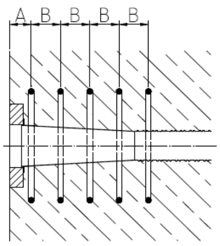


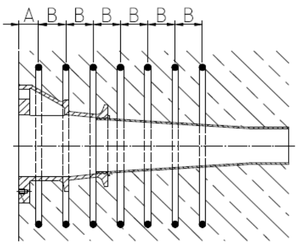
BBV-Internal Bonded Strand Post-tensioning System, type i	Annex A4
Description of the product Dimensions of Anchor Components	

Helix and Additional Reinforcement (Strirups)

Tendon Type		L3	L4	L5	L7	L9	L12	L15	L19	L22	L27	L31
Helix												
Bar Diameter												
$f_{cmj,cube}$=28/30 N/mm²	mm	14	14	14	14	14	14	14	16	16	16	16
$f_{cmj,cube}$ =34 N/mm²	mm	14	14	14	14	14	14	16	16	16	16	16
$f_{cmj,cube}$ =40 N/mm²	mm	14	14	14	14	14	14	14	16	16	16	16
$f_{cmj,cube}$ =45 N/mm²	mm	14	14	14	14	14	14	14	16	16	16	16
Outer Diameter												
$f_{cmj,cube}$=28/30 N/mm²	mm	140	160	180	200	240	300	345	390	430	490	520
$f_{cmj,cube}$ =34 N/mm²	mm	135	150	170	190	230	300	340	380	410	450	480
$f_{cmj,cube}$ =40 N/mm²	mm	130	135	160	190	225	285	320	360	380	430	460
$f_{cmj,cube}$ =45 N/mm²	mm	120	120	140	180	220	270	315	340	365	410	430
Min. Length												
$f_{cmj,cube}$=28/30 N/mm²	mm	200	230	250	300	350	350	400	450	450	550	550
$f_{cmj,cube}$ =34 N/mm²	mm	180	210	240	270	310	300	350	400	450	470	470
$f_{cmj,cube}$ =40 N/mm²	mm	170	200	220	250	290	300	300	350	350	450	450
$f_{cmj,cube}$ =45 N/mm²	mm	160	180	200	250	275	250	250	300	300	350	350
Pitch												
$f_{cmj,cube}$=28/30 N/mm²	mm	40	40	40	50	50	50	50	50	50	50	50
$f_{cmj,cube}$ =34 N/mm²	mm	40	40	40	50	50	50	50	50	50	50	50
$f_{cmj,cube}$ =40 N/mm²	mm	40	40	40	50	50	50	50	50	50	50	50
$f_{cmj,cube}$ =45 N/mm²	mm	40	40	40	50	50	50	50	50	50	50	50
Helix Turns												
$f_{cmj,cube}$=28/30 N/mm²	n	6	7	7.5	7	8	8	9	10	10	12	12
$f_{cmj,cube}$ =34 N/mm²	n	5.5	6.5	7	6.5	7	7	8	9	10	10.5	10.5
$f_{cmj,cube}$ =40 N/mm²	n	5.5	6	6.5	6	7	7	7	8	8	10	10
$f_{cmj,cube}$ =45 N/mm²	n	5.0	5.5	7	6	6.5	6	6	7	7	8	8
Stirrup reinforcement		Nos x dia.	Nos x dia.	Nos x dia.	Nos x dia.	Nos x dia.	Nos x dia.	Nos x dia.	Nos x dia.	Nos x dia.	Nos x dia.	Nos x dia.
$f_{cmj,cube}$=28/30 N/mm²	mm	4x Ø10	4x Ø12	4x Ø14	4x Ø14	5x Ø14	6x Ø12	5x Ø14	6x Ø16	7x Ø16	11x Ø16	12x Ø16
$f_{cmj,cube}$ =34 N/mm²	mm	4x Ø10	5x Ø10	5x Ø12	5x Ø12	5x Ø14	6x Ø14	8x Ø14	7x Ø16	8x Ø16	9x Ø20	10x Ø20
$f_{cmj,cube}$ =40 N/mm²	mm	4x Ø8	4x Ø12	5x Ø12	5x Ø12	5x Ø14	5x Ø16	6x Ø16	7x Ø16	6x Ø20	8x Ø20	10x Ø20
$f_{cmj,cube}$ =45 N/mm²	mm	4x Ø8	4x Ø10	4x Ø12	4x Ø12	6x Ø12	5x Ø16	6x Ø16	8x Ø16	8x Ø16	8x Ø20	9x Ø20
Position behind Bearing plate or												
Cast-iron anchor body		A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
$f_{cmj,cube}$=28/30 N/mm²	mm	45 / 60	45 / 70	50 / 75	55 / 95	55 / 80	50 / 70	50 / 95	50 / 90	50 / 80	60 / 60	60 / 55
$f_{cmj,cube}$ =34 N/mm²	mm	45 / 55	45 / 50	50 / 55	55 / 65	55 / 75	50 / 65	50 / 55	50 / 70	50 / 65	60 / 65	60 / 55
$f_{cmj,cube}$ =40 N/mm²	mm	45 / 55	45 / 60	50 / 50	55 / 60	55 / 70	50 / 70	50 / 65	50 / 60	50 / 75	60 / 65	60 / 55
$f_{cmj,cube}$ =45 N/mm²	mm	45 / 50	45 / 55	50 / 60	55 / 75	55 / 50	50 / 65	50 / 60	50 / 55	50 / 50	60 / 60	60 / 55

