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Authorised and notified according to Article 10 of the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products (89/106/EEC)

Deutsches Institut für Bautechnik

DIBt

Mitglied der EOTA
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European Technical Approval ETA-11/0123

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Handelsbezeichnung *Trade name*	BBV Externes Spannverfahren Typ E *BBV External Post-tension System Type E*
Zulassungsinhaber *Holder of approval*	BBV Systems GmbH Industriestraße 98 67240 Bobenheim-Roxheim DEUTSCHLAND
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	BBV Spannverfahren mit 3 bis 31 Litzen (140 und 150 mm²) zur externen Vorspannung *BBV Post-tensioning System for 3 to 31 strands (140 and 150 mm²) for external prestressing*
Geltungsdauer: / *Validity:* vom / *from*	21 April 2011
bis / *to*	21 April 2016
Herstellwerk *Manufacturing plant*	BBV Systems GmbH Industriestraße 98 67240 Bobenheim-Roxheim DEUTSCHLAND

Diese Zulassung umfasst *This Approval contains*	46 Seiten einschließlich 30 Anhänge *46 pages including 30 annexes*

EOTA

Europäische Organisation für Technische Zulassungen
European Organisation for Technical Approvals

I LEGAL BASES AND GENERAL CONDITIONS

1 This European technical approval is issued by Deutsches Institut für Bautechnik in accordance with:

- Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products[1], modified by Council Directive 93/68/EEC[2] and Regulation (EC) N° 1882/2003 of the European Parliament and of the Council[3];
- Gesetz über das In-Verkehr-Bringen von und den freien Warenverkehr mit Bauprodukten zur Umsetzung der Richtlinie 89/106/EWG des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedstaaten über Bauprodukte und anderer Rechtsakte der Europäischen Gemeinschaften (Bauproduktengesetz - BauPG) vom 28. April 1998[4], as amended by law of 31 October 2006[5];
- Common Procedural Rules for Requesting, Preparing and the Granting of European technical approvals set out in the Annex to Commission Decision 94/23/EC[6];
- Guideline for European technical approval of "Post-tensioning kits for prestressing of structures", ETAG 013.

2 Deutsches Institut für Bautechnik is authorized to check whether the provisions of this European technical approval are met. Checking may take place in the manufacturing plant. Nevertheless, the responsibility for the conformity of the products to the European technical approval and for their fitness for the intended use remains with the holder of the European technical approval.

3 This European technical approval is not to be transferred to manufacturers or agents of manufacturers other than those indicated on page 1, or manufacturing plants other than those indicated on page 1 of this European technical approval.

4 This European technical approval may be withdrawn by Deutsches Institut für Bautechnik, in particular pursuant to information by the Commission according to Article 5(1) of Council Directive 89/106/EEC.

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6 The European technical approval is issued by the approval body in its official language. This version corresponds fully to the version circulated within EOTA. Translations into other languages have to be designated as such.

[1] Official Journal of the European Communities L 40, 11 February 1989, p. 12
[2] Official Journal of the European Communities L 220, 30 August 1993, p. 1
[3] Official Journal of the European Union L 284, 31 October 2003, p. 25
[4] *Bundesgesetzblatt Teil I 1998*, p. 812
[5] *Bundesgesetzblatt Teil I 2006*, p. 2407, 2416
[6] Official Journal of the European Communities L 17, 20 January 1994, p. 34

II SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of product and intended use

1.1 Definition of the construction product

The present European Technical Approval applies to a kit:

BBV External Post-Tensioning System Type E

consisting of 3 to 31 strands with a nominal tensile strength 1770 N/mm² or 1860 N/mm² (Y1770 S7 or Y1860 S7), 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; see Annex 1):

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 and 31 strands,

3 Bursting reinforcement (helixes and stirrups)

4 Sheathing (ducts)

5 Corrosion protection

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

1.2 Intended use

The Post-Tensioning System is assumed to be used for external prestressing of normal-weight concrete structures or elements. The tendon path shall be placed outside of the cross section of the concrete element but inside its envelope. The structural members are to be designed in accordance with national regulations.

Optional use categories:

- Resstressable tendon
- Exchangeable tendon
- Tendon for use in composite structures

Working life:

The provisions made in this European Technical Approval are based on an assumed working life of the PT-System of 100 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer (or the Approval Body), 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.

2 Characteristics of product and methods of verification

2.1 Characteristics of product

2.1.1 General

The components comply with the drawings and provisions given in this European Technical Approval including the Annexes. The characteristic material values, dimensions and tolerances of the components not indicated in the Annexes shall correspond to the respective values laid down in the technical documentation[7] of this European Technical Approval. The arrangement of the tendons, the design of the anchorage zones, the anchorage components and the ducts shall correspond to the attached descriptions and drawings; the dimensions and materials shall comply with the values given therein.

2.1.2 Strands

Only 7-wire strands shall be used in accordance with national provisions 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 confusion only strands with one nominal diameter shall be used on one site. If the use of strands with R_m=1860 N/mm² is intended on site, these shall solely be used there.

Only strands stranded in the same direction shall be used in a tendon. For further characteristic values of the strands see Annex 21.

2.1.3 Wedges

Wedges type 30, smooth or knurled, (see Annex 6) are approved. The knurled wedges shall only be used for pre-wedged (pre-locked) fixed anchors. The segments of the wedges for strands Ø 15.7 mm shall be marked with "0.62".

2.1.4 Anchor heads

The conical boreholes of the anchor heads shall be clean and stainless and provided with corrosion protection mass.

2.1.5 Bearing plates

For 3 to 9 strands, rectangular bearing plates shall be used. The long side of the bearing plates shall be installed parallel to the largest centre or edge distance (see Annexes 2, 4 and 6).

2.1.6 Cast-iron anchor bodies

For 12 to 31 strands multi-surfaced cast-iron anchor bodies shall be used (see Annex 6).

[7] The technical documentation of this European Technical Approval is deposited with the Deutsches Institut für Bautechnik and, as far as relevant for the tasks of the approved bodies involved in the attestation of conformity procedure, is handed over to the approved bodies.

2.1.7 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 section 4.2.3.

2.1.8 Corrosion protection of the anchorage zone and of the free tendon length

Each tendon is fully encapsulated in a duct over its whole length.

After tightening, but before stressing of the tendon, the duct will be filled completely on site with hot corrosion protection mass. The corrosion protection mass shall comply with ETAG 013, Annex C4.1 or C4.2, respectively, and with national provisions.

The connection duct provides the transition from the PE-duct to the free length of the tendon to the anchorage (see Annexes 10 to 12).

The connection duct overlaps with the trumpet and is swathed with PE-tape for leak tightness.

After the wax has cooled down and before the stressing of the tendon, every high point is re-injected with "cold" corrosion protection mass (see Annexes 16 to 18 and 25 to 30).

After stressing, the protection measures for the anchorages shall be carried out according to the description in Annexes 25 to 30 and as specified in the Annexes 8 and 9.

2.1.9 Corrosion protection of exposed steel components

Exposed steel components which are not covered sufficiently by concrete (at least 5 cm) or which are not protected by corrosion protection material (e.g. wax) shall be protected against corrosion by one of the following protective paint systems according to EN ISO 12944-5:2007:

a) without metallic coating: A5M.02, A5M.04, A5M.06, A5M.07

b) with zinc coating (galvanized): A7.10, A7.11, A7.12, A7.13

The surface preparation of the steel components shall be carried out according to EN ISO 12944-4:1998. For execution of the paint work EN ISO 12944-7:1998 shall be observed. Local approved and recognised corrosion protection principles can be used instead, if admissible at the place of use.

2.1.10 Clearances at anchorages, minimum width of crossbeams

The anchorages are schematically shown in Annexes 8 to 12.

At the entrances of the crossbeams, trumpet-like widenings shall be provided, with a minimum of $\Delta\alpha = 3°$. The widenings shall allow for unscheduled deviations from the planned position of the tendon axis (tendon path) without kink up to the angle $\Delta\alpha$.

In the case of fixed anchors at the entrance of the structure/crossbeam, the maximum admissible strand displacement due to stressing shall not exceed 10 cm (see Sections 4.2.9 and 4.2.11). The minimum width of the crossbeam at both the stressing and the fixed anchors is given in Annexes 10 and 11, in the case of deviations behind the anchorage area in Annex 12. Over the length min. L1 the tendon path must be straight.

2.1.11 Ducts

Along their free length, the tendons shall be ensheathed with PE-ducts according to Annexes 2 to 5. The scheme of the duct installation and the duct connectors are shown in Annex 16.

PE-ducts or PE-reducing sockets will be assembled by means of heated tool butt-welding or helical heating element welding. For welding of PE-ducts the guideline DVS 2207-1:2005-09 or equivalent regulations at the place of use shall be observed.

The welding shall be carried out by professional plastic welders with a valid welder's approval according to Test Category I of the guideline DVS 2212-1:2006-05 or comparable Certification valid at the place of use.

The trumpets at the active and passive anchors are manufactured from PE-material of at least 3.5 mm thickness. At their ends the trumpets overlap with the connection ducts.

The maximum admissible deviation angle of the strands inside the anchors (at the end of the wedges and in the transition area between trumpet and connection duct) is 2.2°. The connection duct is attached to the trumpet by adhesive tape winding.

At the fixed anchor, the duct is positioned inside the connection duct till approximately 5 cm before the trumpet, and behind (outside) the crossbeam the duct is attached to the connection duct with a tensile-proof connection.

At the stressing anchor, before tightening the tendon, the duct shall extend at least 10 cm the deviated area of the crossbeam. The duct in the free tendon length at the stressing anchor glides into the connection duct during the stressing process.

At the stressing anchor, the tensile-proof connection between connection duct and duct is assembled after the prestressing has been completed.

2.1.12 Deviators

In the area of deviation, the minimum radius of curvature shall always be above the values given in Annexes 2 to 5, depending on the grade of the prestressing steel, the tendon size and the diameter of the duct.

The minimum radius of curvature shall also be complied with in the area of the provided trumpet-shaped widenings.

The formation of the area of deviation is shown in the Annexes 13 to 15. At the ends of the areas of deviation (entrance of the crossbeam), there are trumpet-like widenings with at least $\Delta\alpha = 3°$, which permit tolerances from the planned position of the tendon axis (tendon path) without kink up to the angle $\Delta\alpha$.

In the area of deviation the duct lies inside a deviation duct which on the inside is coated with grease and protrudes about 10 cm out of the area of deviation. In the case of the deviation type S, the maximum admissible deviation length max L_{zul} shall be observed (see Annex 14).

At the stressing and the fixed anchors in the distance min L1 from the anchor heads deviations may be planned (see Annex 12). At the stressing anchor, before the tightening of the tendon, the duct shall protrude from the curved (deviation) zone inside the crossbeam by at least 10 cm.

2.2 Methods of verification

2.2.1 General

The assessment of the fitness of the BBV-External Post-Tensioning System Type E for the intended use in relation to the requirements for mechanical resistance and stability in the sense of Essential Requirement 1 has been made in accordance with the "Guideline for European Technical Approval of Post-tensioning kits for Prestressing of structures, ETAG 013".

The release of dangerous substances (Essential Requirement 3) is determined according to ETAG 013, clause 5.3.1. A declaration was made by the manufacturer, that the product does not contain any dangerous substances.

In addition to the specific clauses relating to dangerous substances contained in this European Technical Approval, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the Construction Products Directive, these requirements need also to be complied with, when and where they apply.

The structural members (normal-weight concrete or composite) prestressed by means of the BBV-External Post-Tensioning System Type E used to be designed in accordance with national regulations.

2.2.2 Tendons

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

The maximum force P_0 applied to a tendon shall not exceed the force $P_{0.max} = 0.9\ A_p\ f_{p0,1k}$ laid down in Table 2 (140 mm²) or in Table 3 (150 mm²). The value of the prestressing initial prestress force P_{m0} applied to the concrete after tensioning and anchoring shall not exceed the force $P_{m0,max} = 0.85\ A_p\ f_{p0,1k}$ laid down in Table 2 (140 mm²) or in Table 3 (150 mm²).

Table 2: Maximal prestressing forces[8] 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	
			$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]
BBV L3 E	3	420	543	575	571	605
BBV L4 E	4	560	724	766	762	806
BBV L5 E	5	700	904	958	952	1008
BBV L7 E	7	980	1266	1341	1333	1411
BBV L9 E	9	1260	1628	1724	1714	1814
BBV L12 E	12	1680	2171	2298	2285	2419
BBV L15 E	15	2100	2713	2873	2856	3024
BBV L19 E	19	2660	3437	3639	3618	3830
BBV L22 E	22	3080	3979	4213	4189	4435
BBV L27 E	27	3780	4884	5171	5141	5443
BBV L31 E	31	4340	5607	5937	5902	6250

Table 3: Maximal prestressing forces[8] 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	
			$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]	$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]
BBV L3 E	3	450	581	616	612	648
BBV L4 E	4	600	775	821	816	864
BBV L5 E	5	750	969	1026	1020	1080
BBV L7 E	7	1050	1357	1436	1428	1512
BBV L9 E	9	1350	1744	1847	1836	1944
BBV L12 E	12	1800	2326	2462	2448	2592
BBV L15 E	15	2250	2907	3078	3060	3240
BBV L19 E	19	2850	3682	3899	3876	4104
BBV L22 E	22	3300	4264	4514	4488	4752
BBV L27 E	27	4050	5233	5540	5508	5832
BBV L31 E	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 completely filled anchors (basic types) also apply to tendons with only partly filled anchor heads. Into the free boreholes in the anchor head the short pieces of strands with wedges have to be pressed in to prevent slipping out. The admissible prestressing force is reduced per left out strand as shown in Table 4.

8 The forces stated in Tables 2 to 4 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 (Y1770 S7) or 1640 N/mm² (Y1860 S7). In this case the prestressing forces of Tables 2 to 4 can be 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 4: Reduction of the prestressing forces[8] when leaving out a strand

A_p	Y1770 S7		Y1860 S7	
	ΔP_{m0} [kN]	ΔP_0 [kN]	ΔP_{m0} [kN]	ΔP_0 [kN]
140 mm²	181	192	190	201
150 mm²	194	205	204	216

For further characteristic values of the tendons (mass per meter, ultimate stressing force F_{pk}) see Annexes 2 to 5.

2.2.3 Losses due to friction and wobble effects

The losses due to friction may normally be determined in the calculation by using the friction coefficients μ = 0,08 given in the Annexes 2 to 5 and the unintentional angular displacement k = 0 (wobble coefficient).

For the determination of strains and forces of prestressing steel friction losses $\Delta P_{\mu S}$ in the stressing anchor zone (see Annexes 2 to 5) shall be taken into account.

2.2.4 Radius of curvature of the tendons in the structure

The smallest admissible radii of curvature (min bending radii) are given in Annexes 2 to 5. An analysis of the edge stresses in the strands can be omitted while following these radii of curvature. The acceptance of the forces due to the deviation of the tendon in the structure shall be verified.
The given smallest admissible radii of curvature are based on the maximum presstressing forces $P_{m0,max}$ according to Tables 2 or 3. If admissible in the place of use, and if strands with higher characteristic yield stressed are 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 0.1m. See also section 2.2.2 and footnote 8.

2.2.5 Concrete strength

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 5 and the Annexes. 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 differing more than 5 %.

Table 5: 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 force, the minimum value of the concrete strength to be proved is 0.5 $f_{cmj,cube}$ or 0.5 $f_{cmj,cyl}$; intermediate values can be interpolated lineally.

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

The centre and edge distances of the tendon anchorages shall not be smaller than the values given in the Annexes depending on the minimum concrete strength. In case of anchorages BBV L3 E to BBV L9 E the large side of the rectangular bearing plate (side length a according to Annex 6) shall be installed parallel to the longer concrete side (maximum value of minimum centre distance).

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 stirrup reinforcement or the outer diameter of the helix. 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.

2.2.7 Reinforcement in the anchorage zone

The anchorages (including reinforcement) are verified by means of tests for the transfer of the prestressing forces to the structural concrete.

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 exceeding the given 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 mutually offset.

In the anchorage zone vertically led gaps for concreting shall be provided for concreting properly.

If in exceptional case[9] – due to an increased amount of reinforcement – the helix or the concrete cannot be properly placed, the helix can be replaced by other equivalent reinforcement.

2.2.8 Slip at the anchorages

The slip at the anchorages (see section 4.2.7) shall be taken into account in the static calculation and the determination of the tendon elongation.

2.2.9 Resistance to fatigue of the anchorages and in the areas of deviation of the tendons

With the fatigue tests for the anchors 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 verified.

