Deutsches Institut für Bautechnik

Anstalt des öffentlichen Rechts

Kolonnenstr. 30 L
10829 Berlin
Germany

Tel.: +49(0)30 787 30 0
Fax: +49(0)30 787 30 320
E-mail: dibt@dibt.de
Internet: www.dibt.de

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)

DIBt

Mitglied der EOTA
Member of EOTA

European Technical Approval ETA-10/0006

English translation prepared by DIBt - Original version in German language

Handelsbezeichnung *Trade name*	VBT BE 1 bis 16 *VBT BE 1 to 16*
Zulassungsinhaber *Holder of approval*	Vorspann-Brückentechnologie GmbH Ruchtifeldsiedlung 51 5303 THALGAU ÖSTERREICH
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	Externes verbundloses Litzenspannverfahren VBT BE 1 bis 16 *External bondless post-tensioning system VBT BE 1 to 16*
Geltungsdauer: vom *Validity: from*	25 March 2010
bis *to*	25 March 2015
Herstellwerk *Manufacturing plant*	Vorspann-Brückentechnologie GmbH Am Schusterbach 18 5310 MONDSEE ÖSTERREICH

Diese Zulassung umfasst *This Approval contains*	36 Seiten einschließlich 15 Anhänge *36 pages including 15 annexes*

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.

5 Reproduction of this European technical approval including transmission by electronic means shall be in full. However, partial reproduction can be made with the written consent of Deutsches Institut für Bautechnik. In this case partial reproduction has to be designated as such. Texts and drawings of advertising brochures shall not contradict or misuse the European technical approval.

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 the product and intended use

1.1 Definition of the construction product

The present European Technical Approval applies to a kit:

VBT-BE External Bondless Strand Post-Tensioning System

consisting of 1 to 16 strands with a nominal tensile strength 1770 N/mm² or 1860 N/mm² (Y1770S7 or Y1860S7), nominal diameter 15,3 mm (0,6“ - 140 mm²) and 15,7 mm (0,62“ - 150 mm²) which are used with following anchorages (stressing anchor and fixed anchor; see Annex 1):

1 Stressing (active) anchor and fixed (passive) anchor with anchor plate (type P) and anchor block for tendons of 1 to 16 strands,

2 Bursting reinforcement (helixes and additional reinforcement/stirrups)

3 Corrosion protection

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

1.2 Intended use

The Post-Tensioning System is assumed to be used for the prestressing of structures.

Categories of use according to type of tendon and material of structure:

External tendon for concrete structures with a tendon path situated outside the cross section of the structure or member but inside its envelope

Optional categories of use:

Restressable tendon

Exchangeable tendon

Tendon for use in structural steel or composite construction as external tendon

When used in steel structures, the zone of force transfer has to be designed to resist 1.1 F_{pk} according to EN 1993-1-1:2005 and EN 1993-1-1:2005/AC:2008.

The structural members used to be designed in accordance with national regulations.

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 correspond to 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 assembling of the tendons shall correspond to the attached description and drawings; the dimensions and materials shall comply with the values given therein.

---

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

2.1.2 Designation

End anchorages can be used as stressing and fixed anchors.

e.g.: VBT-BE 4x4-150-1860 or
VBT-BE 16-150-1860

The first number of the designation identifies the number of strands (16) or the number of strand for each band and the number of bands (4x4). An additional first letter of designation defines the type of anchorage (P - plate anchorage). The nominal cross section area of single strand is given by the following number (e.g. "150" for 150 mm²) and the strength of the strands is given by the last number (e.g. "1860" for Y1860S7).

The components (including helix and additional reinforcement) fit for tendons with both nominal section area and steel grade of strands.

2.1.3 Strands

Only 7-wire stands shall be used in accordance with national provisions with the characteristics given in Table 1.