L3 – L9





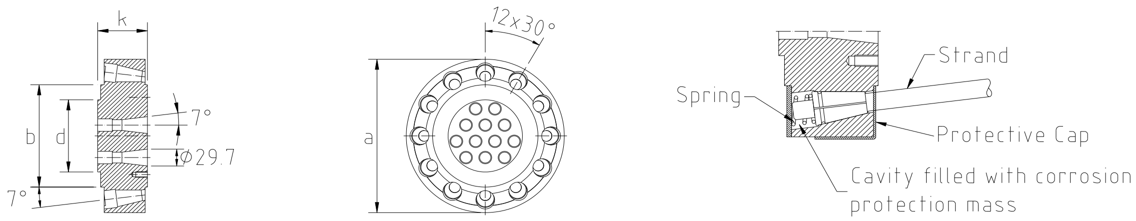
L12 – L31

BBV-Internal Bonded Strand Post-tensioning System, type i

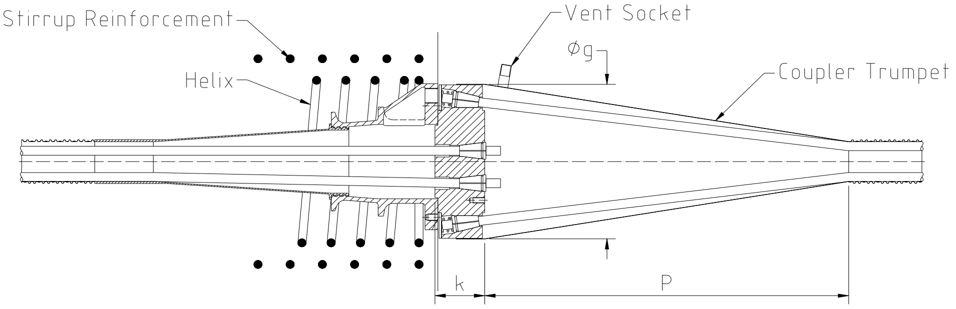
Description of the product
Helix and Additional Reinforcement

Annex A5

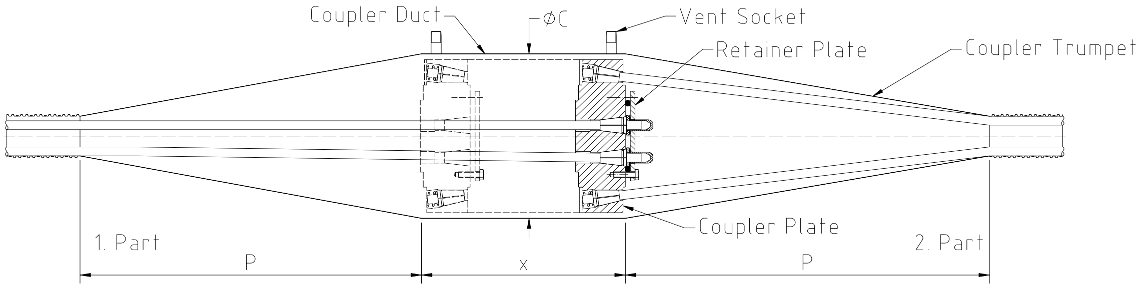
COUPLER (ÜK)



Fixed Coupler (FÜK)



Movable Coupler (BÜK)



Min. length of coupler duct: for one-end stressing $x = k + 1{,}15\ \Delta l + 30mm$
for both ends stressing $x = k + 1{,}15\ \Delta l + 60\ mm$ (Δl = elongation)

Tendon type			L3	L4	L5	L7	L9	L12	L15	L19	L22	L27	L31
Coupler Plate													
Diameter	Øa	mm	194	194	205	222	245	270	290	310	335	380	405
Thickness	k	mm	85	85	85	85	85	85	90	98	110	120	130
Diameter bearing area	b	mm	104	104	115	132	160	180	200	220	245	265	280
Coupler Trumpet													
Length	p	mm	≥440	≥420	≥440	≥490	≥545	≥605	≥640	≥710	≥765	≥875	≥920
Diameter fixed coupler	g	mm	197	197	208	225	248	273	293	313	338	383	408
Diameter movable coupler	C	mm	214	214	225	242	265	290	310	330	355	400	425

Anchor plate, trumpet, helix and reinforcement see Annexes A4 and A5

BBV-Internal Bonded Strand Post-tensioning System, type i

Description of the product
Couple (ÜK)

Annex A6

Dimensions and Properties of 7-Wire Strands

Designation	Symbol	Unit	Value	
Tensile strength	R_m/F_{pk}	MPa	1770 or 1860	
Strand				
Nominal diameter	D	mm	15.3	15.7
Nominal cross section	A_p	mm²	140	150
Nominal mass	M	g/m	1093	1172
Surface configuration	-	-	plain	
Strength at 0,1%	$f_{p0,1k}$	MPa	1520 or 1600*	
Strength at 0,2%	$f_{p0,2}$	MPa	1570 or 1660	
Modulus of elasticity	E	MPa	≈ 195,000	
Individual wires				
External wire diameter	d	mm	5.0 ± 0.04	5.2 ± 0.04
Core wire diameter	d'	mm	1.02 to 1.04 d	1.02 to 1.04 d

* If admissible in the place of use, strands with higher characteristic yield stresses might be used, but not more than $f_{p0,1k}$ = 1560 N/mm² (Y1770S7) or 1640 N/mm² (Y1860S7).

As long as prEN 10138-3:2009-08 does not exist 7-wire strands in accordance with national provisions and with the characteristics given in the table above shall be used.

BBV-Internal Bonded Strand Post-tensioning System, type i	Annex A7
Description of the product Dimensions and Properties of 7-wire Strands	

1 Intended use

The Post-Tensioning System is assumed to be used for internal bonded tendons for normal-weight concrete structures or elements.

No optional use category is intended. The structural members used to be designed in accordance with national regulations.

2 Methods of verification

2.1 General

The structural members prestressed by means of the BBV-Internal Bonded Strand Post-Tensioning System have to be designed in accordance with national regulations.

2.2 Tendons

Prestressing and overtensioning forces are specified in the respective national provisions.

The maximum force P_{max} applied to a tendon shall not exceed the force $P_{max} = 0.9\ A_p\ f_{p0,1k}$ (see Table B 1 (140 mm²) or Table B 2 (150 mm²) for $f_{p0,1k}$ = 1520 N/mm² or 1600 N/mm²). The value of the prestressing initial prestress force $P_{m0}(x)$ applied to the concrete after tensioning and anchoring shall not exceed the force $P_{m0}(x) = 0.85\ A_p\ f_{p0,1k}$ (see Table B 1 (140 mm²) or Table B 2 (150 mm²) for $f_{p0,1k}$ = 1520 N/mm² or 1600 N/mm²).