In the areas of deviation of tendons a stress range of 35 N/mm² at $2x10^6$ load cycles can be assumed as verified. Due to national provisions at the place of use, higher stress ranges up to 80 N/mm² might be assumed as verified in the areas of deviation.

2.2.10 Guidance of Tendons through Construction Members

Where tendons are guided through a straight penetration of a construction member, an appropriate size of the opening in the construction member, taking into account the construction tolerances, shall be provided to ensure that the tendons have no contact with the construction member.

2.2.11 Protection of the Tendons

The tendons shall be protected against failure resulting from extraneous cause (e.g. vehicle impact, elevated temperatures in case of fire, vandalism). The requirements shall be investigated on a case by case basis and rated according to the specific project conditions. Tendons enclosed by a box girder are classified as sufficiently protected.

Tendons enclosed by a box girder are supposed to be sufficiently protected against corrosion. For tendons placed outside a box girder, especially in corrosion enhancing, conditions, the applicability of the tendons shall be verified.

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

3 Evaluation and attestation of conformity and CE marking

3.1 System of attestation of conformity

According to the decision 98/456/EC of the European Commission[10] the system 1+ of attestation of conformity applies.

This system of attestation of conformity is defined as follows:

System 1+: Certification of the conformity of the product by a approved certification body on the basis of:

(a) Tasks for the manufacturer:

(1) factory production control;

(2) further testing of samples taken at the factory by the manufacturer in accordance with a prescribed test plan;

(b) Tasks for the approved body:

(3) initial type–testing of the product;

(4) initial inspection of factory and of factory production control;

(5) continuous surveillance, assessment and approval of factory production control;

(6) audit–testing of samples taken at the factory.

3.2 Responsibilities

3.2.1 Tasks of the manufacturer

3.2.1.1 Factory production control

The manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the 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 insure that the product is in conformity with this European Technical Approval.

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

The factory production control shall be in accordance with the "Control Plan of 10 January 2011" relating to the European Technical Approval ETA-11/0123 issued on 21 April 2011 which is part of the technical documentation of this European Technical Approval. The "Control Plan" is laid down in the context of the factory production control system operated by the manufacturer and deposited at the Deutsches Institut für Bautechnik.[11]

The basic elements of the Control Plan comply with ETAG 013, Annex E1 (see Annexes 22 and 23).

The results of factory production control shall be recorded and evaluated in accordance with the provisions of the "Control Plan".

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 initial material or of the components

[10] Official Journal of the European Communities L 201/112 of 3 July 1998

[11] The "control plan" is a confidential part of the European technical approval and only handed over to the approved body involved in the procedure of attestation of conformity. See section 3.2.2.

- 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 submitted to the approved body. On request they shall be presented to Deutsches Institut für Bautechnik.

If the test result is not satisfactory, the manufacturer shall take immediate measures to eliminate the deficiency. Construction products and components which do not comply with the requirements shall be handled such 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.

3.2.1.2 Other tasks of manufacturer

The manufacturer shall, on the basis of a contract, involve a body which is approved for the tasks referred to in section 3.1 in the field of Post-Tensioning Kits for Prestressing of Structures in order to undertake the actions laid down in section 3.2.2. For this purpose, the "Control Plan" referred to in sections 3.2.1.1 and 3.2.2 shall be handed over by the manufacturer to the approved body involved.

The manufacturer shall make a declaration of conformity, stating that the construction product is in conformity with the provisions of the European Technical Approval ETA-11/0123 issued on 21 April 2011.

At least once a year, each components manufacturer shall be audited by the kit manufacturer.

At least once a year specimens shall be taken from one job site and one series of single tensile element test shall be performed according ETAG 013, Annex E3 (see Annex 24). The results of these test series shall be made available to the approved body.

3.2.2 Tasks of approved body

3.2.2.1 General

The approved body shall perform the measures according to sections 3.2.2.2 to 3.2.2.5 and in accordance with the provisions laid down in the "Control Plan of 10 January 2011 relating to the European Technical Approval ETA-11/0123 issued on 21 April 2011".

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

The approved certification body involved by the kit manufacturer (BBV Systems GmbH) shall issue an EC certificate of conformity of the product stating the conformity with the provisions of this European Technical Approval.

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

3.2.2.2 Initial type-testing of the product

For initial type-testing the results of the tests performed as part of the assessment for the European Technical Approval may by used unless there are changes in the production line or plant. In such cases the necessary initial type-testing has to be agreed between the Deutsches Institut für Bautechnik and the approved body involved.

3.2.2.3 Initial inspection of factory and of factory production control

The approved 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 2.1 as well as in the Annexes to the European Technical Approval.

3.2.2.4 Continuous surveillance, assessment and approval of factory production control

The approved body shall visit the factory at least once a year. It has to be verified that the system of factory production control and the specified manufacturing process are maintained taking account of the "Control Plan".

Continuous surveillance and assessment of factory production control have to be performed according to the "Control Plan".

The results of product certification and continuous surveillance shall be made available on demand by the approved body to the Deutsches Institut für Bautechnik.

3.2.2.5 Audit-testing of samples taken at the factory

During surveillance inspections the approved body shall take samples of components of the Post-tensioning system for independent testing. For the most important components Annex 24 contains the minimum procedures which have to be performed by the approved body.

The basic elements of the Audit testing comply with ETAG 013, Annex E2 (see Annex 24)

3.3 CE marking

The CE marking shall be affixed on the delivery note. The letters "CE" shall be followed by the identification number of the approved certification body, where relevant, and be accompanied by the following additional information:

- the name and address of the producer (legal entity responsible for the manufacture),
- the last two digits of the year in which the CE marking was affixed,
- the number of the EC certificate of conformity for the product,
- the number of the European Technical Approval,
- the number of the guideline for European Technical Approval
- the identification of the product (trade name)
- nominal cross section and tensile strength of the strands

4 Assumptions under which the fitness of the product for the intended use was favourably assessed

4.1 Manufacturing

The European Technical Approval is issued for the product on the basis of agreed data/information, deposited with the Deutsches Institut für Bautechnik, which identifies the product that has been assessed and judged. Changes to the product or production process, which could result in this deposited data/information being incorrect, should be notified to the Deutsches Institut für Bautechnik before the changes are introduced. The Deutsches Institut für Bautechnik will decide whether or not such changes affect the ETA and consequently the validity of the CE marking on the basis of the ETA and if so whether further assessment or alterations to the ETA shall be necessary.

The tendons are assembled on site.

4.2 Installation

4.2.1 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 the BBV-External Post-tensioning System Type E. The company's site manager shall have a certificate of the ETA holder certifying that he is instructed by the ETA holder and has the required knowledge and experience with this post-tensioning system. Standards and regulations valid on side shall be considered.

The ETA holder is responsible to inform anyone concerned about the use of the BBV-External Post-tensioning System Type E. 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.

4.2.2 Welding

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

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

b) For ensuring the central positioning, the helix may be attached to the bearing plate or anchor body by tack-welding.

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

4.2.3 Installation of the anchorages, the helixes and the additional reinforcement

The conical boreholes of the anchor heads shall be clean and stainless and coated with corrosion protection mass. The central position of the helix and the stirrups shall be ensured by tack-welding to the bearing plate or the cast-iron anchor body or by means of mounting brackets. The bearing plate or cast-iron anchor body and the anchor head shall be positioned vertically to the axis of the tendon.

The tendon shall be placed straight over the length min. L1 behind the anchor head (see Annexes 10 to 12). Distinction shall be drawn between anchorages where the tendon is placed straightforward and anchorages where the tendon is deviated in proximity to the anchorage.

The joint between trumpet and connection duct shall be sealed carefully with PE-tape, first to avoid the penetration of concrete and later to avoid leakage of corrosion protection material.

The minimum width of the crossbeam at both the active and passiv anchorages is shown in Annexes 10 to 12.

4.2.4 Installation of the strands and the ducts

All recess ducts (in the area of anchorages and deviations) shall be fastened in such a way that they cannot be moved during concreting.

At all locations where the tendons exit from the construction member trumpet-like extensions $\Delta\alpha$ shall be provided, which allow for unscheduled deviation from the planned position of the tendon axis without kink up to a minimum of 3°. The installation of the ducts and the strands shall be carried out according to the description in Annexes 25 to 30. The duct scheme with connections and joints is shown in Annex 16.

At both the stressing and fixed anchors, connection ducts are installed (see Annexes 10 to 12). At the fixed anchors, the duct ends about 5 cm in front of the trumpet and is permanently connected with the duct of the free tendon length. At stressing anchors the duct is shifted into the crossbeam until it reaches beyond the deviation zone by at least 10 cm.

The required insertion length of the duct at stressing and fixed anchors shall be measured in advance and marked. Before tightening the right position of the tendon at the stressing anchor shall be checked once more and it shall be recorded in writing how far the tendon reaches inside the crossbeam.

Recess clearances, deviation form parts and deviation ducts at the deviation points shall be clean and smooth. Before pulling in the ducts, the deviation ducts shall be greased inside.

4.2.5 Prohibition of transversal oscillation of tendons

Critical transversal oscillations of the tendons caused by traffic, wind or other excitations shall be avoided by constructive measures.

If at the place of the use no other regulation is valid for bridges of box girders a fixing distance for the tendons of about 35 m is recommended. Transversal oscillations which occur nevertheless usually do not have any harmful effects.

Outside of box girders smaller fixing distances are required.

The fixings shall be performed in such a way that the duct will not be damaged and the movement in longitudinal direction of the tendon is not obstructed.

4.2.6 Unscheduled contact of the tendon and free lift-off at entrances of the building/crossbeams

Unscheduled contact of the tendon with the building structure is inadmissible.

At entrances of anchorages or deviation points the tendon shall lift-off freely (the tendon shall have no unscheduled contact (no kink), see section 4.2.9). After the tightening of the tendon and before filling in hot corrosion protection mass the free lift-off should be checked at all entrances.

4.2.7 Wedging force, slip, wedge securing and corrosion protection mass in the wedge-seating area

The wedges of fixed anchors shall be pre-wedged with 1.1 $P_{m0,max}$ (see section 2.2.2), if knurled wedges type 30 are used.

Without pre-wedging the slip to be taken into account for the determination of the elongations/ movements of the strands is 4 mm at fixed anchorages. In the case of hydraulic pre-wedging with 1.1 $P_{m0,max}$ no slip shall be taken into account for the determination of the elongations/ movements of the strands.

The wedges of stressing anchors shall be pre-wedged after tensioning with the minimum force of 0.1 $P_{m0,max}$. In this case the slip is 3 mm.

The wedges shall be secured by securing caps.

4.2.8 Tightening and filling with corrosion protection mass

At the stressing anchorage, the way of the duct shall already be documented during the tightening (see also section 4.2.4).

Before the stressing and the filling with hot corrosion protection mass the duct shall be tightened with a minimum of 5 % and a maximum of 10 % $F_{pK.}$

After the temporary sealing of the duct at the stressing anchor, the duct shall be injected from one anchor with hot corrosion protection mass with a maximum temperature of 100 C (usually from one point close to an anchor and in proximity to the next low point).

Without further inlets a length of not more than 100 m is allowed to be injected. In a distance of not more than 100 m inlets and containers with hot corrosion protection mass or their supply pipes, respectively, shall be provided.

Once corrosion protection mass emerges from an inlet, further injection shall be carried out from this inlet. In the case of short tendons (tendon length < 50 m) injection of hot corrosion material shall be carried out until hot liquid corrosion protection mass emerges from the venting.

Before further work is carried out, the corrosion protection material shall have cooled down to ambient air temperature (about 30 °C). To this end, usually one day is sufficient.

After cooling down of the corrosion protection mass, all high points shall be post-injected with cold corrosion protection mass (see Annexex 15 to 17 and 25 to 30). After the drilling of the necessary inlets, the temperature of the corrosion protection mass in the duct shall be measured, in order to check whether it has cooled down sufficiently.

All voids shall be filled completely with corrosion protection material. Complete filling with corrosion protection material shall be checked by tapping along the tendon over its full length.

Possible defects shall be post-injected. When setting the inlets and ventings care must be taken to ensure that their distance to the deviation zone is sufficient so that they will not been pulled inside the deviation zone during stressing or re-stressing.

4.2.9 Prestressing and admissible elongation way/prestressing path

All strands of a tendon shall be stressed simultaneously.

In the case of straight tendons it is permitted to stress strand by strand. The order of the strands to be stressed shall be determined in such a way that the anchor carries only the eccentricity of the prestressing force of one stand at a time, in order to keep the eccentric load of the anchor head at a minimum.

At the fixed anchor the elongation/ movement of the strands resulting from stressing and re-stressing at the entrance from the structure/crossbeam shall not t exceed 10 cm.

At every deviation point and at the stressing anchor, during stressing the amount of inner gliding (difference of the movement of the strand and the movement of the duct at the marking) and outer gliding (movement of the duct) shall be documented by the company carrying out the work.

At the stressing anchor, the movement of the duct shall already be documented during the tightening. At the stressing anchor, during stressing or re-stressing the duct in the free length glides into the connection duct.

For determination of the way/ movement with inner gliding the measured values between 10 % F_{pk} and 100 % of the prestressing force (target load) shall be taken into account. The movement of the strands shall be recorded in the stressing manual for each deviation point and for the stressing anchor.

After the tightening and the cooling of the corrosion protection mass at the stressing anchorage and at all deviators the duct shall be provided with markings and the initial positions of the markings shall be measured (see Annex 18).

At the stressing anchor the temporary sealing of the telescoping joint shall be opened again and a clamp for fastening of a chain hoist at the duct shall be installed.

If necessary, for achieving outer gliding of the duct at the stressing anchor as well, simultaneous pulling of the chain hoist and the duct together with the movement (stressing) of the strands is possible. In the case of tendons deviated in proximity behind the stressing anchor (see annex 12) pulling of the duct usually is not necessary.

The movements of the ducts shall be measured and compared with the calculated elongations/ movements of the strands (each deviation point and stressing anchor).

The amount of inner gliding (difference of the movement of the strands and the movement of the duct at the marking) during stressing (after tightening) must not exceed 10 % of the total elongation or 10 cm (the lower of the two values is decisive).

The amount of outer gliding of the duct (movement of the duct) shall be at least 90 % of the total elongation. When fulfilling this requirement no limitation of the prestressing way (elongation) is necessary. This requirement is not relevant for straight tendons without scheduled or unscheduled deviations.

At the stressing anchor the duct shall not be compressed. To verify that in the final state the position of the duct according to Annexes 10 or 12, respectively, Drawing C, is available, additionally the initial position and the full movement of the duct shall be measured and documented.

It is admissible to re-stress the tendons by releasing and re-using the wedges. After re-stressing and setting of the wedges, wedge marks on the strands resulting from first stressing shall be moved to the outside by at least 15 mm. Re-stressing paths < 15 mm are not admissible.

Not later than after the stressing to the full target load at the entrances of anchors and deviators it shall be checked whether the tendons lift-off freely. In cases where the tendon does not lift-off freely, the tendon shall be dismantled and the corresponding place in the concrete member shall be repaired. Whether the same tendon may be re-installed, shall be decided after consultation with the client.

4.2.10 Corrosion protection measures after prestressing

Anchors shall be protected against corrosion with retainer caps and protective caps, which shall be filled with corrosion protection mass (see Annexes 8 and 9). Before setting the retainer caps the whole surface of the anchor heads shall be rubbed with cold corrosion protection mass.

At the stressing anchor, the joint between the connection duct and the duct shall be closed permanently with a transition electro welding sleeve.

Voids shall be filled completely with corrosion protection mass. Complete filling shall be checked by tapping at the protective caps.

4.2.11 Re-stressing

Re-stressing of the tendons by releasing and re-using of the wedges is admissible.

Preparatory works are: removing the protective and the retainer caps and the joint between the connection duct and the duct at the stressing anchorage. In the same way as for prestressing, the duct shall be provided with markings whose initial positions shall be measured.

The movements of the duct shall be measured and compared with the calculated elongations/ movement of the strands (each deviation point and stressing anchorage). The amount of inner gliding (difference of the movements of the strands and the movement of the duct at the marking) during stressing shall not exceed 10 % of the total elongation or 10 cm (the lower of the two values is decisive).

The movements achieved during prestressing shall be taken into account. When fulfilling this requirement, limitation of the re-stressing elongation is not necessary. In case the value of 10 cm for inner gliding at one point of the structure is reached, further re-stressing of the tendon is not allowed. In the case that the value of 10 cm already has been reached during prestressing, re-stressing is not admissible.

At the stressing anchor the duct shall not be compressed (see section 4.2.9). After re-stressing corrosion protection measures according to section 4.2.10 shall be carried out.