Table 1: Characteristic of 7-wire strands in accordance to prEN 10138-3:2009[8]

Designation of strand			**Y1770S7**	**Y1860S7**	**Y1770S7**	**Y1860S7**
Tensile strength	R_m	[N/mm²]	1770	1860	1770	1860
Diameter	d	[mm]	15,3	15,3	15,7	15,7
Nominal cross sectional area	A_p	[mm²]	140	140	150	150
Nominal mass per meter	m	[kg/m]	1,093	1,093	1,172	1,172
Permitted deviation from nominal mass		[%]	±2			
Characteristic value of maximum force	F_{pk}	[kN]	248	260	266	279
Characteristic value of 0.1% proof force	$F_{p0,1}$	[kN]	213	224	229	240
Minimum elongation at max. force, L_0≥500mm	A_{gt}	[%]	3,5			
Relaxation after 1000h						
At 0,7 . f_{pk}		[%]	2,5[9]			
At 0,8 . f_{pk}		[%]	4,5[10]			
Modulus of elasticity	E_p	[N/mm²]	195000[11]			

To avoid confusions 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 prestressing strands with very low relaxation shall be used.

The prestressing strands are equipped with corrosion protection, consisting of grease and the protection sheath (sheath 1) of high-density polyethylene. The sheath has defined minimum initial wall thicknesses (see Annex 10, section 4.2). The manufacturer covers these mono strands with a second outer protection sheath (sheath 2) of high-density polyethylene of a thickness of 3 mm (see Annex 2), which can encompass two or four mono strands into one band.

The sheath 2 is cut open in the middle of one of both narrow sides in longitudinal direction and the mono strands (2 or 4 see Annex 2) are embedded. Afterwards the sheath 2 is closed by mirror-imaged welding or by V-welds again. Welding works shall be carried out only by plastic welders instructed by the manufacturer.

8 Suitable strands according to standards and regulations valid at the place of use may also be used.

9 For specific applications the relaxation requirement may be agreed between supplier and purchaser at time of enquiry and order.

10 The requirement for 0,7f_{pk} is mandatory. Values for 0.8f_{pk} may be agreed at time of enquiry and order.

11 Standard value

2.1.4 Ring wedges

Ring wedges (see Annex 8) consisting of three parts are used. Single parts are fixed together by a spring ring.

Wedges of one supplier only may be used at one construction site.

2.1.5 Anchor blocks

The anchor blocks of stressing and fixed anchorages are identical. Determination is only needed due to execution of construction works.

The conical drills of the anchor blocks shall be clean, stainless and provided with grease.

2.1.6 Anchor plate

The anchor plates have a quadratic form (see Annex 5 and Annex 11, page 2).

2.1.7 Helixes and additional reinforcement (stirrups)

The steel grade and dimensions of the helixes and of the additional reinforcement shall comply with the values given in Annex 12. The central position in the structural concrete member on site shall be ensured according the section 4.2.3.

Each end of the helix shall be welded to a closed ring. The welding of inner end of helix can be omitted if the length of helix is increased by 1 ½ additional turns.

2.1.8 Trumpets

The trumpets at stressing and fixed anchors are manufactured from 8 mm thick PE-Material (see Annex 4). If the trumpets are made of steel special requirements on the mono strand wall thickness or inserts are necessary (see Annex 10, 4.1).

In addition to the well-planned length of the straight part of the trumpet the trumpet-like expansions about the length D_a (see Annex 4) are to be intended at the end to allow variations of the tendon from the well-planed position. The value from $D_a = \Delta\alpha * R$ depends on the radius of curvature R and the angle $\Delta\alpha$ [radian]. If at the place of the use no other regulation is valid $\Delta\alpha = 0.05$ rad (corresponds to 3°) is recommended. The radius R shall not be less than the appropriate minimum radius given in Annex 10, section 4.2.1.

2.1.9 Corrosion protection

If corrosion protection in the area of anchorages is done by grout according to EN 445:2007 it shall be proceeded according to EN 447:2007.

If corrosion protection is done by special filling materials only for the system applicable greases according to an ETA based on ETAG 013, C4.1 or according to national regulations valid at the place of use shall be used.

Parts of the prestressing strands at the end anchors, which are not protected through a high-density polyethylene sheath (protective sheath 1), shall be completely covered by transitions pipes, protections caps, cover pipes etc.

At the final stage the length of overlapping of protective sheath 1 into the transition pipes shall be ≥ 200 mm (see Annex 6) and the length of overlapping of protective sheath 2 into the trumpet shall be ≥ 500 mm (see Annexes 4). If these lengths cannot be provided special measures has to be carried out in respect to the project conditions.