Table B 1: Maximal prestressing forces[1] for tendons with A_p = 140 mm²

Tendon Designation	Number of strands	Cross section A_p [mm²]	Prestressing force Y1770 S7 $f_{p0,1k}$ = 1520 N/mm²		Prestressing force Y1860 S7 $f_{p0,1k}$ = 1600 N/mm²	
			$P_{m0}(x)$ [kN]	P_{max} [kN]	$P_{m0}(x)$ [kN]	P_{max} [kN]
BBV L3	3	420	543	575	571	605
BBV L4	4	560	724	766	762	806
BBV L5	5	700	904	958	952	1008
BBV L7	7	980	1266	1341	1333	1411
BBV L9	9	1260	1628	1724	1714	1814
BBV L12	12	1680	2171	2298	2285	2419
BBV L15	15	2100	2713	2873	2856	3024
BBV L19	19	2660	3437	3639	3618	3830
BBV L22	22	3080	3979	4213	4189	4435
BBV L27	27	3780	4884	5171	5141	5443
BBV L31	31	4340	5607	5937	5902	6250

[1] The forces stated in Tables B 1 to B 3 are maximum values referring on $f_{p0,1k}$ = 1520 N/mm² or 1600 N/mm². The actual prestressing forces are to be found in national regulations valid in the place of use. If admissible in the place of use, strands with higher characteristic yield stresses might be used, but not more than $f_{p0,1k}$ = 1560 N/mm² (Y1770S7) or 1640 N/mm² (Y1860S7). In this case the prestressing forces of Tables B 1 to B 3 can be linearly increased by multiplying them with the factor ($f_{p0,1k}$ / 1520) or ($f_{p0,1k}$ / 1600).

Compliance with the stabilisation and crack width criteria in the load transfer test was verified to a load level of 0,80*F_{pk}.

Table B 2: Maximal prestressing forces[1] for tendons with A_p = 150 mm²

Tendon Designation	Number of strands	Cross section A_p [mm²]	Prestressing force Y1770 S7 $f_{p0,1k}$ = 1520 N/mm²		Prestressing force Y1860 S7 $f_{p0,1k}$ = 1600 N/mm²	
			$P_{m0}(x)$ [kN]	P_{max} [kN]	$P_{m0}(x)$ [kN]	P_{max} [kN]
BBV L3	3	450	581	616	612	648
BBV L4	4	600	775	821	816	864
BBV L5	5	750	969	1026	1020	1080
BBV L7	7	1050	1357	1436	1428	1512
BBV L9	9	1350	1744	1847	1836	1944
BBV L12	12	1800	2326	2462	2448	2592
BBV L15	15	2250	2907	3078	3060	3240
BBV L19	19	2850	3682	3899	3876	4104
BBV L22	22	3300	4264	4514	4488	4752
BBV L27	27	4050	5233	5540	5508	5832
BBV L31	31	4650	6008	6361	6324	6696

The number of strands in a tendon may be reduced by leaving out strands lying radial-symmetrically in the anchor head (not more than four strands). The provisions for tendons with anchors (basic types) completely filled also apply to tendons with anchor heads only partly filled. Into the free drills in the anchor head the short pieces of strands with wedges have to be pressed to prevent slipping out. The admissible prestressing force is reduced per strand left out as shown in Table B 3.

Table B 3: Reduction of the prestressing force[1] when leaving out a strand

A_p	Y1770 S7		Y1860 S7	
	$\Delta P_{m0}(x)$ [kN]	ΔP_{max} [kN]	$\Delta P_{m0}(x)$ [kN]	ΔP_{max} [kN]
140 mm²	181	192	190	201
150 mm²	194	205	204	216

Further characteristic values of the tendons (mass per meter, ultimate stressing force F_{pk}) see Annex A2.

2.3 Radius of curvature of the tendons in the structure

The smallest admissible radii of curvature are given in Annex B3, section 4.2.

2.4 Concrete strength

Concrete complying with EN 206-1:2000, EN 206-1/A1:2004 and EN 206-1/A2:2005 shall be used.
At the time of transmission of the full prestressing force the mean concrete strength of the normal weight concrete in the anchor zone shall be at least $f_{cmj,cube}$ or $f_{cmj,cyl}$ according to Table B 4. The mean concrete strength shall be verified by means of at least three specimens (cylinder or cube with the edge length of 150 mm), which shall to be stored under the same conditions as the concrete member, with the individual values of specimen not differ more than 5 %.

Table B 4: Necessary mean concrete strength f_{cmj} of the specimens at time of prestressing

$f_{cmj,cube}$ [N/mm²]	$f_{cmj,cyl}$ [N/mm²]
28*)/30**)	23*)/25**)
34	28
40	32
45	35

*) 12 to 31 strands

**) 3 to 9 strands

For partial prestressing with 30 % of the full prestressing the minimum value of the concrete compressive strength to be proven is 0.5 $f_{cmj,cube}$ or 0.5 $f_{cmj,cyl}$; intermediate values can be interpolated lineally.

2.5 Centre and edge distances of the tendon anchorages, concrete cover

The centre and edge distances of the tendon anchorages must not be smaller than the values given in the Annexes depending on the minimum concrete strength. In case of anchorages BBV L3 to BBV L9 the large side of the bearing plate (side length a according to Annex A4) shall be installed parallel to the large concrete side (the maximum spacing of concrete axis).

The values of the centre or edge distances of the anchors given in the Annexes may be reduced in one direction up to 15 %, however, not to a smaller value than the external dimensions of the additional reinforcement (stirrups or the outer diameter of the helix, Annex A5). In this case the centre and the edge distances in the other direction shall be increased for keeping the same concrete area in the anchor zone.

All centre and edge distances have only been specified with a view to load transfer to the structure; therefore, the concrete cover given in national standards and provisions shall be taken into account additionally.

2.6 Reinforcement in the anchorage zone

The anchorages (including reinforcement) for the transfer of the prestressing forces to the structural concrete are verified by means of tests. The resistance to the forces occurring in the structural concrete in the anchorage zone outside (behind) the helix shall be verified. An adequate transverse reinforcement shall be provided here in particular for the occurring transverse tension forces (not shown in the attached drawings).

The steel grades and dimensions of the additional reinforcement (stirrups) shall follow the values given in the Annexes. This reinforcement must not be taken into account as part of the statically required reinforcement. However, existing reinforcement in a corresponding position more than the statically required reinforcement may be taken into account for the additional reinforcement. The given reinforcement consists of closed stirrups (stirrups closed by means of bends or hooks or an equivalent method). The stirrup locks (bends or hooks) shall be placed staggered.