4.2.12 Exchange of tendons

The dismounting of tendons and the following installation of new tendons is possible (see Annex 30; Point 11). The conditions for future displacement of tendons, the number of tendons that can be dismounted at the same time and the on-site provisions, which already shall be planned during the design of the building, shall be determined for each single case.

For every cutting of tendons the relevant working instructions and the safety provisions for workers shall be determined by the operating company and agreed upon by the client.

5 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.

For transport and handling of the strands the provisions of the strand manufacturer shall be observed.

The ducts shall be transported in such a way that bending is avoided.

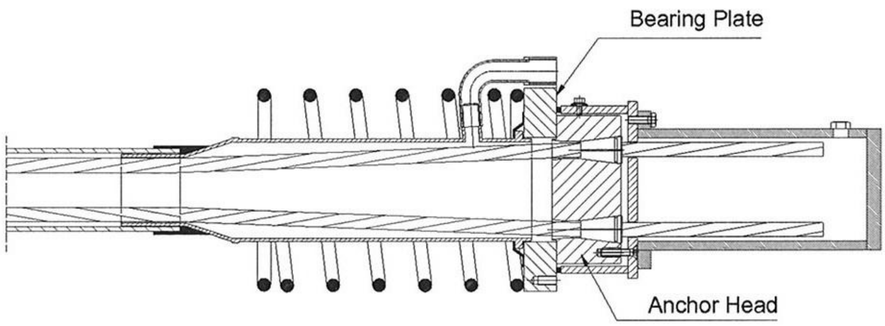
Georg Feistel
Head of Department

beglaubigt:
Schlack

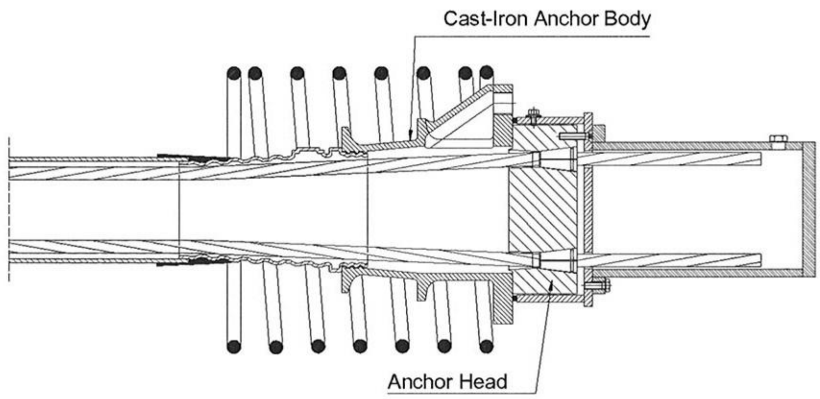
BBV External PT-System

Overview Anchorages

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

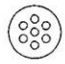
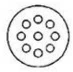


2. Active Anchor (S) and Passive Anchor (F) BBV L12 E – BBV L31 E



BBV External Post-tension System Type E	Annex 1
Overview Anchorages	

STEEL GRADE Y1770
Technical Details BBV L3 E - BBV L9 E
Active Anchor (S) and Passive Anchor (F)

Tendon Type	Dim.	**BBV L3 E**	**BBV L4 E**	**BBV L5 E**	**BBV L7 E**	**BBV L9 E**
Strand Pattern						
Number of Strands, Y1770	n	3	4	5	7	9
150mm² : Nom. Cross Section A_p	mm²	450	600	750	1050	1350
150mm² : Nominal Mass M	kg/m	3,54	4,72	5,9	8,26	10,62
150mm² : $P_0 = 0{,}90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	616	821	1026	1436	1847
150mm² : $P_{m0} = 0{,}85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	581	775	969	1357	1744
150 mm² : F_{pk}	kN	797	1062	1328	1859	2390
140mm² : Nom. Cross Section A_p	mm²	420	560	700	980	1260
140mm² : Nominal Mass M	kg/m	3.30	4.40	5.50	7.69	9.89
140mm² : $P_0 = 0{,}90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	575	766	958	1341	1724
140mm² : $P_{m0} = 0{,}85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	543	724	904	1266	1628
140 mm² : F_{pk}	kN	743	991	1239	1735	2230
Friction Losses						
Active Anchor $\Delta P_\mu S$	%	1,2	1,2	1,2	1,1	1,0
Mean Friction coefficient μ	-	0,08	0,08	0,08	0,08	0,08
PE-Duct						
Inner Diameter	mm	40,8	53,6	53,6	66,0	66,0
Wall Thickness	mm	4,6	4,7	4,7	4,5	4,5
Outer Diameter	mm	50	63	63	75	75
Min. Bending Radius	m	3,00	3,00	3,00	3,10	3,90
Strand Protrusion **	mm	200	200	700	700	800
Anchorages (S) and (F)						
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 (see section 2.2.6 of specific conditions).

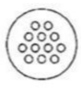
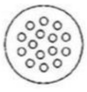
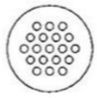
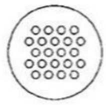
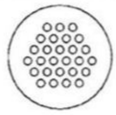
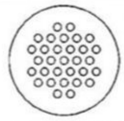
** Distance from anchor head front face for placing of jack

*** Based on $f_{p0.1k}$ = 1520 N/mm² (Y1770)

**** Minimum edge distance: min. centre distance /2+20mm (rounding up at 5mm intervals)

BBV External Post-tension System Type E	Annex 2
Steel Grade: Y 1770 Technical Details BBV L3 E – BBV L9 E	

STEEL GRADE Y1770
Technical Details BBV L12 E - BBV L31 E
Active Anchor (S) and Passive Anchor (F)

Tendon Type	Dim.	BBV L12 E	BBV L15 E	BBV L19 E	BBV L22 E	BBV L27 E	BBV L31 E
Strand Pattern							
Number of Strands, Y1770	n	12	15	19	22	27	31
150mm² : Nom. Cross Section A_p	mm²	1800	2250	2850	3300	4050	4650
150mm² : Nominal Mass M	kg/m	14,16	17,70	22,42	25,96	31,86	36,58
150mm² : $P_0 = 0{,}90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2462	3078	3899	4514	5540	6361
150mm² : $P_{m0} = 0{,}85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2326	2907	3682	4264	5233	6008
150 mm² : F_{pk}	kN	3186	3983	5045	5841	7169	8231
140mm² : Nom. Cross Section A_p	mm²	1680	2100	2660	3080	3780	4340
140mm² : Nominal Mass M	kg/m	13,19	16,49	20,88	24,18	29,67	34,07
140mm² : $P_0 = 0{,}90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2298	2873	3639	4213	5171	5937
140mm² : $P_{m0} = 0{,}85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2171	2713	3437	3979	4884	5607
140 mm² : F_{pk}	kN	2974	3717	4708	5452	6691	7682
Friction Losses							
Active Anchor $\Delta P_\mu S$	%	0,8	0,8	0,8	0,6	0,8	0,8
Mean Friction coefficient μ	-	0,08	0,08	0,08	0,08	0,08	0,08
PE-Duct (SDR17)							
Inner Diameter	mm	79,2	96,8	96,8	96,8 / 110,2	110,2	123,4
Wall Thickness	mm	5,4	6,6	6,6	6,6 / 7,4	7,4	8,3
Outer Diameter	mm	90	110	110	# 110 / 125	125	140
Min. Bending Radius	m	4,00	3,80	4,80	5,50 / 4,80	6,00	5,80
PE-Duct (SDR22)							
Inner Diameter	mm	-	100	100	100 / 113,6	113,6	127,2
Wall Thickness	mm	-	5,0	5,0	5,0 / 5,7	5,7	6,4
Outer Diameter	mm	-	110	110	# 110 / 125	125	140
Min. Bending Radius	m	-	4,10	5,20	6,0 / 5,10	6,30	6,10
Strand Protrusion **	mm	800	800	1200	1200	1200	1200
Anchorages (S) and (F)							
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

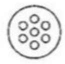
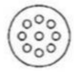
* and ** and *** see Annex 2

*** Based on $f_{p0.1k}$ = 1520 N/mm² (Y1770)

Use of the smaller duct diameters to be confirmed by BBV Systems GmbH

BBV External Post-tension System Type E	Annex 3
Steel Grade: Y 1770 Technical Details BBV L12 E – BBV L31 E	

STEEL GRADE Y1860
Technical Details BBV L3 E - BBV L9 E
Active Anchors (S) and Passive Anchors (F)

Tendon Type	Dim.	BBV L3 E	BBV L4 E	BBV L5 E	BBV L7 E	BBV L9 E
Strand Pattern						
Number of Strands, Y1860	n	3	4	5	7	9
150mm² : Nom. Cross Section A_p	mm²	450	600	750	1050	1350
150mm² : Nominal Mass M	kg/m	3,54	4,72	5,9	8,26	10,62
150mm² : $P_0 = 0{,}90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	648	864	1080	1512	1944
150mm² : $P_{m0} = 0{,}85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	612	816	1020	1428	1836
150 mm² : F_{pk}	kN	837	1116	1395	1953	2511
140mm² : Nom. Cross Section A_p	mm²	420	560	700	980	1260
140mm² : Nominal Mass M	kg/m	3,30	4,40	5,50	7,69	9,89
140mm² : $P_0 = 0{,}90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	605	806	1008	1411	1814
140mm² : $P_{m0} = 0{,}85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	571	762	952	1333	1714
140 mm² : F_{pk}	kN	781	1042	1302	1823	2344
Friction Losses						
Active Anchor $\Delta P_{\mu}S$	%	1,2	1,2	1,2	1,1	1,0
Mean Friction coefficient μ	-	0,08	0,08	0,08	0,08	0,08
PE Duct						
Inner Diameter	mm	40,8	53,6	53,6	66,0	66,0
Wall Thickness	mm	4,6	4,7	4,7	4,5	4,5
Outer Diameter	mm	50	63	63	75	75
Min. Bending Radius	m	3,20	3,10	3,10	3,30	4,10
Strand Protrusion **	mm	200	200	700	700	800
Anchorages (S) and (F)						
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 (see section 2.2.6 of specific conditions).

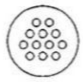
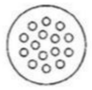
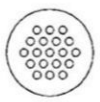
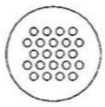
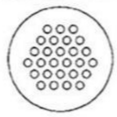
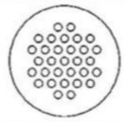
** Distance from anchor head front face for placing of jack

*** Based on $f_{p0.1k}$ = 1600 N/mm² (Y1860)

**** Minimum edge distance : min. centre distance /2+20mm (rounding up at 5mm intervals)

BBV External Post-tension System Type E	Annex 4
Steel Grade: Y 1860 Technical Details BBV L3 E – BBV L9 E	

STEEL GRADE Y1860
Technical Details BBV L12 E - BBV L31 E
Active Anchors (S) and Passive Anchors (F)

Tendon Type	Dim.	BBV L12 E	BBV L15 E	BBV L19 E	BBV L22 E	BBV L27 E	BBV L31 E
Strand Pattern							
Number of Strands, Y1860	n	12	15	19	22	27	31
150mm² : Nom. Cross Section A_p	mm²	1800	2250	2850	3300	4050	4650
150mm² : Nominal Mass M	kg/m	14,16	17,70	22,42	25,96	31,86	36,58
150mm² : $P_0 = 0{,}90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2592	3240	4104	4752	5832	6696
150mm² : $P_{m0} = 0{,}85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2448	3060	3876	4488	5508	6324
150 mm² : F_{pk}	kN	3348	4185	5301	6138	7533	8649
140mm² : Nom. Cross Section A_p	mm²	1680	2100	2660	3080	3780	4340
140mm² : Nominal Mass M	kg/m	13,19	16,49	20,88	24,18	29,67	34,07
140mm² : $P_0 = 0{,}90 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2419	3024	3830	4435	5443	6250
140mm² : $P_{m0} = 0{,}85 \cdot f_{p0.1k} \cdot A_p$ ***	kN	2285	2856	3618	4189	5141	5902
140 mm² : F_{pk}	kN	3125	3906	4948	5729	7031	8072
Friction Losses							
Active Anchor $\Delta P_\mu S$	%	0,8	0,8	0,8	0,6	0,8	0,8
Mean Friction coefficient μ	%	0,08	0,08	0,08	0,08	0,08	0,08
PE Duct (SDR17)							
Inner Diameter	mm	79,2	96,8	96,8	96,8 / 110,2	110,2	123,4
Wall Thickness	mm	5,4	6,6	6,6	6,6 / 7,4	7,4	8,3
Outer Diameter	mm	90	110	110	# 110 / 125	125	140
Min. Bending Radius	m	4,10	4,00	5,00	5,80 / 5,10	6,30	6,10
PE Duct (SDR22)							
Inner Diameter	mm	-	100	100	100 / 113,6	113,6	127,2
Wall Thickness	mm	-	5,0	5,0	5,0 / 5,7	5,7	6,4
Outer Diameter	mm	-	110	110	# 110 / 125	125	140
Min. Bending Radius	m	-	4,40	5,50	6,30 / 5,40	6,70	6,40
Strand Protrusion **	mm	800	800	1200	1200	1200	1200
Anchorages (S) and (F)							
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 4

*** Based on $f_{p0.1k}$ = 1600 N/mm² (Y1860)

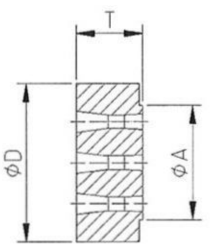
Use of the smaller duct diameters to be confirmed by BBV Systems GmbH

BBV External Post-tension System Type E	Annex 5
Steel Grade: Y 1860 Technical Details BBV L12E – BBV L31 E	

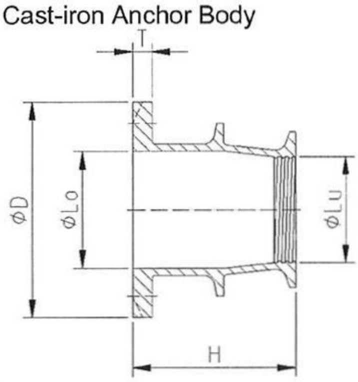
Geometry of Components

Tendon Type		Dim.	L3 E	L4 E	L5 E	L7 E	L9 E	L12 E	L15 E	L19 E	L22 E	L27 E	L31 E
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 Body													
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 - Ø, top	Lo	mm						131	150	163	183	199	208
Hole - Ø, 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
Hole Circle	e1	mm	45	54	56	66	86	*Grid	56	*Grid	*Grid	*Grid	*Grid
Hole Circle	e2	mm							120				
Trumpet													
Max. Outer Diameter		mm	70	79	81	91	111	131	147	156	173	184	190
Min. Length		mm	≥325	≥355	≥375	≥425	≥475	≥265	≥265	≥340	≥365	≥465	≥320

Anchor Head

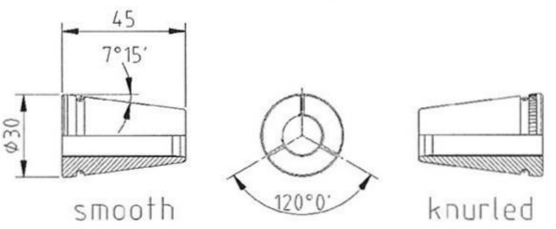


Cast-iron Anchor Body

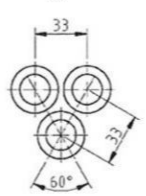


Wedges

Wedge Type 30

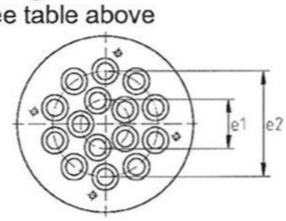


<u>Strand Pattern of Anchor Head:</u>
<u>BBV L12 E; 19 E; 22 E; 27 E; 31 E</u>
Conical borings are in line,
lines result in a grid



<u>Strand Pattern of Anchor Head:</u>
<u>BBV L3 E; 4 E; 5 E; 7 E; 9 E; 15 E</u>
All conical borings are aligned on one or two circles (e1 and e2). See table above

Example: BBV L15 E



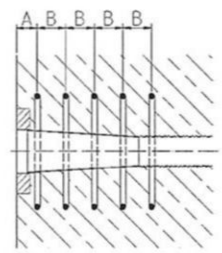
Wedges for different strand diameters must be clearly distinguishable. Wedges for strands with 150 mm² cross sectional area are marked with "0.62" on the front face.

For pre-wedged passive anchors knurled wedges can be used optionally.