Appropriate sealants shall be applied accurately. The cavities shall be completely filled with grease (see Annex 13 and 14, page 2).

2.1.10 Corrosion protection of uncovered steel parts

Any steel parts, which are not protected by concrete, cement grout or corrosion protection grease, shall be, unless made of stainless steel, protected against corrosion by one of the following protections systems of EN ISO 12944-5:2008:

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

b) galvanized: A7.10, A7.11, A7.12, A7.13

Surface preparation shall be carried out in accordance with EN ISO 12944-4:1998; corrosion protection operations shall be carried out in accordance with EN ISO 12944-7:1998. Local approved and well-known corrosion protection principles can be used instead.

2.1.11 Description of the Prestressing System

Construction of the tendons, design of the anchors, deviation saddles, anchoring elements and corrosion protection shall be in accordance with the descriptions and drawings in the attached Annexes. The measurements and material parameters as well as the production process of tendons and corrosion protection shall comply with the described details.

The tendons can be tensioned from one or both sides.

2.1.12 Deviation Saddles

Deviations saddles shall be designed as specified in Annex 9. Especially the minimum radii in Annex 10, section 4.2.1 in every case shall be kept. If due to unexpected situations the minimum radii are not kept, inserts and adjustments to the existing saddles are allowed to meet the requirements, while maintaining all in this ETA specified guidelines.

Deviation saddles may be covered by a sliding agent in the areas touched by tendons before the installation of the tendons, to assist more far-reaching outside sliding.

In addition to the well-planned length of the deviation saddles trumpet-like expansions about the length D_a (see Annex 9) are to be intended at the ends to allow variations of the tendon from the well-planed position. The value from $D_a = \Delta\alpha * R$ depends on the radius of curvature R and the angle $\Delta\alpha$ [radian]. If at the place of the use no other regulation is valid $\Delta\alpha = 0.05$ rad (corresponds to 3°) is recommended. The radius R shall not be less than the appropriate minimum radius given in Annex 10, section 4.2.1.

2.1.13 Protection cap

The protection caps are made of plastics or metal sheets and fitted by screws onto the anchor block.

2.2 Methods of verification

2.2.1 General

The assessment of the fitness of the VBT-BE External Bondless Strand Post-Tensioning System for the intended use in the 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 kit manufacturer that the product does not contain any dangerous substances.

In addition to the specific clauses related to dangerous substances contained in the European Technical Approval, there may be other requirements applicable to the products failing 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 prestressed by means of the VBT-BE External Bondless Strand Post-Tensioning System used to be designed in accordance with national regulations.

2.2.2 Tendons

Prestressing and over-tensioning forces are specified in the respective national provisions.

The maximum force P_0 in accordance with EN 1992-1-1:2004 and EN 1992-1-1:2004/AC:2008, clause 5.10.2.1 shall not exceed the force $P_{0,max}$=min{0.9 A_p $f_{p0,1k}$, 0.8 A_p f_{pk}) laid down in Table 2 (140 mm²) or in Table 3 (150 mm²). The value of the initial prestressing force P_{m0} immediately after tensioning and anchoring in accordance with EN 1992-1-1:2004 and EN 1992-1-1:2004/AC:2008, clause 5.10.3 shall not exceed the force $P_{m0,max}$ = min{0.8 $F_{p0.1k}$; 0.75 F_{pk}} laid down in Table 2 (140 mm²) or in Table 3 (150 mm²). Overstressing is permitted if the force in the prestressing jack can be measured to an accuracy of ±5% of the final value of the prestressing force. In such case the value of the maximum prestressing force P_{max} in accordance with EN 1992-1-1:2004 and EN 1992-1-1:2004/AC:2008, clause 5.10.2.1(2) shall not exceed the force P_{max}=0.95 $F_{p0,1k}$ laid down in Table 2 (140 mm²) or in Table 3 (150 mm²).