In the anchorage zone vertically led gaps for concreting shall be provided for concreting properly. If in exceptional case[2] - due to an increased amount of reinforcement - the helix or the concrete cannot be properly placed, the helix can be replaced by different equivalent reinforcement.

[2] This requires the approval for individual case according to the national regulations and administrative provisions.

2.7 Slip at the anchorages

The slip at the anchorages (see Annex B2, section 3.1.5) shall be taken into account in the static calculation and the determination of the tendon elongation.

2.8 Resistance to fatigue of the anchorages and couplers

With the fatigue tests carried out in accordance with ETAG 013, the stress range of 80 N/mm² of the strands at the maximum stress of 0.65 f_{pk} at 2×10^6 load cycles was demonstrated.

2.9 Increased tension losses at couplers

For verification of crack control and stress ranges increased tension losses of prestressing forces shall be taken into account at the couplers due to creep and shrinkage of the concrete. The losses in prestressing force of the tendons, determined without the influence of the couplers, shall be multiplied in the coupling zone by the factor 1.5. No increase need be taken into account for the movable couplers.

2.10 Couplers

The couplers shall only be used if the calculated stressing force at the coupler is at least 0.7 $P_{m0}(x)$ (see Annex B2, section 2.2). Couplers shall be positioned in straight tendon sections with straight length of at least 1.0 m to each side. For movable couplers the position and length of the coupler duct shall ensure that a movement is possible over the length of at least 1.15 $\Delta\ell$ + 30 mm, where $\Delta\ell$ is the maximum elongation length at the time of prestressing.

For movable couplers BÜK it shall be ensured that the final position of the coupler plate after prestressing corresponds to that shown in the lower figure of Annex A6.

The prestressing force in the 2nd construction stage of fixed couplers shall be lower than in the 1st construction stage.

3 Assumptions under which the performance of the product for the intended use was favourably assessed

3.1 Installation

3.1.1 General

Assembly and installation of the tendons shall only be performed by qualified post-tensioning specialist companies which have the required technical skills and experiences with this BBV-Post-tensioning System. The company's site manager shall have a certificate of the manufacturer certifying that he is instructed by the manufacturer and has the required knowledge and experience with this post-tensioning system. Standards and regulations valid on site shall be considered.

The manufacturer is responsible to inform anyone concerned about the use of this BBV-Post-tensioning System. Additional information as listed in ETAG 013, Section 9.2 shall be held available at the ETA holder and shall be distributed as needed.

The tendons and the components shall be handled carefully.

3.1.2 Welding

Welding at the anchorages is only permitted at the following points:

a) Welding of the end of the helix to a closed ring.

b) For ensuring of the central position the helix may be attached to the bearing plate or cast-iron anchor by tack-welding.

After placing the strands in the ducts, no more welding shall be performed at the anchorages.

3.1.3 Installation of the tendon

The central position of the helix or stirrups shall be ensured by tack-welding to the bearing plate or the cast-iron anchor or by means of mounting brackets. The bearing plate or cast-iron anchor and the anchor head shall be in direction vertical to the axis of the tendon.

The tendon shall be placed straightforward the first meter at the anchorage.

PE pipes shall be fixed in the right position and the length of the trumpets shall ensure the right deflection angle of the strands (see section 1.8 of European Technical Assessment).

The connection between trumpet and duct shall be sealed carefully by tape in order to prevent the penetrating of concrete.

3.1.4 Coupler

The outer strands shall be colour-marked for showing the necessary depth of putting in.

3.1.5 Wedging force, slip at anchorages, wedge securing and corrosion protection mass

If the calculated prestressing force is less than 0.7 $P_{m0}(x)$ or if knurled wedges type 30 are used, the wedges of fixed anchorages shall be pre-wedged with 1.1 $P_{m0}(x)$ (see Annex B1, section 2.2).

The wedges of movable couplers in the parallel drills shall be pre-wedged with 1.1 $P_{m0}(x)$ (see Annex B1, section 2.2), if knurled wedges type 30 are used.

Without pre-wedging the slip within the anchorage to be taken into account for the determination of the elongations is 4 mm at the fixed anchorages and 8 mm at the movable couplers. In the case of hydraulic pre-wedging with 1.1 $P_{m0}(x)$ no slip shall be taken into account for the determination of the elongations, except for couplers (4 mm).

The wedges of all anchorages (fixed anchors and couplers) which are no more accessible during tensioning shall be secured by means of securing plates and bolts. The wedging area of fixed anchors to be cast in concrete and of inner part of movable couplers shall be filled with corrosion protection mass (Denso-Jet, Vaseline FC 284 or Nontribos MP-2) and provided with a sealing cap filled with corrosion protection mass (see Annexes A3 and A6). Compositions of the different types of these masses have been deposited with the Deutsches Institut für Bautechnik by the manufacturer. In the case of couplers the voids of the outer coupler tendon (see Annex A6) shall be filled with corrosion protection mass.

The wedges of the stressing anchors shall be wedged after tensioning with at least 0.1 $P_{m0}(x)$. In this case the slip is 3 mm. If the wedges are not compressed, the slip shall be about 6 mm (a reset plate shall be used to fix the wedges).

3.1.6 Tensioning

Before tensioning the minimum mean concrete strength shall comply with the values given in Annex B1, section 2.4.

It is admissible to restress the tendons by releasing and re-using the wedges. After restressing and anchoring, wedge marks on the strands resulting from first stressing shall be moved to the outside by at least 15 mm.

The minimum straight length for tensioning behind the anchorages (strand protrusion) is given in Annexes 2 to 5. All strands of a tendon shall be stressed simultaneously. This can be done by centrally controlled individual jacks or by a bundle jack.

3.1.7 Grouting

3.1.7.1 Grout and Grouting procedures

Grout according section 1.9 of ETA shall be used. Grouting procedures shall be carried out in accordance with EN 446:2007.

3.1.7.2 Water rinse

Normally, tendons shall not be rinsed with water.

3.1.7.3 Grouting speed

The grouting speed shall be in the range between 3m/min and 12m/min.

3.1.7.4 Grouted section and re-grouting

The length of a grouted section shall not exceed 120 m for tendons BBV L3 to L22, 95 m for tendons BBV L27 and 80 m for BBV L31. When exceeding these tendon lengths, additional grouting openings shall be provided. Where the tendon is led via distinct high points, re-groutings shall be performed in order to avoid voids. For re-groutings corresponding measures shall be taken into account already in design.