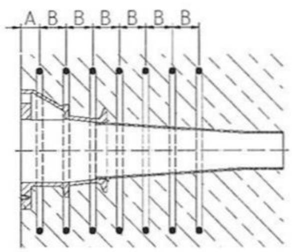
BBV External Post-tension System Type E	Annex 6
Geometry of Components BBV L3 E – BBV L31 E	

Helix and Additional Reinforcement

Tendon Type	Dim.	L3 E	L4 E	L5 E	L7 E	L9 E	L12 E	L15 E	L19 E	L22 E	L27 E	L31 E
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		No. x Ø	No. x Ø	No.x Ø	No. x Ø	No. x Ø	No. x Ø	No. x Ø	No. x Ø	No. x Ø	No. x Ø	No. x Ø
$f_{cmj,cube}$= 28/30 N/mm²	mm	4x Ø10	4x Ø12	4x Ø14	4x Ø14	5x Ø14	6x Ø12	5x Ø14	6x Ø16	7x Ø16	11xØ16	12xØ16
$f_{cmj,cube}$ = 34 N/mm²	mm	4x Ø10	5x Ø10	5x Ø12	5x Ø12	5x Ø14	6x Ø14	8x Ø14	7x Ø16	8x Ø16	9x Ø20	10xØ20
$f_{cmj,cube}$ = 40 N/mm²	mm	4x Ø8	4x Ø12	5x Ø12	5x Ø12	5x Ø14	5x Ø16	6x Ø16	7x Ø16	6x Ø20	8x Ø20	10xØ20
$f_{cmj,cube}$ = 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 / 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 E – L9 E



L12 E – L31 E

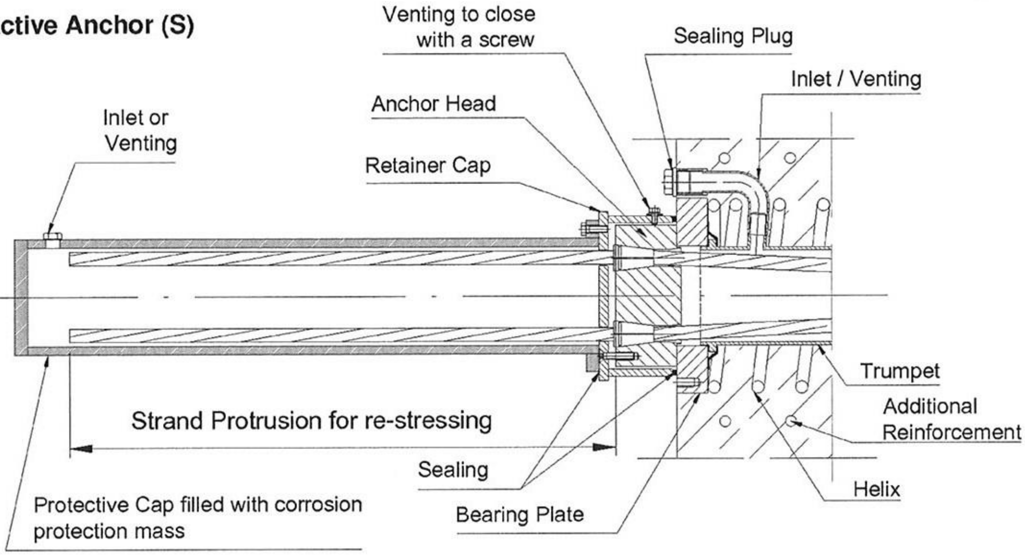
BBV External Post-tension System Type E

Helix and Additional Reinforcement
BBV L3 E – BBV L31 E

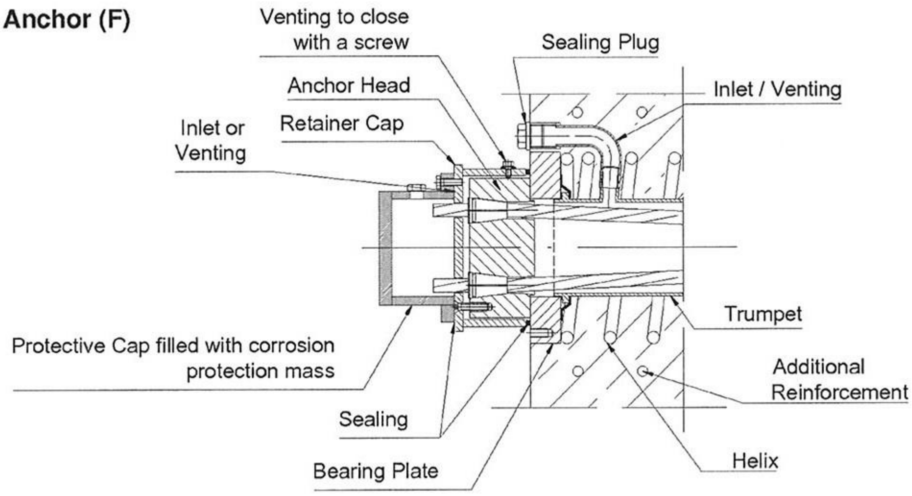
Annex 7

Anchorages with Bearing Plate L 3 E to L 9 E

Active Anchor (S)

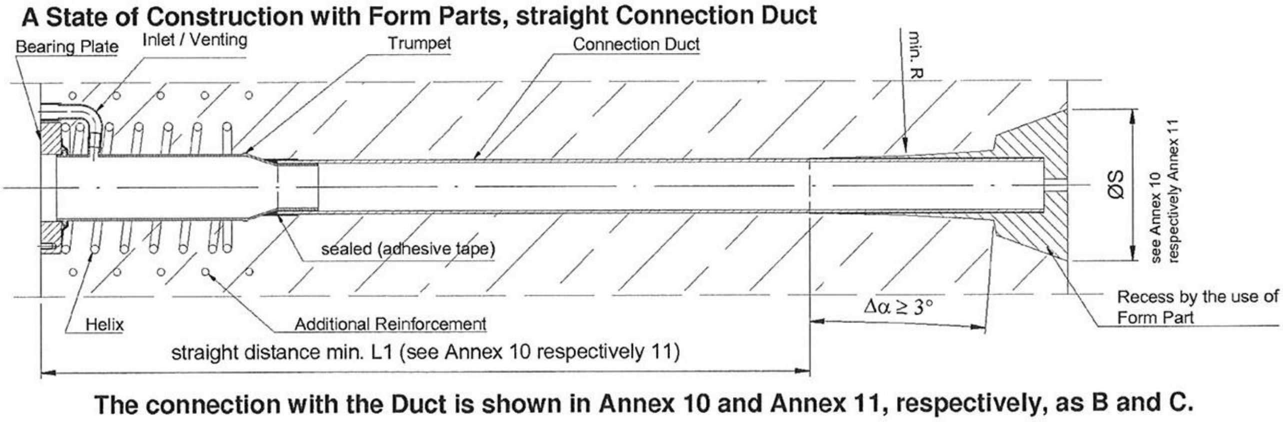


Passive Anchor (F)



Connection Anchorage – Duct (Bearing Plate)

A State of Construction with Form Parts, straight Connection Duct

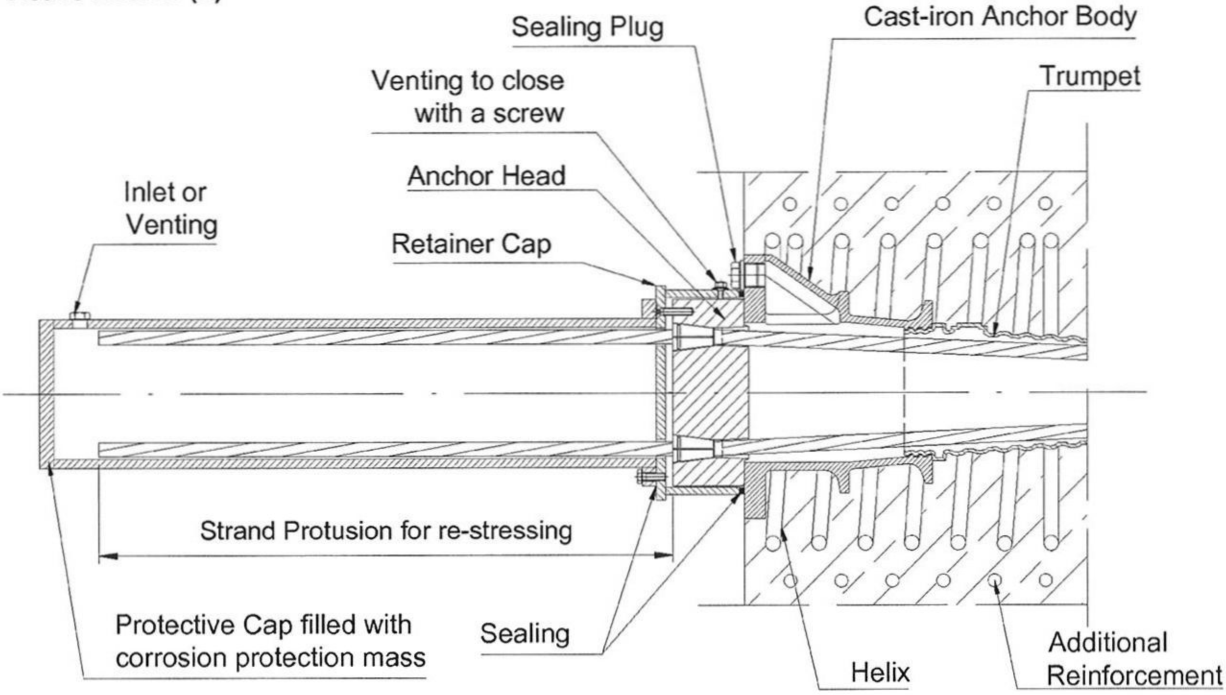


The connection with the Duct is shown in Annex 10 and Annex 11, respectively, as B and C.

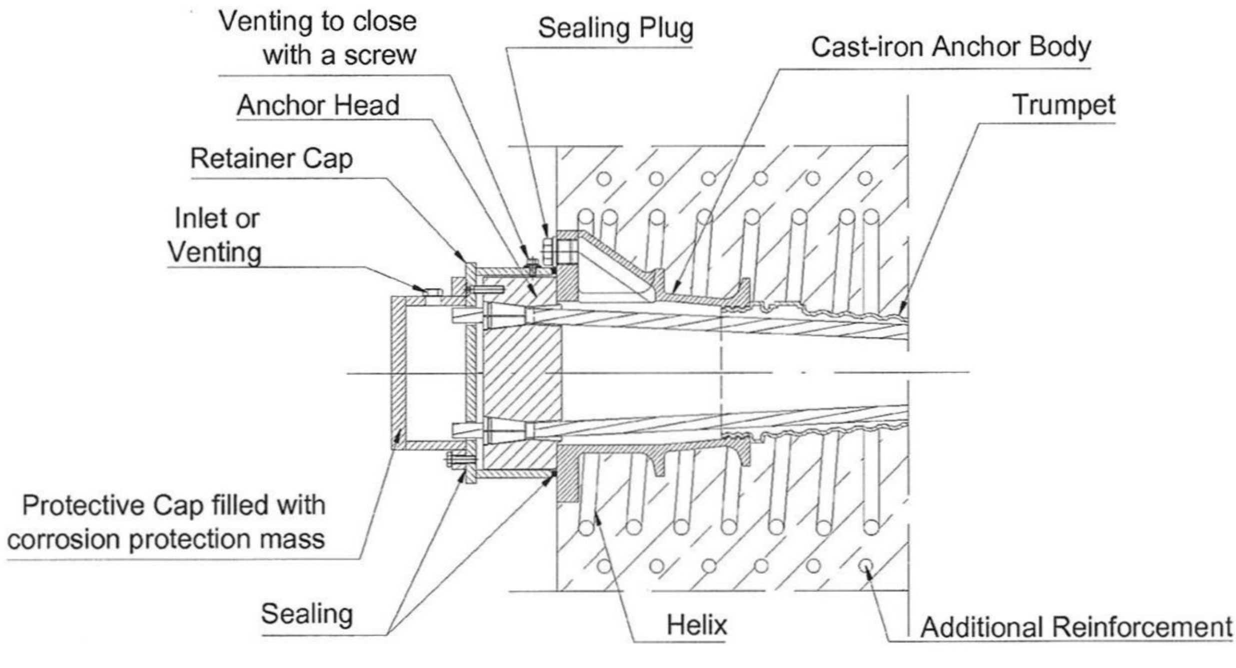
BBV External Post-tension System Type E	Annex 8
Active Anchor and Passive Anchor and Connection with the Duct BBV L3 E – BBV L9 E	

Anchorages with Cast-iron Anchor Body L12 E to L31 E

Active Anchor (S)



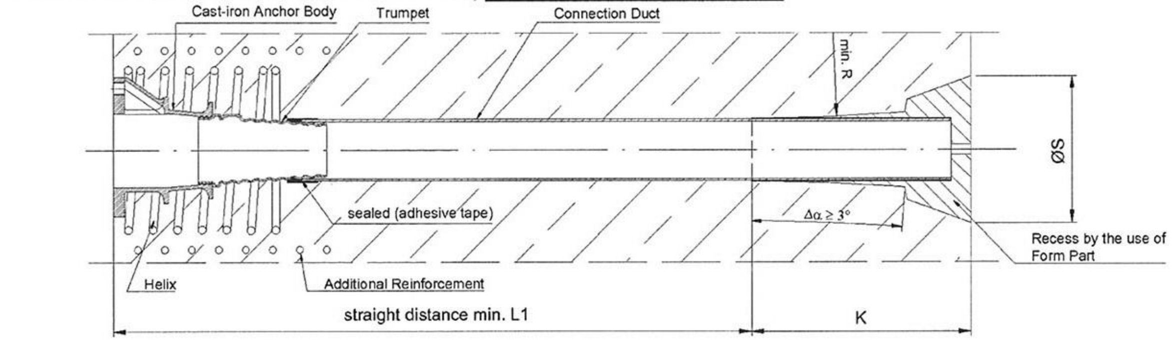
Passive Anchor (F)



BBV External Post-tension System Type E	Annex 9
Active Anchor and Passive Anchor BBV L12E – BBV L31 E	

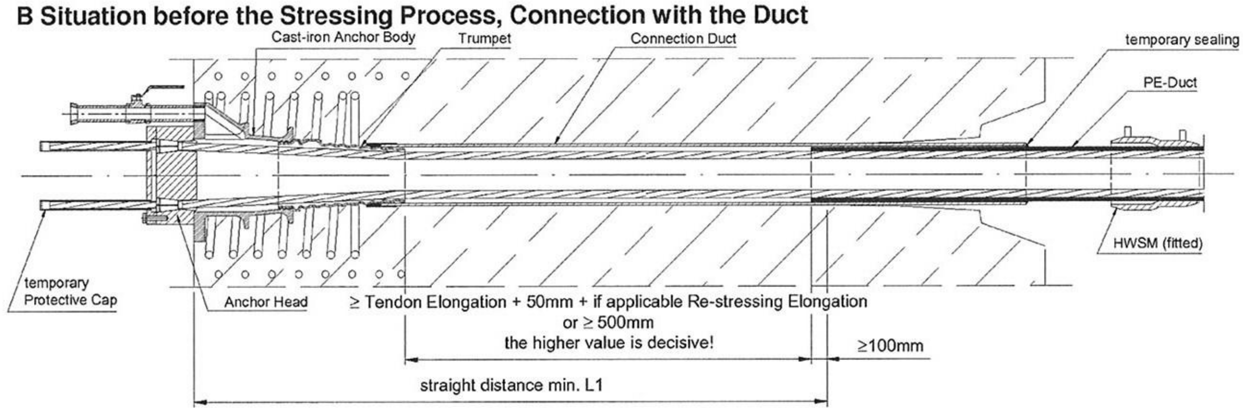
Connection Active Anchor – Duct

A State of Construction with Form Part, Straight Connection Duct

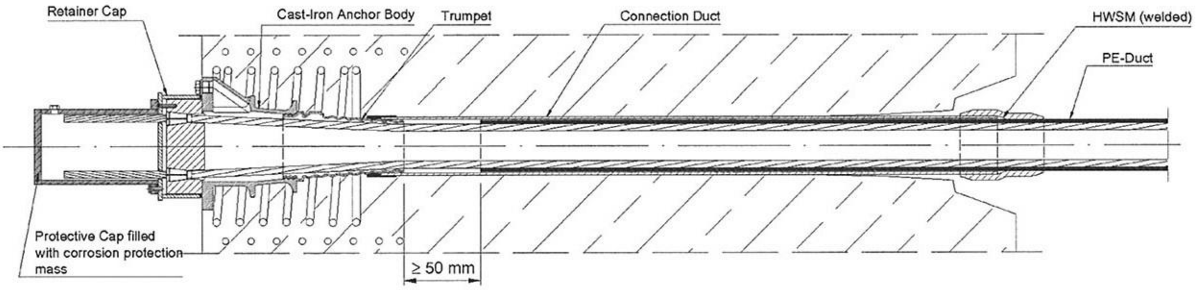


Recess Form Part ØS: Depending on the chosen electro welding sleeve and after consultation with BBV Systems, smaller recesses are possible.

B Situation before the Stressing Process, Connection with the Duct



C Final State, Connection with the Duct



HWSM = electro welding sleeve

Tendon Type	Dim.	L3 E	L4 E	L5 E	L7 E	L9 E	L12 E	L15 E	L19 E	L22 E	L27 E	L31 E
Outer Diameter PE-Duct	mm	50	63	63	75	75	90	110	110	110/125	125	140
Connection Duct												
Outer Diameter	mm	63	75	75	90	90	110	125	125	140	140	160
Min. Wall Thickness	mm	4,3	4,3	4,3	5,1	5,1	6,3	4,8	4,8	4,3	4,3	6,2
Recess Form Part ØS	mm	201	213	213	233	238	263	279	285	288/285	311	330
Length Form Part K	mm	338	331	331	348	411	421	435	519	575/512	613	592
Straight Distance min. L1												
PE-Duct SDR 17	mm	660	780	860	870	1100	1270	1530	1440	1420/1710	1870	2370
PE-Duct SDR 22	mm	-	-	-	-	-	-	1580	1500	1480/1760	2020	2430

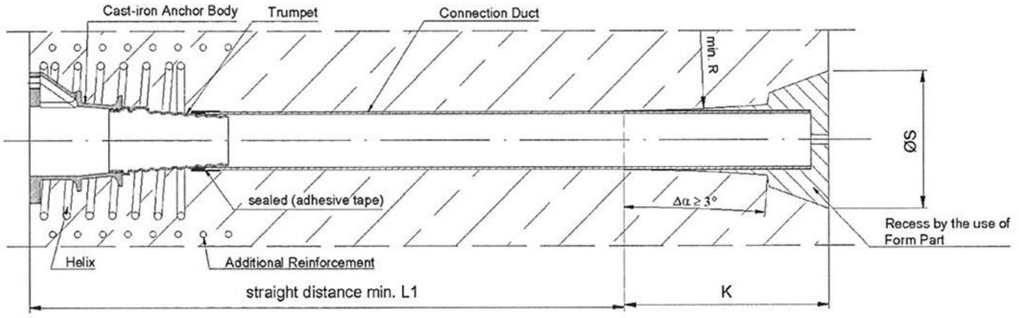
BBV External Post-tension System Type E

Active Anchor
Connection with the Duct
BBV L3 E – BBV L31 E

Annex 10

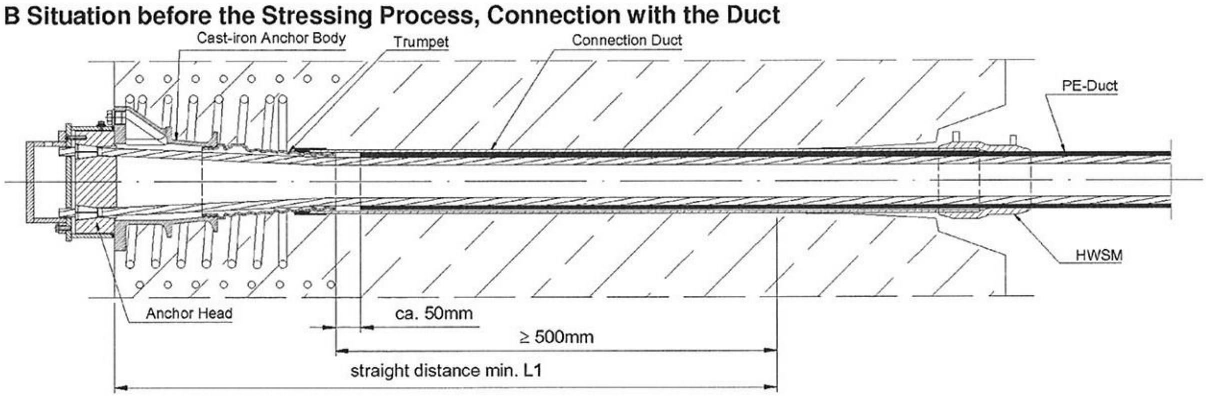
Connection Passive Anchor – Duct

A State of Construction with Form Part, Straight Connection Duct

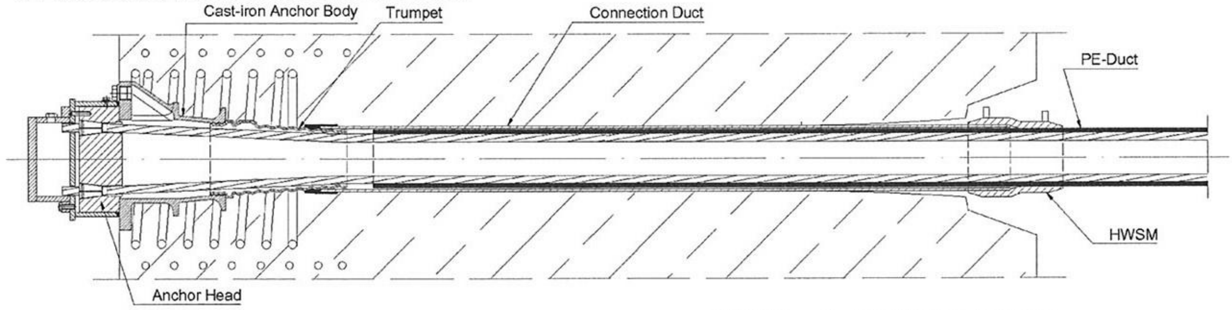


Recess Form Part ØS: Depending on the chosen electro welding sleeve and after consultation with BBV Systems, smaller recesses are possible.

B Situation before the Stressing Process, Connection with the Duct



C Final State, Connection with the Duct



HWSM = electro welding sleeve

Tendon Type	Dim.	L3 E	L4 E	L5 E	L7 E	L9 E	L12 E	L15 E	L19 E	L22 E	L27 E	L31 E
Outer Diameter PE-Duct	mm	50	63	63	75	75	90	110	110	110/125	125	140
Connection Duct												
Outer Diameter	mm	63	75	75	90	90	110	125	125	140	140	160
Min. Wall Thickness	mm	4,3	4,3	4,3	5,1	5,1	6,3	4,8	4,8	4,3	4,3	6,2
Recess Form Part ØS	mm	201	213	213	233	238	263	279	285	288/285	311	330
Length Form Part K	mm	338	331	331	348	411	421	435	519	575/512	613	592
Straight Distance min. L1												
PE-Duct SDR 17	mm	660	780	860	870	1100	1270	1530	1440	1420/1710	1870	2370
PE-Duct SDR 22	mm	-	-	-	-	-	-	1580	1500	1480/1760	2020	2430

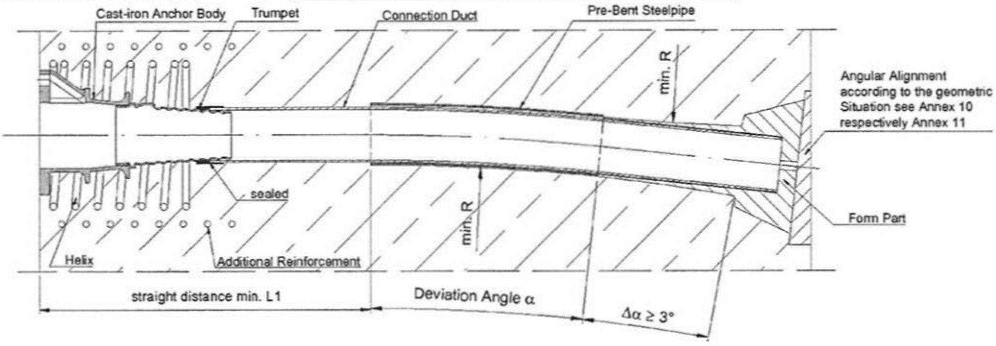
BBV External Post-tension System Type E

Passive Anchor
Connecting with the Duct
BBV L3 E – BBV L31 E

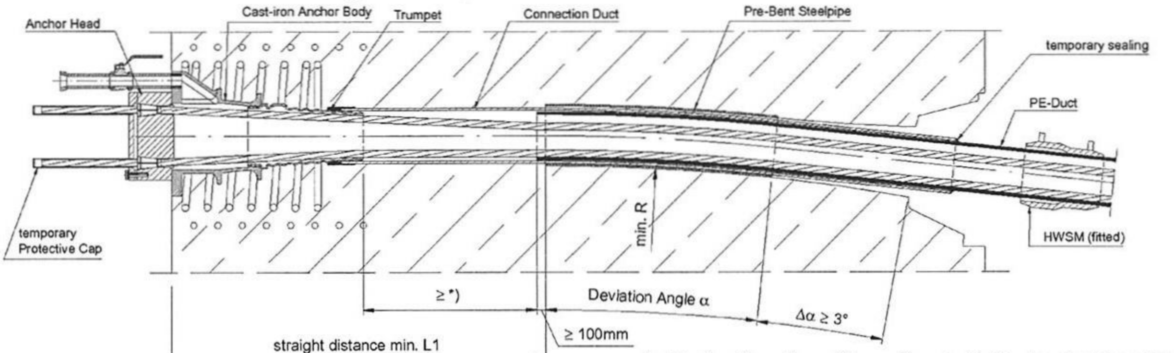
Annex 11

Connection Anchor Close Deviation – Duct

A State of Construction with Form Part, Connection Duct, Pre-Bent Steel Pipe

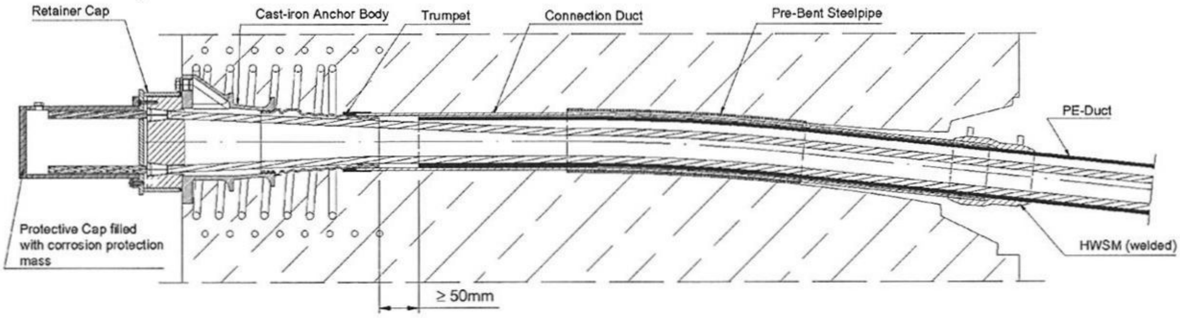


B Situation before the Stressing Process, Connection with the Duct



*) ≥ Tendon Elongation + 50mm + if applicable Re-stressing Elongation
or ≥ 500mm
the higher value is decisive!

C Final State, Connection with the Duct



HWSM = electro welding sleeve

Tendon Type	Dim.	L3 E	L4 E	L5 E	L7 E	L9 E	L12 E	L15 E	L19 E	L22 E	L27 E	L31 E
Outer Diameter PE-Duct	mm	50	63	63	75	75	90	110	110	110/125	125	140
Connection Duct												
Outer Diameter	mm	63	75	75	90	90	110	125	125	140	140	160
Min. Wall Thickness	mm	4,3	4,3	4,3	5,1	5,1	6,3	4,8	4,8	4,3	4,3	6,2
Straight Distance min. L1												
PE-Duct PE SDR 17	mm	910	1150	910	1270	1300	1410	1940	1650	1660/1940	2080	2360
PE-Duct PE SDR 22	mm	-	-	-	-	-	-	1940	1650	1670/1940	2080	2420
Pre-Bent Steel Pipe												
Outer Diameter d_S	mm	76,1	88,9	88,9	101,6	101,6	127	139,7	139,7	159	159	177,8
Wall Thickness	mm	2,9	3,2	3,2	3,6	3,6	4,0	4,0	4,0	4,5	4,5	5

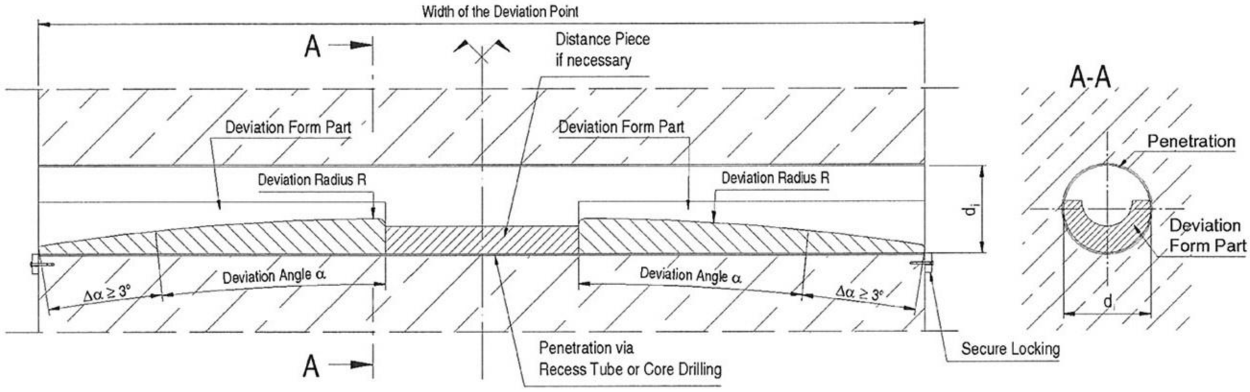
BBV External Post-tension System Type E

Anchor Close Deviation
Connecting with the Duct
BBV L3 E – BBV L31 E

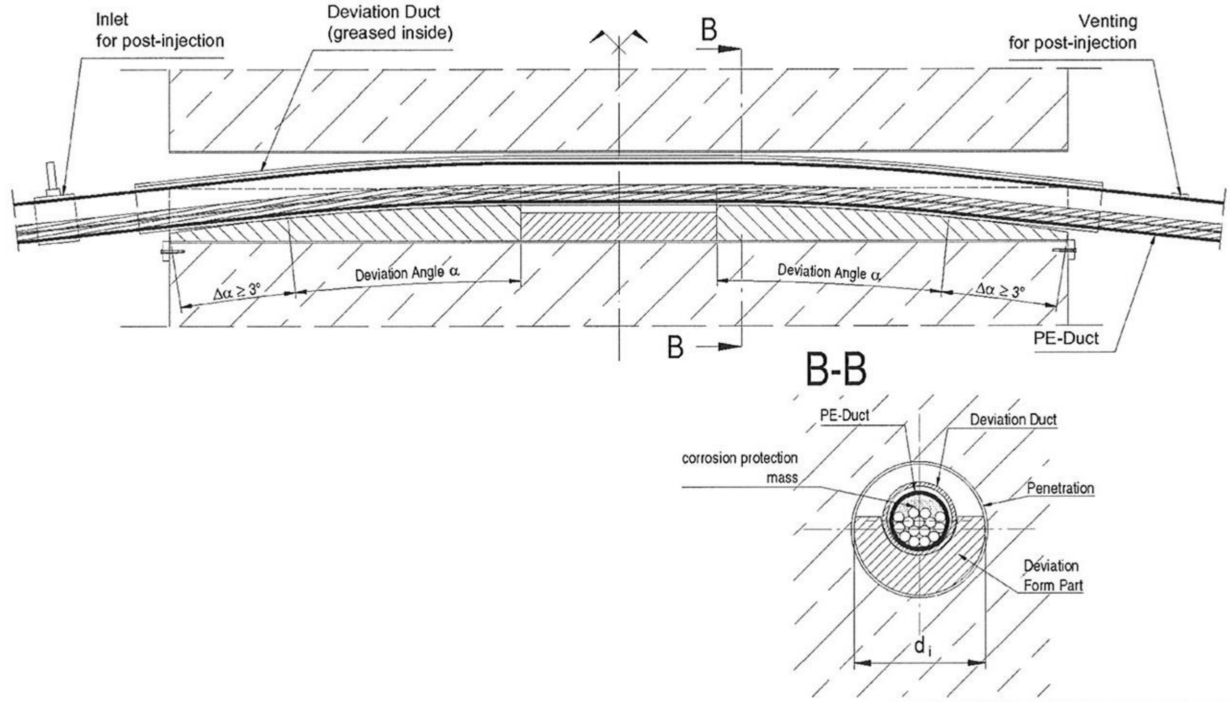
Annex 12

Deviation type F: Penetration with inserted Form Parts

State of Construction:



Final State:



Tendon Type	Dim.	L3 E	L4 E	L5 E	L7 E	L9 E	L12 E	L15 E	L19 E	L22 E	L27 E	L31 E
Outer Diameter PE-Duct	mm	50	63	63	75	75	90	110	110	110/125	125	140
Deviation Angle Δα	°	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3
Deviation Duct												
Outer Diameter	mm	63	75	75	90	90	110	125	125	125/140	140	160
Wall Thickness	mm	4,3	4,3	4,3	5,1	5,1	6,3	4,8	4,8	4,8/4,3	4,3	6,2
Penetration d_i	mm	After Consultation with BBV Systems										

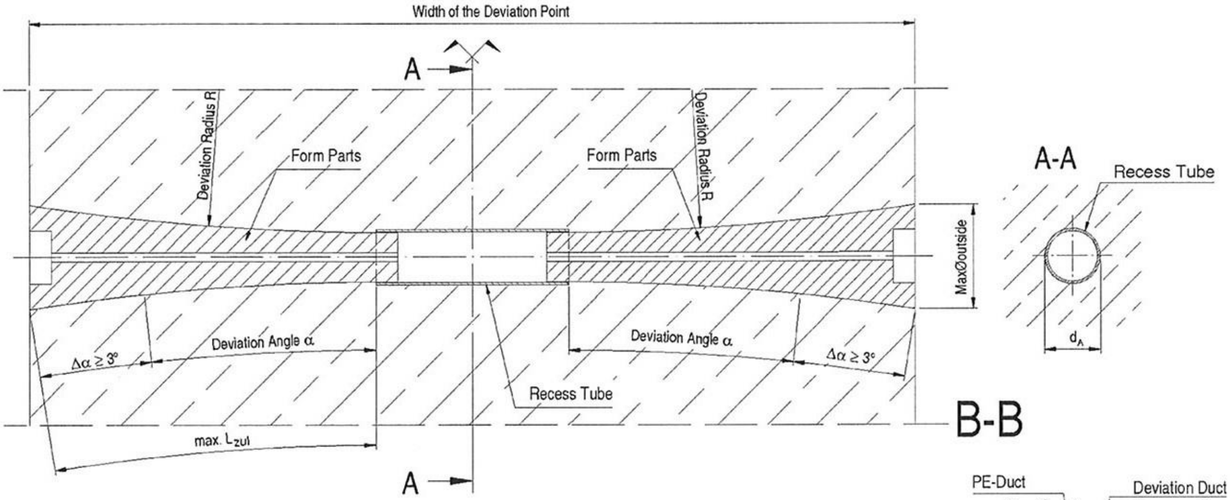
During construction, dislocation of the penetration tubes shall be avoided.

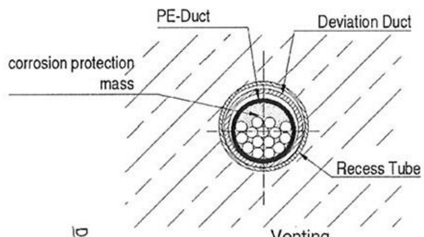
The deviation form parts are made of plastic or steel. The penetration consists of galvanized steel-, PVC- or PE-tube or can be made by core drilling.

BBV External Post-tension System Type E	Annex 13
Deviation type F	

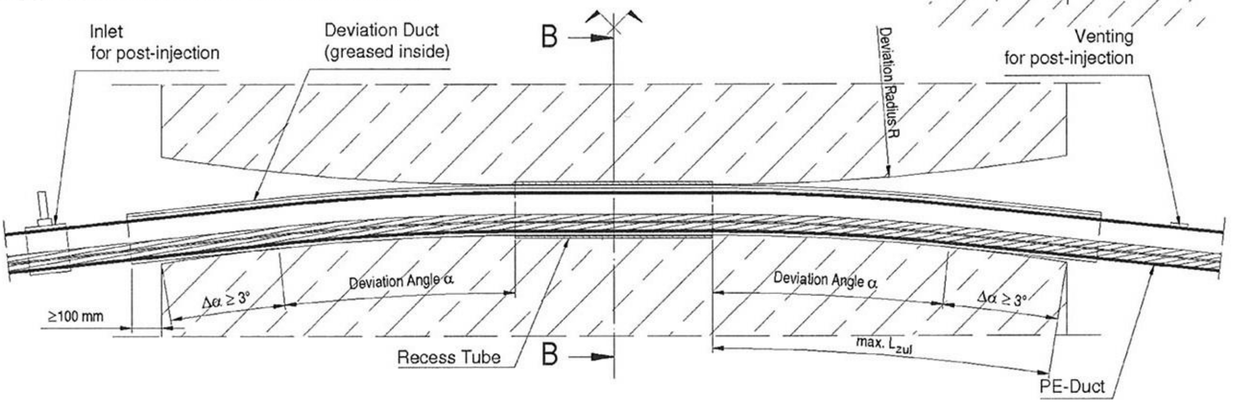
Deviation type S:

State of Construction:





Installation Deviation Duct and Duct:



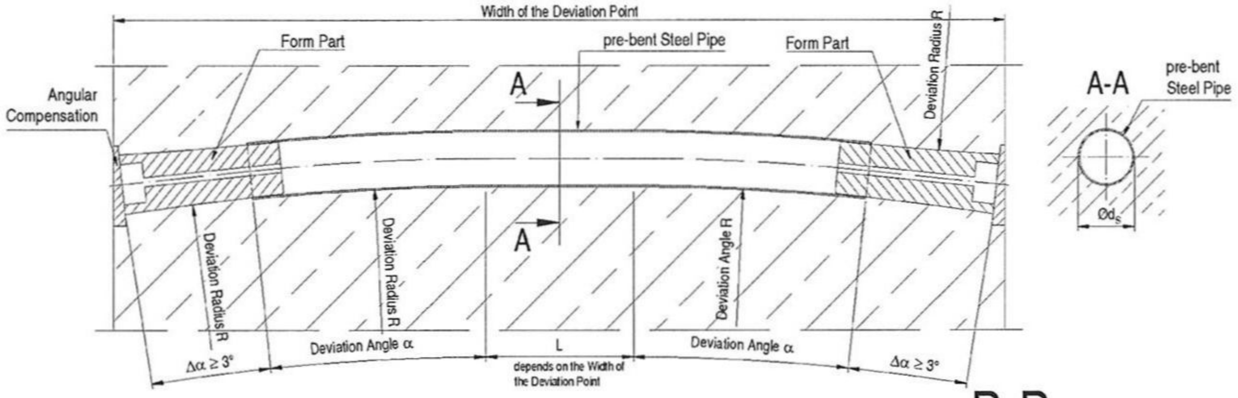
Tendon Type	Dim.	L3 E	L4 E	L5 E	L7 E	L9 E	L12 E	L15 E	L19 E	L22 E	L27 E	L31 E
Outer Diameter PE-Duct	mm	50	63	63	75	75	90	110	110	110/125	125	140
Deviation Angle α	°	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5
Deviation Angle Δα	°	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3
Allowed Length max. L_{zul}	mm	100	170	170	240	240	410	750	750	750/1100	1100	1500
Deviation Duct												
Outer Diameter	mm	63	75	75	90	90	110	125	125	125/140	140	160
Wall Thickness	mm	4,3	4,3	4,3	5,1	5,1	6,3	4,8	4,8	4,8/4,3	4,3	6,2
Recess Tube												
Outer Diameter d_A	mm	75	90	90	110	110	125	140	140	140/160	160	180
Wall Thickness	mm	3,6	4,3	4,3	5,3	5,3	6	4,1	4,1	4,1/7,7	7,7	8,6
Form Part MaxØoutside	mm	Depends on the Tendon Size and the chosen Deviation Angle										

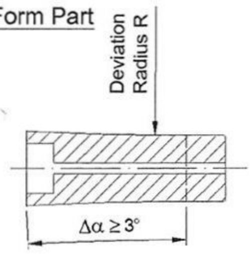
During construction, dislocation of the form parts and the recess tube shall be avoided. The recess tube can be made of galvanised steel, PVC or PE.

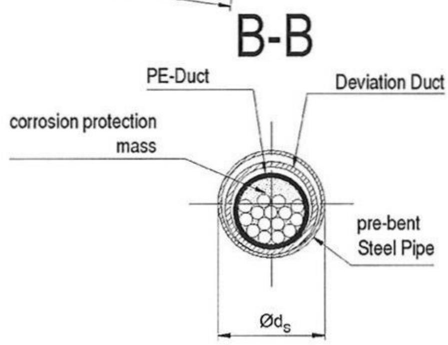
BBV External Post-tension System Type E	Annex 14
Deviation type S	

Deviation type R: Penetration with a (pre-bent) Pipe

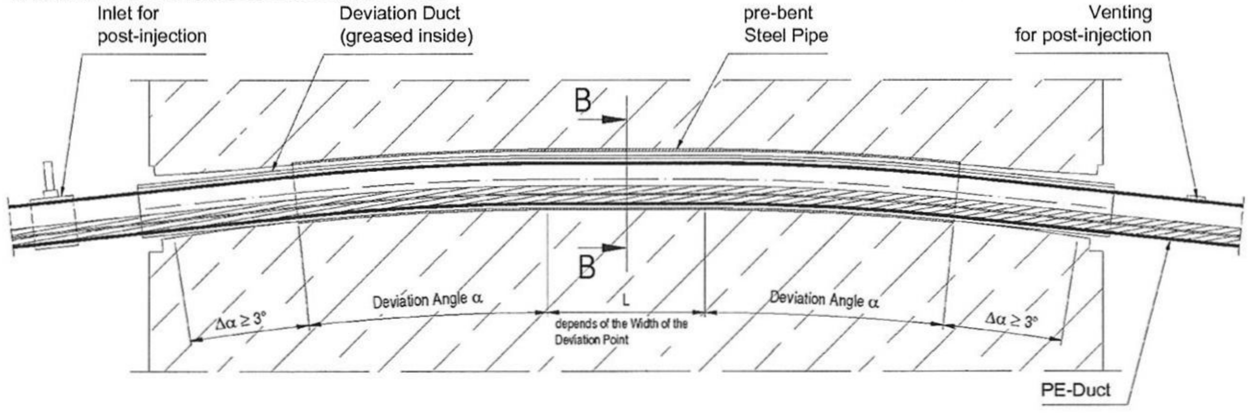
State of Construction:







Installation Deviation Duct and Duct:



The form parts (cf. Deviation type S, Annex 14) will be connected to both ends of the penetration tube (steel, galvanised) and allow for unscheduled Deviation of $\Delta\alpha$.

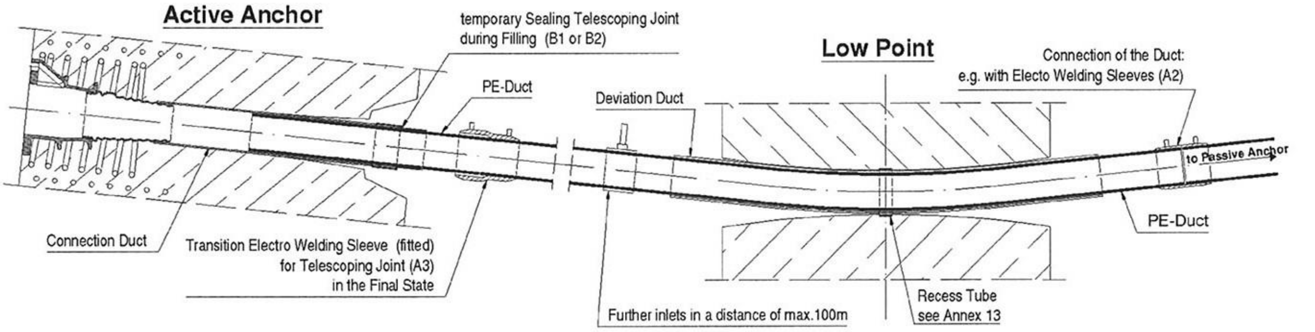
Tendon Type	Dim.	L3 E	L4 E	L5 E	L7 E	L9 E	L12 E	L15 E	L19 E	L22 E	L27 E	L31 E
Outer Diameter PE-Duct	mm	50	63	63	75	75	90	110	110	110/125	125	140
Deviation Angle $\Delta\alpha$	°	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3	≥ 3
Deviation Duct												
Outer Diameter	mm	63	75	75	90	90	110	125	125	125/140	140	160
Wall Thickness	mm	4,3	4,3	4,3	5,1	5,1	6,3	4,8	4,8	4,8/4,3	4,3	6,2
pre-bent Steel Pipe												
Outer Diameter d_S	mm	76,1	88,9	88,9	101,6	101,6	127	139,7	139,7	139,7/159	159	177,8
Wall Thickness	mm	2,9	3,2	3,2	3,6	3,6	4,0	4,0	4,0	4,0/4,5	4,5	5

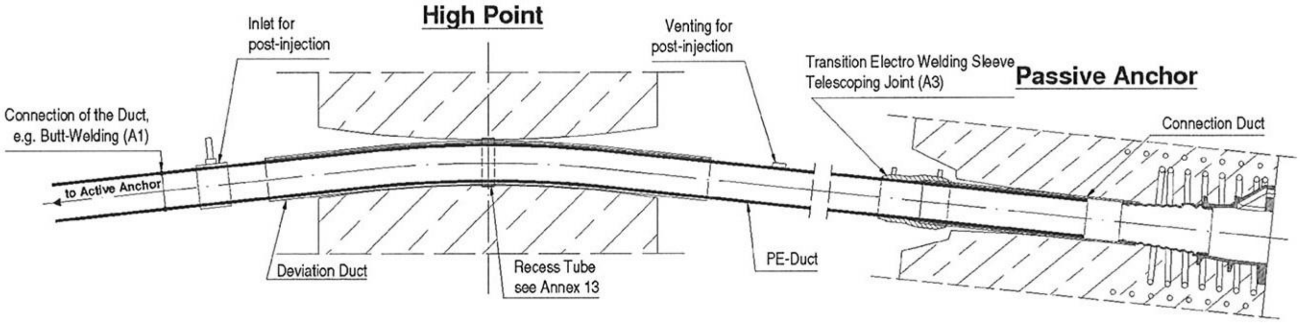
BBV External Post-tension System Type E

Deviation type R

Annex 15

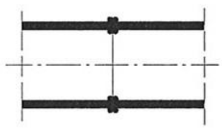
Duct Scheme with Connections and Joints



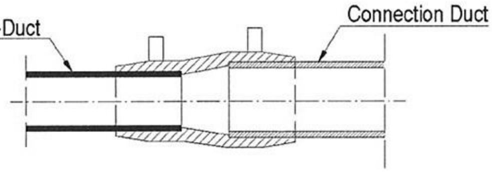


A) Tensile-proof Connections and Joints

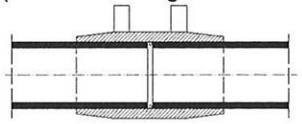
A1) Heated Tool Butt-Welding (HS)



A3) Transition Electro Welding Sleeve
Telescoping Joint

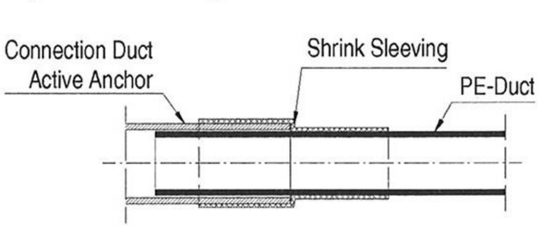


A2) Electro Welding Sleeves (HM)
(Helical Heating Element Welding)