3.1.7.5 Surveillance

Surveillance according to EN 446:2007 shall be carried out.

3.1.8 Packaging, transport and storage

The components and the tendons shall be protected against moisture and staining.

The tendons shall be kept away from areas where welding procedures are performed.

During transport the smallest admissible diameter of curvature of tendons with duct up to 22 strands is 1.65 m and exceeding 22 strands is 2.0 m. For tendons without duct the smallest diameter of curvature during transport is 1.65 m.

4 Description of Post-Tensioning System

4.1 Tendons

The tendons consist of 7-wire strands with a nominal diameter of 0.60” (15,3 mm) and a nominal cross section of 140 mm² or with a nominal diameter of 0.62” (15,7 mm) and a nominal cross section of 150 mm². Steel grades Y1770S7 or Y1860S7 are allowed. Anchorages depending on the tendon sizes are identically for both steel grades.

Table B 5: The strands are bundled to the following tendons and stressing forces:

Steel Grade Nominal Diameter		**Y1770 0.60”**	**Y1770 0.62”**	**Y1860 0.60”**	**Y1860 0.62”**
Tendon Designation	**No. of strands**	**$P_{m0}(x)$ [kN]**	**$P_{m0}(x)$ [kN]**	**$P_{m0}(x)$ [kN]**	**$P_{m0}(x)$ [kN]**
BBV L 3	3	543	581	571	612
BBV L 4	4	724	775	762	816
BBV L 5	5	904	969	952	1020
BBV L 7	7	1266	1357	1333	1428
BBV L 9	9	1628	1744	1714	1836
BBV L 12	12	2171	2326	2285	2448
BBV L 15	15	2713	2907	2856	3060
BBV L 19	19	3437	3682	3618	3876
BBV L 22	22	3979	4264	4189	4488
BBV L 27	27	4884	5233	5141	5508
BBV L 31	31	5607	6008	5902	6324

Based on $f_{p0,1k}$ = 1520 N/mm² (Sorte Y 1770S7) and 1600 N/mm² (Grade Y 1860S7)

$P_{m0(x)} = 0{,}85 \times f_{p0,1k} \times A_p$

The number of strands in a tendon can be reduced by omitting single strands always maintaining a symmetrical pattern, see Annex B1, section 2.2, Table B3

The strands of tendons are combined in a duct without spacer. They are stressed simultaneously and anchored individually in the anchor head by means of wedges.

Round or oval profiled corrugated ducts are used according to EN 523:2003-11 and connected by threaded couplers. For tendons BBV L 3 and BBV L 4 oval ducts can also be used. All duct connections are sealed carefully by PVC tape.

4.2 Radius of curvature of the tendons in the structure

The smallest admissible radius of curvature of the tendons with circular duct depending on the strand strength, the cross section of the strand and the diameter of the duct is given in Table B 6 to B 9.

Table B 6: Smallest radius of curvatur[3] (circular duct) for strands Y1770 S7 with A_p = 140 mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])		
BBV L 3	3.50 (40)		
BBV L 4	4.20 (45)	4.10 (50)	3.90 (55)
BBV L 5	4.70 (50)	4.40 (55)	4.20 (60)
BBV L 7	4.80 (55)	4.50 (60)	4.40 (65)
BBV L 9	5.30 (65)	5.10 (70)	4.90 (75)
BBV L 12	6.10 (75)	5.90 (80)	5.50 (90)
BBV L 15	7.00 (80)	6.70 (85)	6.50 (90)
BBV L 19	7.90 (90)	7.60 (95)	
BBV L 22	8.60 (95)	8.20 (100)	7.80 (110)
BBV L 27	9.20 (110)	8.90 (115)	
BBV L 31	10.00 (115)	9.50 (125)	

Table B 7: Smallest radius of curvatur[3] (circular duct) for strands Y1770 S7 with A_p = 150 mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])		
BBV L 3	3.70 (40)		
BBV L 4	4.50 (45)	4.40 (50)	4.20 (55)
BBV L 5	4.90 (50)	4.60 (55)	4.40 (60)
BBV L 7	5.10 (55)	4.80 (60)	4.60 (65)
BBV L 9	5.60 (65)	5.30 (70)	5.20 (75)
BBV L 12	6.50 (75)	6.10 (80)	5.80 (90)
BBV L 15	7.40 (80)	7.10 (85)	6.80 (90)
BBV L 19	8.50 (90)	8.00 (95)	
BBV L 22	9.40 (95)	8.90 (100)	8.20 (110)
BBV L 27	9.90 (110)	9.40 (115)	
BBV L 31	10.80 (115)	10.00 (125)	

[3] The given smallest admissible radii of curvature refer on the maximum presstressing forces P_{max} according to Tables B 1 or B 3. If admissible in the place of use, and if strands with higher characteristic yield stressed will be used, the given radii of curvature shall be linearly increased by multiplying them with the factor ($f_{p0,1k}$ / 1520) or ($f_{p0,1k}$ / 1600) and rounded up in steps of 0.1 m. See also Annex B1, section 2.2.2 and footnote 1.

Table B 8: Smallest radius of curvatur[3] (circular duct) for strands Y1860 S7 with A_p = 140 mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])		
BBV L 3	3.70 (40)		
BBV L 4	4.40 (45)	4.30 (50)	4.10 (55)
BBV L 5	4.80 (50)	4.50 (55)	4.40 (60)
BBV L 7	5.00 (55)	4.70 (60)	4.50 (65)
BBV L 9	5.40 (65)	5.20 (70)	5.00 (75)
BBV L 12	6.30 (75)	6.00 (80)	5.70 (90)
BBV L 15	7.20 (80)	6.90 (85)	6.70 (90)
BBV L 19	8.20 (90)	7.80 (95)	
BBV L 22	9.00 (95)	8.60 (100)	8.00 (110)
BBV L 27	9.60 (110)	9.20 (115)	
BBV L 31	10.50 (115)	9.70 (125)	

Table B 9: Smallest radius of curvatur[3] (circular duct) for strands Y1860 S7 with A_p = 150 mm²

Tendon	Radius of curvature [m] (Inner diameter of the duct [mm])		
BBV L 3	4.00 (40)		
BBV L 4	4.70 (45)	4.60 (50)	4.40 (55)
BBV L 5	5.00 (50)	4.70 (55)	4.50 (60)
BBV L 7	5.50 (55)	5.00 (60)	4.70 (65)
BBV L 9	6.00 (65)	5.50 (70)	5.30 (75)
BBV L 12	6.90 (75)	6.50 (80)	5.90 (90)
BBV L 15	7.60 (80)	7.20 (85)	7.00 (90)
BBV L 19	9.10 (90)	8.60 (95)	
BBV L 22	9.90 (95)	9.40 (100)	8.60 (110)
BBV L 27	10.50 (110)	10,10 (115)	
BBV L 31	11.60 (115)	10.60 (125)	

According to ETAG 013 for tendons with at least five strands and circular ducts the following formula for calculation of the minimal radius of curvature can be used if admissible at the place of use:

$$R_{min} = \frac{2 \cdot P_{m0,max} \cdot d_{strand}}{p_{R,max} \cdot d_{duct}}$$

with

- R_{min} minimum admissible radius of curvature in [m]
- $P_{m0}(x)$ $P_{m0}(x) = 0.85\ A_p\ f_{p0,1k}$ according to Annex B 1, section 2.2 in [kN]
- d_{strand} diameter of the strands in [mm]
- $p_{R,max}$ maximum admissible pressure under a strand ($p_{R,max}$ = 130 to 150 kN/m)
- d_{duct} inner duct diameter in [mm]

R_{min} shall be given with an accuracy of 0.1m (shall be rounded up).

The smallest admissible radius of curvature of the tendons with oval duct depending on the bending axis is given in Table B 10. For oval ducts bending only is allowed around one axis (the stiff or the weak).

Table B 10: Smallest radius of curvatur[3] (oval duct)

Tendon	**Inner duct dimensions [mm x mm]**	**Radius of curvature [m]**	
		Bending axis	
		stiff	weak
BBV L 3	60 x 21	5.30	2.50
BBV L 4	80 x 21	7.20	2.50

5 Anchorages

The anchorage with anchor plate or cast-iron anchor body and anchor head is used as active anchor or accessible passive anchor. If the anchor head is tack welded to the anchor plate/anchor body and sealed, this type can also be used as an embedded anchorage. Within the anchorage zone the corrugated duct is replaced by a trumpet (PE or steel) with a larger diameter, in which the strands are deflected by a maximum of 2.6° or 2.1° respectively (see section 1.8 of European Technical Assessment). If using a steel trumpet, this one shall be equipped with a PE-inlet. Consecutive part is the anchor plate / cast-iron anchor body and anchor head with 3 to 31 conical borings – depending on the tendon size – in which the strands are anchored with round wedges, each consisting of three segments.

For anchorage of dia. 0.62” strands wedges with marking “0.62” on the front face shall be installed. The wedges of the embedded passive anchors have to be sealed and secured by a retainer plate.

The bursting forces caused by the load transfer to the concrete member shall be carried by a helix made of ribbed steel. Additional reinforcement such as straight bars or stirrups is required. At the fixed anchors without pre-wedging the slip is 4 mm.

At the stressing anchors the slip is 3 mm (see Annex B2, section 3.1.5).

6 Couplers

Tendons can be coupled with fixed or movable couplers. The coupler consists of a coupler disc in which the strands of the arriving tendon are anchored in the same way as in the active anchor. The strands of the departing tendon are held in a radial pattern of conical borings and anchored by three-segment wedges in the coupler. These wedges are retained by a spring and a lock washer in their seating. The coupler is pre-assembled and consists of a coupler plate, a lock washer and a cover cap for the conical holes which is removed prior to installation of the tendon. The cones are filled with corrosion protection mass.

The correct position of the strands within the coupler is checked by marks on the strands. During the stressing of the tendon a wedge slip of 4 mm occurs due to the seating of these wedges, if the arriving tendon is pre-wedged. Without pre-wedging the slip of a movable coupler is 8 mm (see Annex B2, section 3.1.5).

7 Stressing

A hydraulic pump unit and a special jack are used for the stressing of tendons. All strands of a tendon are stressed simultaneously. Stressing in load steps and resetting of the jacks is easily done. After stressing, the round wedges are power seated by means of a seating device within the jack. A wedge slip of approx. 3 mm remains after the wedge seating procedure.

Straight tendons strands can be stressed individually by mono jacks.

8 Grouting

For bond and corrosion protection of the strands, the ducts are grouted after stressing. The grout is injected into the grouting cap or through grout pipes. The ducts are vented at the ends of the tendons by means of venting pipes or grouting caps.

Intermediate venting points are necessary in case of long tendons. Couplers are always equipped with vents. Grouting shall be executed in accordance with national regulations and standards.

1 Performance of the Product

1.1 Losses due to friction and wobble effects

The losses due to friction may usually be determined in the calculation by using the friction coefficients µ and the unintentional angular displacement k (wobble coefficient) given in the Annex A2. The values µ and k depend on the given duct dimensions and distances between tendon supports.

The given values of k only apply if the strands are in the ducts at the time of concreting.

If the strands are arranged after concreting, the given values µ shall only be used in the calculation if the ducts are adequately stiffened during concreting, e.g. by means of PE and/or PVC pipes, or if reinforced ducts are used in connection with smaller distances between tendon supports.

For the determination of strains and forces of prestressing steel friction losses $\Delta P_{\mu S}$ in the stressing anchor zone and $\Delta P_{\mu ÜK}$ in the movable coupling zone (see Annex A2) shall be taken into account.

BBV-Internal Bonded Strand Post-tensioning System, type i	Annex C
Performance of the Product Prestressing losses due to Friction and Wobble Effects	

1 System of Verification and Assessment of Constrancy of Performance

The manufacturer shall draw up the declaration of performance and determine the product-type on the basis of the assessments and verifications of constancy of performance carried out under the following system

System 1+

(a) The manufacturer shall carry out:
- (1) Factory production control;
- (2) further testing of samples taken at the manufacturing plant by the manufacturer in accordance with a prescribed test plan.