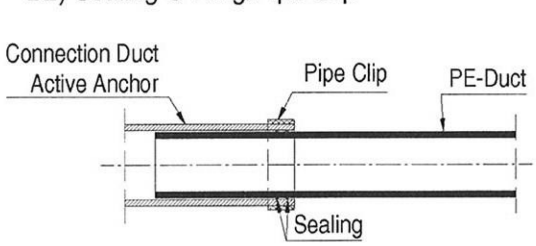


B) Temporary Sealing of the Telescoping Joint

B1) Shrink Sleeving



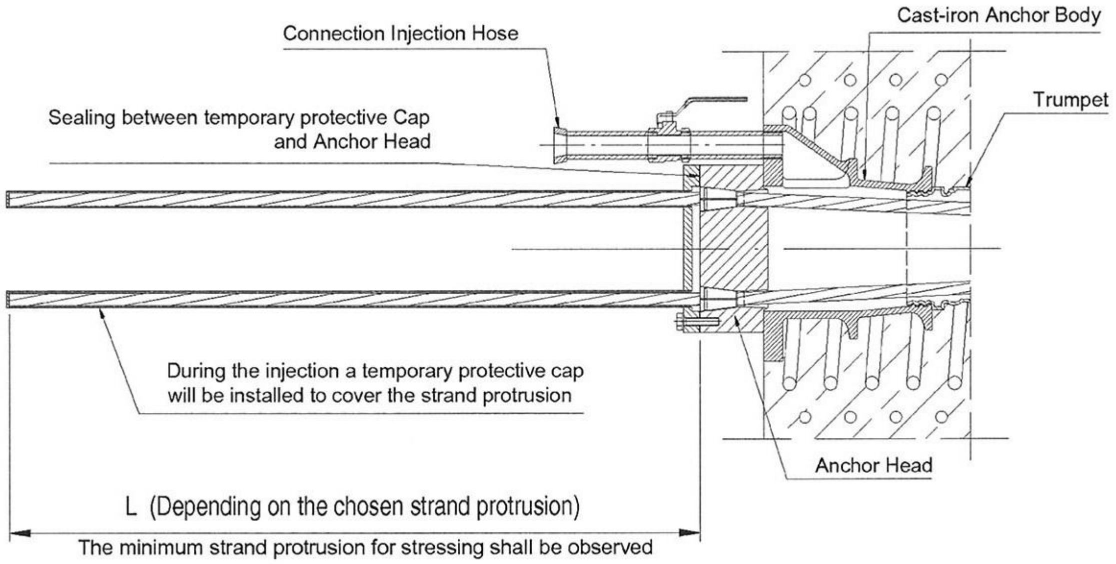
B2) Sealing O-Ring/Pipe Clip



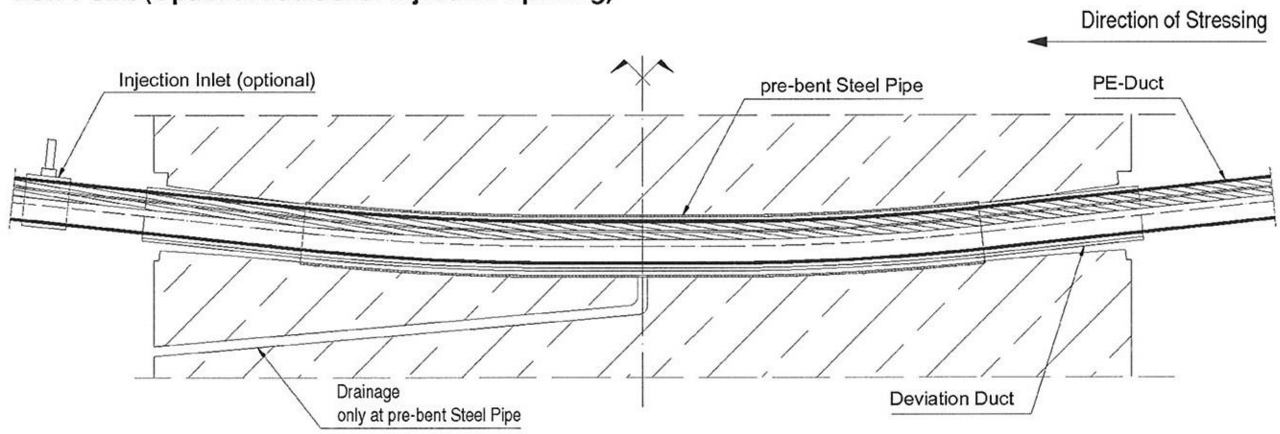
BBV External Post-tension System Type E	Annex 16
Duct Scheme with Connections and Joints	

Injection of the Duct, Connection Points

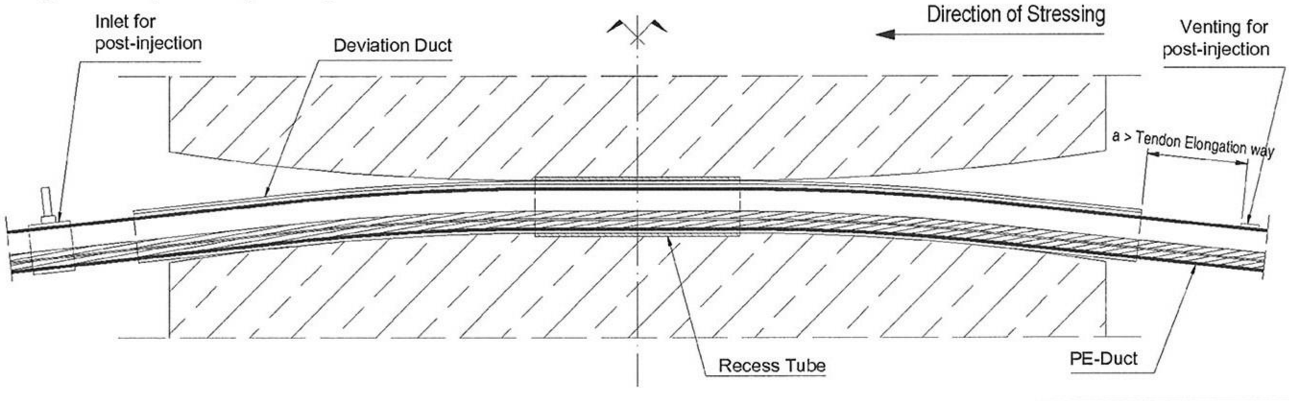
Anchorage (in case of S)



Low Point (Optional additional Injection Opening)



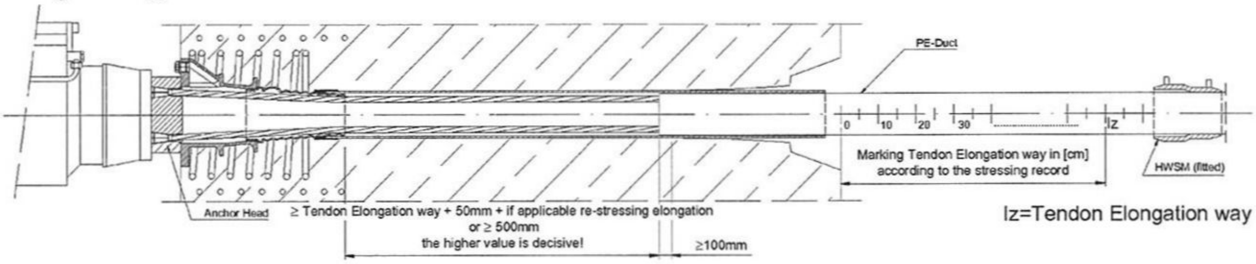
High Point (Post-Injection)



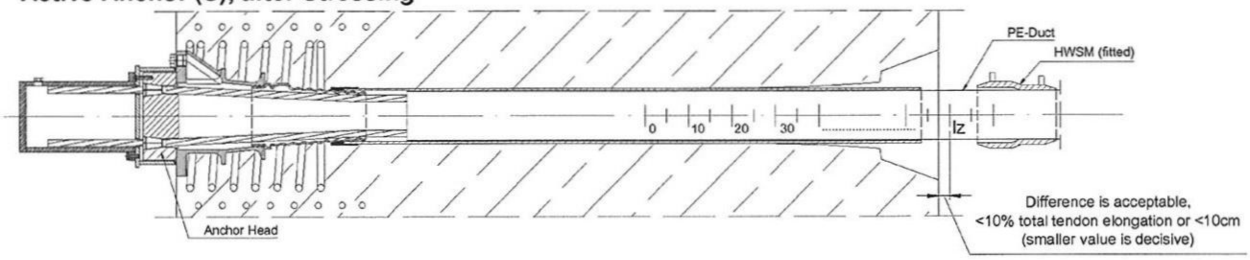
BBV External Post-tension System Type E	Annex 17
Injection of the Duct, Connection Points	

Marking of the Tendon Elongation on the Smooth Plastic Duct

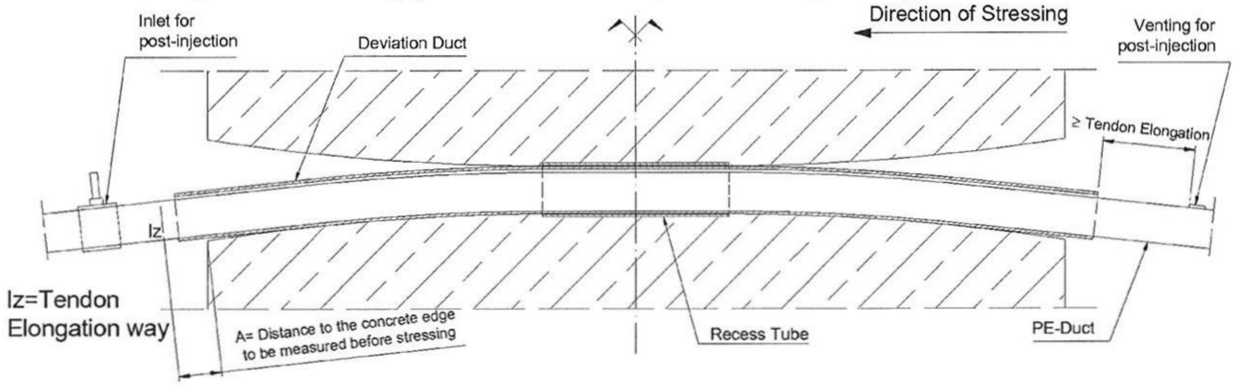
Active Anchor (S), before Stressing (Reference Measurement for Determination of Internal Slip after Thightening)



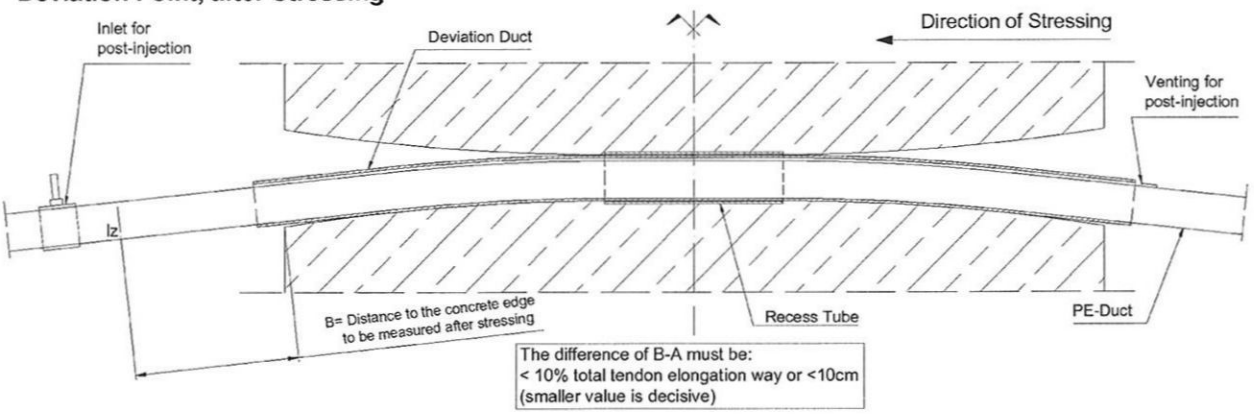
Active Anchor (S), after Stressing



Deviation Point, before Stressing (Reference Measurement after Thightening)



Deviation Point, after Stressing



BBV External Post-tension System Type E	Annex 18
Marking Strand Elongation way on the Duct	

Material of Components and related Standards

Designation	Material	Material code	Standard
ANCHORAGE			
Bearing Plate	deposited at Deutsches Institut für Bautechnik		EN 10025-2:2004
Cast-iron Anchor Body	deposited at Deutsches Institut für Bautechnik		
Wedge	deposited at Deutsches Institut für Bautechnik		
Anchor Head	deposited at Deutsches Institut für Bautechnik		EN 10083-2:2006
Helix for: S, F	R_e=500 MPa (ripped reinforced Steel)		EN 10080:2005-08
Additional Reinforcement for S, F	R_e=500 MPa (ripped reinforced Steel		EN 10080:2005-08
Trumpet	PE, deposited at Deutsches Institut für Bautechnik		
Retainer Cap	S235JR	1.0038	EN 10025-2:2004
Protective Cap	PE or Steel, deposited at Deutsches Institut für Bautechnik		
Connection Duct	PE, deposited at Deutsches Institut für Bautechnik		EN 12201/1+2:2003
Duct			
Duct	PE, deposited at Deutsches Institut für Bautechnik		EN 12201/1+2:2003
Electrowelding Sleeve Transition Electrowelding Sleeve	PE		DIN 16963-7:1989-10
Shrink Sleeving	deposited at Deutsches Institut für Bautechnik		DIN 30672-1:1991-09
Corrosion Protection Mass			
Wax or Grease*)	according to ETAG 013, Annex C4.1 or C4.2 and according to the regulations valid at the place of use		
DEVIATION			
Deviation Duct	PE, deposited at Deutsches Institut für Bautechnik		EN 12201/1+2:2003
Deviation Form Part (Type F) Steel (coated or galvanised)	at least S235JR or EN GJS-400-15 or EN GJS-400-15U		EN 10025-2:2004 EN 1563:1997+A1:2002+ A2:2005
Deviation Form Part (Type F) Plastic Material	plastics form part PE (deposited at DIBt)		EN ISO 1872-1:1999
Penetration Tube (Type F) and Recess Tube (Type S)	Steel (galvanised), S235JR PVC-U or PE		EN 10025-2:2004 DIN 8061: 2009-10 DIN 8062: 2009-10 EN 12201/1+2:2003
pre-bent Steel Pipe (Deviation Type R)	Steel (galvanised), S235JR		EN 10025-2:2004
Form Part (Deviation Type R and S)	PE or PA, deposited at Deutsches Institut für Bautechnik		
Grease*)	according to ETAG 013, Annex C4.1 and according to the regulations valid at the place of use		

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

*) Not covered by ETA-11/0123

BBV External Post-tension System Type E	Annex 19
Material of Components	

Wax specification[1)]

	Characteristics	Test method / Standard	Acceptance criteria
1	Congealing point	NFT 60-128:1974-12	≥ 65 °C
2	Penetration (1/10mm) at –20 °C	NFT 60-119:1970-05	No cracking
3	Bleeding at 40 °C	BS 2000:2005 PT121 (1982) modified	≤ 0.5 %
4	Resistance to oxidation 100 hours at 100 °C	ASTM D942	≤ 0.03 MPa
5	Copper-strip corrosion 100 hours at 100 °C	ISO 2160:1998	Class: 1a
6	Corrosion protection 168 hours at 35 °C 168 hours at 35 °C	 NFX 41-002 (Salt spray) [2)] NFX 41-002 (Distilled water spray) [2)]	 Pass No corrosion
7	Content of aggressive elements: Cl^-, S^{2-}, NO_3^-: SO_4^{2-}:	 NFM 07-023:1969-02 NFM 07-023:1969-02	 ≤ 50 ppm (0.005 %), ≤ 100 ppm (0.010 %),

Grease specification[1)]

	Characteristics	Test method / Standard	Acceptance criteria
1	Cone penetration, 60 strokes (1/10mm)	ISO 2137	250 - 300
2	Dropping point	ISO 2176	≥ 150 °C
3	Oil separation at 40 °C	DIN 51 817	At 72 hours: ≤ 2.5 % At 7 days: ≤ 4.5 %
4	Oxidation stability	DIN 51 808	100 hours at 100°C: ≤ 0.06 MPa 1000 hours at 100°C: ≤ 0.2 MPa
5	Corrosion protection 168 hours at 35 °C 168 hours at 35 °C	 NFX 41-002 (salt spray) [2)] NFX 41-002 (distilled water spray) [2)]	 Pass No corrosion
6	Corrosion test	DIN 51 802	Grade: 0
7	Content of aggressive elements: Cl^-, S^{2-}, NO_3^-: SO_4^{2-}:	 NFM 07-023 [3)] NFM 07-023 [3)]	 ≤ 50 ppm (0.005 %), ≤ 100 ppm (0.010 %),

1) In addition for grease and wax the following acceptance criteria shall be fulfilled:

congealing point	50 – 56 °C	DIN ISO 2207
penetration / 25 °C	165 – 185 x 1/10 mm	DIN 51580
viscosity / 100 °C	6,5 – 11 mm2/s	DIN 51562

2) NFX 41-002:1975-08: Test sample consists of a structural steel plate Fe 510 with a surface roughness comparable to prestressing wire and strand. The plate is covered with a layer of grease of a maximum thickness corresponding of the declared mass of filling material per linear meter of monostrand divided by the nominal strand surface per linear meter (based on nominal strand diameter).