(b) The notified product certification body shall decide on the issuing, restriction, suspension or withdrawal of the certificate of constancy of performance of the construction product on the basis of the outcome of the following assessments and verifications carried out by that body:
- (1) initial inspection of the manufacturing plant and of factory production control;
- (2) continuing surveillance, assessment and evaluation of factory production control;
- (3) audit-testing of samples taken by the notified product certification body at the manufacturing plant or at the manufacturer's storage facilities.

2 Responsibilities

2.1 Tasks of the manufacturer

2.1.1 Factory production control

The kit manufacturer shall keep available an updated list of all component manufacturers. The list is to be made available to the notified product certification body and to the Technical Assessment Body.

The kit manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the kit manufacturer shall be documented in a systematic manner in the form of written policies and procedures, including records of results performed. This production control system shall ensure that the product is in conformity with this European Technical Assessment.

The kit manufacturer may only use initial materials stated in the technical documentation of this European Technical Assessment.

The factory production control shall be in accordance with the Control Plan relating to the European Technical Assessment ETA-05/0202 (latest version) which is part of the technical documentation of this European Technical Assessment. The Control Plan is laid down in the context of the factory production control system operated by the manufacturer and deposited with Deutsches Institut für Bautechnik [4]

The basic elements of the Control Plan comply with ETAG 013, Annex E1.

[4] The Control Plan is a confidential part of the European Technical Assessment and only handed over to the notified product certification body involved in the system of assessment and verification of constancy of performance (see Annex D1, section 2.2).

The records shall contain at least the following information:

- Designation of the product or of the initial material and the components;
- Kind of control or testing;
- Date of manufacture and of testing of product or components and of basic material of components;
- Results of controls and tests and, where relevant, comparison with the requirements;
- Signature of person responsible for the factory production control.

The records shall be kept for at least ten years and on request they shall be presented to Deutsches Institut für Bautechnik.

If the test result is not satisfactory, the kit manufacturer shall take immediate measures to eliminate the deficiency. Construction products and components which do not comply with the requirements shall be handled in such way that they cannot be mistaken for products complying with the requirements. After elimination of the deficiency the relevant test shall be immediately repeated as far as is technically possible and necessary for verifying the deficiency elimination.

2.1.2 Declaration of performance and other tasks of manufacturer

The kit manufacturer shall, on the basis of a contract, involve a product certification body which is notified for the tasks referred to in Annex D1, section 1 in the field of Post-Tensioning Kits for prestressing of structures in order to undertake the actions laid down in Annex D1, section 2.2. For this purpose, the control plan referred to in Annex D1, sections 2.1.1 and 2.2 shall be handed over to the notified product certification body by the manufacturer.

For the product a declaration of performance shall be drawn up. The manufacturer can make a declaration of performance for the essential characteristics due to section 3 of specific part of this European Technical Assessment if the acceptance criteria due to ETAG 013 are fulfilled and the certificate of constancy of performance of a notified product certification body is available.

The control of the manufacturer of the components, the sampling and tests in the factory production control as well as a series of single tensile element tests shall be carried out in consideration of ETAG 013, section 8.2.1.1. The results of this test series must be given to the notified product certification body for information.

2.2 Tasks of the notified product certification body

2.2.1 General

The notified product certification body shall perform the measures according to Annex D1, sections 2.2.2 to 2.2.4 and in accordance with the provisions laid down in the Control Plan in the latest version.

The notified product certification body shall retain the essential points of its actions referred to above and state the results obtained and conclusions drawn in written reports.

The notified product certification body involved by the kit manufacturer shall issue a certificate of constancy of performance of the product stating that all provisions for the assessment and verification of constancy of performance and the performance named in the European Technical Assessment are applied due to System 1+ and stating compliance of the construction product with all applicable requirements.

In cases where the provisions of the European Technical Assessment and its "Control Plan" are no longer fulfilled the notified product certification body shall withdraw the declaration of conformity and inform Deutsches Institut für Bautechnik without delay.

2.2.2 Initial inspection of the manufacturing plant and of factory production control

The notified product certification body shall ascertain that, in accordance with the "Control Plan", the factory, in particular the staff and equipment, and the factory production control are suitable to ensure a continuous and orderly manufacturing of the Post-tensioning system with the specifications mentioned in section 1 of the Specific Part of the European Technical Assessment as well as in the Annexes to the European Technical Assessment.

2.2.3 Continuing surveillance, assessment and evaluation of factory production control

The notified product certification body shall inspect the manufacturing plant at least once a year. The production of components shall be included in the surveillance with consideration of ETAG 013, Section 8.2.2.4 (8). It has to be verified that the system of factory production control and the specified manufacturing process are carried out in accordance with the control plan's latest version.

Continuing surveillance, assessment and evaluation of factory production control have to be performed according to the latest version of the control plan.

The results of continuing surveillance, assessment and evaluation of factory production control shall be made available on demand by the notified product certification body to the Deutsches Institut für Bautechnik.

2.2.4 Audit-testing of samples

During surveillance inspections, the notified product certification body shall take samples of components of the Post-tensioning system for independent testing. For the most important components, Annex D3 contains the minimum procedures which have to be performed by the notified product certification body.

The basic elements of the Audit testing comply with ETAG 013, Annex E2 (see Annex D3).

3 CE marking

The CE marking shall be affixed on the delivery note. The letters "CE" shall be followed by the following additional information:

- the two last digits of the year in which it was first affixed;
- the name and the registered address of the manufacturer, or the identifying mark allowing identification of the name and address of the manufacturer easily and without any ambiguity;
- the unique identification code of the product-type;
- the reference number of the declaration of performance;
- the level or class of the performance declared;
- the reference to the harmonised technical specification applied;
- the identification number of the notified product certification body, if applicable;
- the intended use as laid down in the harmonised technical specification applied.

Criteria of the Control Plan

Component	Item	Test/ Check	Traceability [4]	Minimum frequency	Documen-tation
Bearing Plate for 3 to 9 strands	material	check	bulk	100 %	"2.2" [1]
	detailed dimensions[5]	test		3 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Cast-iron Anchor Body for 12 to 31 strands	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		5% ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Anchor Head	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Coupler	material	check	full	100 %	"3.1" [2]
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Wedge	material	check	full	100 %	"3.1" [2]
	treatment, hardness	test		0,5 % ≥ 2 specimen	yes
	detailed dimensions[5]	test		5 % ≥ 2 specimen	yes
	visual inspection[3]	check		100 %	no
Duct	material	check	full	100 %	"CE"
	visual inspection[3]	check		100 %	no

Continuation of Control Plan and footnotes see Annex D2 page 2/2

Criteria of the Control Plan - continued

Component	**Item**	**Test/ Check**	**Traceability** [4]	**Minimum frequency**	**Documen-tation**
Tensile element strand	material [6]	check	full	100 %	yes
	diameter	test		each coil/bundle	no
	visual inspection[3]	check		each coil/bundle	no
Constituents of filling Material as per EN 447	cement	check	full	100 %	yes
	admixtures, additions	check		100 %	yes
Helix	material	check	bulk	100 %	yes
	visual inspection[3]	check		100 %	no
Springs for Couplers	material	check	full	100 %	"2.2"[1]
	visual inspection[3]	check		100 %	no
Grease	material[7]	check	full	100 %	"CE"[9]
Wax	material[8]	check	full	100 %	"CE"[9]

1 "2.2" : Test report type "2.2" according to EN 10204
2 "3.1" : Inspection certificate type "3.1" according to EN 10204
3 Visual inspections means e.g.: Main dimensions, gauge testing, correct marking or labelling, appropriate performance, surface, fins, kinks, smoothness, corrosion, coating, etc., as given in the Control Plan
4 full : Full traceability of each component to its raw material.
bulk : Traceability of each delivery of components to a defined point.
5 Detailed dimensions mean measuring of all dimensions and angles according to the specification as given in the Control Plan
6 Characteristic material properties see Annex A7
7 Grease according to the composition deposited by the supplier at the Deutsches Institut für Bautechnik. Characteristic material properties shall comply with ETAG 013, Annex C4.1
8 Wax according to the composition deposited by the supplier at the Deutsches Institut für Bautechnik. Characteristic material properties shall comply with ETAG 013, Annex C4.2
9 If the basis of CE marking is not available, the prescribed control plan has to include appropriate measures. The certificate shall be based on specific testing on the fabrication lot from which the supply has been produced, to confirm specified properties, and shall be prepared by a department of the supplier which is independent of the production department.

All samples shall be randomly selected and clearly identified.

Criteria of Audit Testing

Component	Item	Test/ Check	Sampling Number of components per audit
Anchor Head	material according to specification	Check / test	1
	detailed dimensions	test	
	visual inspection [1]	check	
Cast-iron Anchor Body	material according to specification	Check / test	1
	detailed dimensions	test	
	visual inspection [1]	check	
Coupler	material according to specification	Check / test	1
	detailed dimensions	test	
	visual inspection [1]	check	
Wedge	material according to specification	Check / test	2
	treatment	test	2
	detailed dimensions	test	1
	main dimensions, surface hardness	test	5
	visual inspection [1]	check	5
Single tensile element test.	ETAG 013 Annex E.3	test	1 series

[1] Visual inspections means e.g.: Main dimensions, gauge testing, correct marking or labelling, appropriate performance, surface, fins, kinks, smoothness, corrosion, etc.

All samples shall be randomly selected and clearly identified.

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Material of Components

Designation	Material	Number	Standard
Bearing plates	S235JR	1.0038	EN 10025-2:2004
Cast-iron Anchor Body	deposited at Deutsches Institut für Bautechnik		
Wedges	deposited at Deutsches Institut für Bautechnik		
Anchor Heads	C45+N	1.0503	EN 10083-2:2006
Couplers	C45+N	1.0503	EN 10083-2:2006
Springs for Couplers	deposited at Deutsches Institut für Bautechnik		
Helixes for S, F, Fe, FÜK [1]	R_e = 500 MPa $f_{yk} \geq 500$ MPa, $\varepsilon_{uk} \geq 50$ ‰		valid provisions at the place of use
Additional Reinforcement for S, F, Fe, FÜK (stirrups) [1]	R_e = 500 MPa		EN 10080:2005-08
Securing plates for Wedges	S235JR	1.0038	EN 10025-2:2004
Trumpets	steel or PE deposited at Deutsches Institut für Bautechnik		
PE Pipes and Caps	PE deposited at Deutsches Institut für Bautechnik		
Corrosion Protection Mass Nontribus MP-2 [2] (grease)	deposited at Deutsches Institut für Bautechnik		
Corrosion Protection Mass Vaseline FC 284 [2] (wax)	deposited at Deutsches Institut für Bautechnik		
Corrosion Protection Mass Denso - Jet [2] (wax)	deposited at Deutsches Institut für Bautechnik		

The technical documentation of the components of this European Technical Approval is deposited at the Deutsches Institut für Bautechnik

[1] deposited at Deutsches Institut für Bautechnik

[2] corrosion protection mass (wax or grease) according to the composition deposited by the supplier at the Deutsches Institut für Bautechnik. Characteristic material properties shall comply with ETAG 013, Annex C4.1 or C4.2.

BBV-Internal Bonded Strand Post-tensioning System, type i	Annex E1
Materials and References Material of Components	

Codes and References

–	prEN 10138-3:2009	Prestressing Steels - Part 3: Strand
–	EN 523:2003-11	Steel Strip Sheaths for Prestressing tendons
–	EN 447:2007	Grout for Prestressing Tendons – Basic Requirements
–	ETAG 013:2002-06	Guideline for European Technical Approval of post-tensioning kits for prestesssing of structures
–	EN 206-1:2001-07	Concrete – Part 1: Specification, Performance, Production an Conformity
–	EN 206-1/A1:2004-10	Concrete – Part 1: Specification, Performance, Production an Conformity; German Version EN 206-1:200/A1:2004
–	EN 206-1/A2:2005-09	Concrete – Part 1: Specification, Performance, Production an Conformity; German Version EN 206-1:200/A2:2005
–	EN 446:2007	Grout for Prestressing Tendons – Grouting procedures
–	EN 10204:2005-01	Metallic Products – Types of Inspection Documents
–	EN 10025-2:2005-04	Holt Rolled Products of Structural Steels – Part 2: Technical Delivery Conditions for Non-Alloy Structural Steels
–	EN 10083-2:2006-10	Quenched and Tempered Steels – Part 2: Technical Delivery Conditions for Unalloyed

BBV-Internal Bonded Strand Post-tensioning System, type i	Annex E2
Materials and References Codes and References	