3) Applied accordingly to grease.

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

As long as a harmonized European standard does not exist 7-wire strands in accordance with national provisions and with the characteristics given in the table above shall be used.

* 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 (Y 1770 S7) or 1640 N/mm² (Y 1860 S7).

CONTENT OF CONTROL PLAN

Component	Item	Test/ Check	Traceability [4]	Minimum frequency	Documentation
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
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 %	yes
	detailed dimensions[5]	check		3 % ≥ 2 specimen	no
	visual inspection[3]	check		100 %	no

Continuation of Control Plan and footnotes see Annex 23

CONTENT OF 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
Helix	material	check	full	100 %	yes
	visual inspection[3]	check		100 %	no
Stirrups	material	check	full	100 %	yes
	visual inspection[3]	check		100 %	no
Grease	material[7]	check	full	100 %	"CE"[9]
Wax	material[8]	check	full	100 %	"CE"[9]

All samples shall be randomly selected and clearly identified.

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 20
7 Grease according to ETAG 013, Annex C.4.1 and according to the regulations valid at the place of use
8 Wax according to ETAG 013, Annex C4.2 and according to the regulations valid at the place of use
9 If the basis of "CE"-marking is not available, the prescribed test 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.

AUDIT TESTING

Component	Item	Test/ Check	Sampling - Number of components per visit
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	
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	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.

BBV External Post-tension System Type E	Annex 24
Audit Testing BBV L 3E – BBV L31 E	

1 Tendons

For the tendons 7-wire strands with a nominal diameter of 15.3 mm and a nominal cross-section of 140 mm² or with a nominal diameter of 15.7 mm and a nominal cross-section of 150 mm² are used. For the prestressing steel grades Y 1770 S7 or Y 1860 S7 are allowed. The stressing system covers tendons from 3 to 31 strands. The anchors are identical for both prestressing steel grades. Different wedges are used for different prestressing steel cross-sections.

The strands are combined to the following tendons:

Prestressing steel grade: Nominal cross-section A_p	Y1770 140 mm²	Y1770 150 mm²	Y1860 140 mm²	Y1860 150 mm²
Tendon	P_{m0} [kN]	P_{m0} [kN]	P_{m0} [kN]	P_{m0} [kN]
BBV L 3 E	543	581	571	612
BBV L 4 E	724	775	762	816
BBV L 5 E	904	969	952	1020
BBV L 7 E	1266	1357	1333	1428
BBV L 9 E	1628	1744	1714	1836
BBV L 12 E	2171	2326	2285	2448
BBV L 15 E	2713	2907	2856	3060
BBV L 19 E	3437	3682	3618	3876
BBV L 22 E	3979	4264	4189	4488
BBV L 27 E	4884	5233	5141	5508
BBV L 31 E	5607	6008	5902	6324

Values are based on $f_{p0.1k}$ = 1520 N/mm² (Y 1770 S7) resp. 1600 N/mm² (Y 1860 S7), where $P_{m0} = 0.85 \times f_{p0.1k} \times \Sigma A_p$.

The number of strands in the tendons may be reduced by omitting strands in such a way that the pattern maintains radially symmetric in the anchorage (see Section 2.2.2 of the Specific Conditions). The strands of the tendons are combined in a duct without spacers. They are stressed simultaneously and then anchored individually with round wedges. Round PE tubes in accordance with DIN EN 12201 are used. The scheme of the duct installation is shown in Annex 16. The tendons may be re-stressed and replaced since the ducts are filled with non-setting corrosion protection mass. The length of the tendons is unlimited.

2 Anchorages

2.1 Wedge anchorages

The two-part anchorage with anchor plate/ cast-iron anchor body and anchor head usually is used as an active anchor (S) or an passive anchor (F) (see Annexes 8 and 9). In the anchorage zone, the duct is replaced by a trumpet, in which the strands are deflected by a maximum of 2.2° (see Section 2.1.11 of the Specific Conditions). This trumpet is trumpet shaped with its diminution pointing towards the duct. For anchoring the 150 mm² strands wedges which can be clearly distinguished from those for 140 mm² strands shall be used (marking with print "0.62", cf. Annex 6). The bursting forces caused by the load transfer to the concrete member shall be carried by a helix made of ribbed reinforcing steel.

Additional reinforcement is also installed. Within the structural design resistance to the forces behind the helix as the result of stressing force transfer shall be verified.

2.2 Strand protrusion for stressing and re-stressing

The protrusion of the strands beyond the anchor head serves the purpose of fitting the prestressing jack for initial stressing and re-stressing. Annexes 2 to 5 specify the strand protrusion generally required for initial stressing. The required strand protrusion and the required space for the prestressing jack might be adapted to specific project requirements after consulting BBV Systems.

2.3 Corrosion protection of the anchor (see Annexes 8 and 9)

The corrosion protection system of the anchors is shown in Annexes 8 and 9. The protective cap and the retainer cap are filled with corrosion protection mass. An inlet for the corrosion protection mass is on the upper side of the protective cap. The anchor head is coated with corrosion protection mass before fitting the retainer cap. In addition, a vent opening is on the upper side of the retainer cap. This vent opening is closed with a screw. Between protective cap and retainer cap and between retainer cap and anchor plate/cast-iron anchor body there is a seal ring (flat gasket).

3 Ducts

PE tubes in accordance with DIN EN 12201-2 are used as ducts. The trumpet is connected to the connection duct in the area of the active and passive anchor. The transition is sealed with adhesive PE tape (at least 2 turns, see Annexes 10 and 11). During the stressing process the duct moves into the larger connection duct at the active anchor. The transition on the active anchor between the connection duct and the duct shall be closed temporarily when filling with corrosion protection mass in order to prevent the escape of corrosion protection mass. The temporary seal is removed after filling and cooling of the corrosion protection mass. The transition is closed permanently after completion of the stressing works.

4 Deviators

4.1 General

The transition of the area of deviation to the free length of the tendon features a trumpet-shaped widening. In addition to the designed deviation angle α the widening permits an unintended deviation angle free of kinks with at least $\Delta\alpha \geq 3°$ in all directions. The deviation radius may not go below the minimum radius of curvature R specified in Annexes 2 to 5. It refers to the plane of curvature of the tendon (this may also be inclined with respect to the vertical). The minimum permitted radius of curvature R shall also be complied with on the trumpet-shaped opening.

4.2 Design variants of the deviators

Three types of deviation points are available:

- Deviation type F: Penetration with inserted deviation form parts

- Deviation type S: Creation of the deviation contour with form parts

- Deflection type R: Penetration with a (pre-bent) pipe

In all types of deviators the duct is guided through a greased deviation duct (Annexes 13, 14 and 15). A minimum protrusion of the deviation duct of at least 10 cm beyond the cross-beam dimensions is required on both sides. The prestressed tendon must lift off free of kinks at the end of the deviation area.

4.2.1 Deviation type F: Penetration with inserted form parts (Annex 13)

For this, a tubular penetration is made, generally by installing a recess pipe. This penetration can also be made, for instance, by core drilling. The tendon is deflected only with the aid of form parts made of plastic or steel, slid into the penetration. The form parts have the required geometry for guiding the tendon and must be adequately secured to the building structure so that duct and form parts are not dislocated when stressing. The form parts can be adapted to cross beams with different dimensions by means of an interior spacer.

4.2.2 Deviation type S: Creation of the deviator contour with form parts (Annex 14)

The deviation is produced by rotationally symmetric form parts with the aid of which the deviation geometry is formed in the structural concrete or in the precast element. A recess pipe can be installed centrally for adapting the deviation point to various lengths of crossbeams.

The intended deviation is limited to a maximum permitted angle per rotationally symmetric form part. In addition, the intended and unintended deflections are limited to a maximum permitted length max. L_{zul} (see Annex 14).

4.2.3 Deviation type R: Penetration with a pre-bent pipe (Annex 15)

The deviation is produced by a pre-bent steel pipe (corrosion-protected). Rotationally symmetric form parts which allow for an unintended deviation of $\Delta\alpha \geq 3°$ on all sides are attached to the ends of the pipe, free of kinks. One option of deviation type R is a deviation with form parts exceeding the unintended deviation. (restriction, see 4.2.2).

Deviation type R can be formed at the active anchor, whereby the requirements regarding the slip conditions shall be observed.
Deflection type R can be formed at the passive anchor if the elongation (stressing and, possibly, re-stressing) at the exit point of the building structure does not exceed 10 cm.

4.2.4 Unintended contact

Unintended contact of the tendon with the building structure is not permitted. Additional unintended deviations of $\Delta\alpha \geq 3°$ shall be arranged at the ends of the areas of deviation and at the exit of the tendon from the concrete member at the active and passive anchors. The minimum radius of curvature shall also be complied with in the area of unintended deviations. The tendon shall lift off free of kinks at the exit from the building structure.

5 Corrosion protection of the exposed steel components

Exposed and cast-in steel components with insufficient concrete coverage (e.g. bearing plates, cast-iron anchor bodies and retainer caps) are coated/galvanised with one of the following protective paint systems (see Section 2.1.9 of the Specific Conditions):

Protective paint systems in accordance with EN ISO 12944-5:2007

a) Without metallic coating: A5M.02, A5M.04, A5M.06 and A5M.07

b) With zinc coating (galvanised): A7.10, A7.11, A7.12 and A7.13

The surfaces shall be prepared in accordance with EN ISO 12944-4:1998. EN ISO 12944-7:1998 shall be complied with when carrying out the paint work.

6 Assembly of the tendons

6.1 Components for casting

On site, bearing plates, cast-iron anchor bodies, trumpets, connection ducts, form parts of the anchor zones, helixes and additional reinforcement are cast in concrete. According to the design, penetration tubes (straight or curved) and, if necessary, form parts are cast in concrete at the deviation points. Deviation points can also be made only with form parts and, if necessary, with recess tubes depending on length of the cross beams. At existing structures, recesses can also be produced e.g. by core drilling.

6.2 Installation of the tendons

6.2.1 Installation of the duct (see Annex 16)

Initially, ducts are pulled into the structure. A transition electrowelding sleeve shall be used for providing a tensile-proof connection between the duct and the connection duct at the active anchor. The duct is then slid into the connection duct at the active anchor to such an extent that the duct lays approx. 10 cm beyond the intended and unintended deviation area in the direction of the active anchor (see Annexes 10 and 12).

The length of the connection duct from the trumpet to the duct at the active anchor shall permit movements with complete outer gliding of the duct while tightening, stressing and possible re-stressing process. The connections of the duct to the connection duct and duct joints on the free length shall be created tensile-proof connection by butt welding with heat elements or by electrowelding sleeves.

6.2.2 Installation of the strands

The strands shall be pulled into the installed ducts either by strand pushing machine or by cable winch.

6.2.3 Tightening of the strands

If tendons have deviation points, they are tightened to a pre-load after pulling in. Deviated tendons have a pre-load of at least 5 % and maximum 10 % of Fpk. The joint between duct and connection duct at the active anchor is temporarily sealed before filling with corrosion protection mass (see Point 3 and Annex 16).

In case of straight tendons (without intended or unintended deviation), the strands can be stressed completely up to the target load. No shifting of the duct occurs during tightening and subsequent stressing. No chain hoist in accordance with Point 7 is used. No measures are required for influencing the gliding conditions.

The duct is filled up with hot corrosion protection mass (maximum approx. 100 °C). Filling generally starts in front of a low point near to an anchorage. Further filling openings are provided with a distance of maximum 100 m to each other apart (in generally in front of a low point). Filling can then continue from these openings. Appropriate supply lines for the corrosion protection mass must be built in at these openings.

6.2.5 Post-Injection at high points (Annexes 16 and 17)

After the filled tendon has cooled, all high points shall be post-injected with cold corrosion protection mass. In order to do this, an inlet or a venting opening must be drilled in front of and behind each deviation point. A thermometer is used to measure the temperature of the corrosion protection mass. In case of temperatures < 30 °C, the high point can be post-injected. A pressure-resistant inlet connecting branch is fixed at the inlet and the supply hose is connected to it. The distance between venting openings of the tendon and the deviation points must be selected in each case so that the definite filling of the tendon's high point is ensured.
The distance between the inlet or venting openings and the deviation points must be selected adequately large that the inlet or venting openings do not move into the deviation area during stressing and re-stressing. Post-injection is finished as soon as corrosion protection mass emerges from the venting opening. Continuous escape of the corrosion protection mass from the venting opening ensures that the high point is reliably permanently protected against corrosion. Subsequently, the openings are sealed professionally with press-fit or sealing-lip closure plugs. By knocking on the duct, it is checked that the duct has been filled completely. Any not filled points shall be post-injected.

7 Initial stressing/stressing

Before initial stressing, the ducts are marked at all deviation points in the direction of the active anchor and at the active anchor (Annex 18). The distance between these markings and the deviation point (e.g. edge of cross beam) shall be measured and recorded before stressing. The mobility of the telescoping joint at the active anchor must be ensured before starting stressing (removal of the temporary seal). On tendons with deviation point(s), mainly outer gliding is required when stressing. Suitable measures must be taken to ensure that the elongation/ movement of the strand and the movement of the duct are parallel. This can be done by means of a chain hoist for instance.

A hydraulic pump unit and a stressing jack are used to stress the tendons. All strands of a tendon are gripped and stressed simultaneously. In case of straight tendons, optionally a single-strand stressing jack can be used. Step-by-step stressing and re-setting of the jack are possible. When stressing, it must be ensured that the duct is moved continuously in accordance with the elongation/movement of the strands (for instance by using a chain hoist for assistance). The duct has to be marked in order to check the duct movement (Annex 18).

The strands are stressed to target load. The duct is moved in parallel in accordance with the elongation by force-fit connection between strand and duct at the deviation points (outer gliding). The movement of the ducts during stressing at the deviation points and in front of the active anchor is determined by measuring the change in spacing between the markings made beforehand and the reference point. These movements are compared with the theoretical elongation of the strands. The relative movement (difference between the movements) between strands and duct (inner gliding) must not exceed 10 % of the total elongation of the strands or 10 cm respectively (the lower of the two values is the decisive value). The duct may not be compressed at the active anchor.

After stressing, the wedges will be pressed into the wedge seat using a wedge seating device. A wedge slip of approx. 3 mm occurs when the stressing force is released.

8 Final works

After completion of the stressing works, the join between duct and connection duct is closed by a transitional electrowelding sleeve for instance. Active and passive anchor are protected against corrosion with a retainer cap and a protective cap. The protective cap covers the strand protrusion and both protective cap and retainer cap are filled completely with corrosion protection mass trough an inlet (see Point 2.3).

9 Re-stressing

A strand protrusion can be planned at the active anchor/ passive anchor for future re-stressing of the tendon after removal of the protective cap and the retainer cap. Based on gliding conditions recorded in the stressing record, it is decided whether the connection between duct and connection duct at the active anchor shall be opened. If opening is necessary, the connection has to be relocked professionally after re-stressing (see Point 8). Professional corrosion protection of the anchorage has to be re-established (see Point 8). During re-stressing, it must be ensured that the relative movement between strands and duct (inner gliding) does not exceed 10 % of the total elongation/ movement of the strands or 10 cm respectively (the lower of the two values is the decisive value). The movements already achieved when stressing have to be considered additionally (see Point 7) (regardless of stressing direction). The duct may be pulled in longitudinal direction at the active anchor in order to assist outer gliding, e.g. with a chain hoist. If using a chain hoist, use an accurately fitting steel clamp for connection to the duct (drawing submitted to DIBt).

10 Check of stressing force

The stressing force may be checked, for instance, by lifting the anchor head approximately 1-2 mm off of the bearing plate/ cast-iron anchor body by means of a stressing jack. The stressing force required for this is considered to be the current stressing force. The stressing jack is positioned on of a stressing chair which transfers the force to on the bearing plate/ cast-iron anchor body. The wedges are not released during this operation.

11 Replacing a tendon

If it becomes necessary to replace a tendon, the tendon must be cut close to an anchor or deviation point (safety aspect). Subsequently, all movable anchorage and deviation components are removed. The bearing plate/ cast-iron anchor body, trumpet, connection duct and other cast-in parts remain in the building structure. The new tendon can then be installed in the same way as the original tendon. Before pulling in the strands, the transitional area between the trumpet and the connection duct on the stressing anchorage has to be examined for signs of damage and if necessary has to be repaired. All installation steps described shall be followed.