Table 2: Maximum prestressing forces[12] for tendons with A_p=140mm²

Tendon Designation	Number of strands	Cross sectional area A_p	Y1770S7 $f_{p0,1k}$=1500N/mm²			Y1860S7 $f_{p0,1k}$=1600N/mm²		
			$P_{m0,max}$	$P_{0,max}$	P_{max}	$P_{m0,max}$	$P_{0,max}$	P_{max}
[-]	[-]	[mm²]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]
1-140	1	140	181	192	202	190	202	213
2-140	2	280	362	383	404	381	403	426
2x2-140 1x4-140	4	560	724	766	809	762	806	851
2x4-140	8	1120	1447	1532	1617	1523	1613	1702
3x4-140	12	1680	2171	2298	2426	2285	2419	2554
4x4-140	16	2240	2894	3064	3235	3046	3226	3405

Table 3: Maximum prestressing forces for tendons with A_p=150mm²

Tendon Designation	Number of strands	Cross sectional area A_p	Y1770S7 $f_{p0,1k}$=1500N/mm²			Y1860S7 $f_{p0,1k}$=1600N/mm²		
			$P_{m0,max}$	$P_{0,max}$	P_{max}	$P_{m0,max}$	$P_{0,max}$	P_{max}
[-]	[-]	[mm²]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]
1-150	1	150	194	205	217	204	216	228
2-150	2	300	388	410	433	408	432	456
2x2-150 1x4-150	4	600	775	821	866	816	864	912
2x4-150	8	1200	1550	1642	1733	1632	1728	1824
3x4-150	12	1800	2326	2462	2599	2448	2592	2736
4x4-150	16	2400	3101	3283	3466	3101	3456	3648

12 The forces stated are maximum values. The actual values are to be found in national regulations valid on place of use. Compliance with the stabilisation and crack width criteria in the load transfer test was verified to a load level of 0.80 F_{pk}.

The number of strands in a tendon may be reduced by leaving out strands lying symmetrically in the anchor block. The provisions for tendons with completely filled anchor blocks (basic type) also apply to tendons with only partly filled anchor blocks. Into the unfilled cones of the anchor blocks short pieces of strands with wedges have to be pressed to assure a sufficient bending stiffness of the anchor blocks.

The admissible prestressing force is reduced per strand left out as shown in Table 4:

Table 4: Reduction of the prestressing force when leaving out one strand

Cross section area	**Y1770 S7**			**Y1860 S7**		
Ap	**ΔP_{m0}**	**ΔP_0**	**ΔP_{max}**	**ΔP_{m0}**	**ΔP_0**	**ΔP_{max}**
[kN]	[kN]	[kN	[kN]	[kN]	[kN	[kN]
140	181	192	202	190	202	213
150	194	205	217	204	216	228

2.2.3 Losses of the prestressing force due to friction

The losses of the prestressing force due to friction and wobble effects may normally be determined in the calculation by using the friction coefficients μ and the unintentional angular displacement k (wobble coefficient) given in Table 5.

Table 5: Friction and wobble effects

Number of stacked band layers	**Friction coefficient**		**Wobble coefficient**
	Without low friction saddle (see Annex 9)	With low friction saddle (see Annex 9)	
[-]	[rad^{-1}]	[rad^{-1}]	[°/m]
1	0,06	0,03	0
2	0,08		
3	0,10		
4	0,12		

2.2.4 Radius of curvature of the tendons in the deviators

The smallest admissible radii of curvature are given in Annex 10, section 4.2.1.

An analysis of the edge stresses in the strands can be omitted while following this curvature values.

2.2.5 Concrete strength

Concrete complying with EN 206-1:2000 and EN 206-1:2000/A2:2005 shall be used.

At the time of transmission of the full prestressing force to the concrete member the mean concrete strength in the anchorage one shall be at least $f_{cmj,cube}$ or $f_{cmj,cyl}$ according to Table 6. The mean concrete strength ($f_{cmj,cube}$ or $f_{cmj,cyl}$) shall be verified by means of at least three specimens (cube with the edge length of 150 mm or cylinder with diameter of 150 mm and height of 300 mm), which shall be stored under the same conditions as the concrete member, with the individual values of specimens not differ no more than 5%.

Table 6: Necessary mean concrete strength f_{cmj} of the specimens at time of prestressing

$f_{cmj,cube}$ [N/mm²]	**$f_{cmj,cyl}$ [N/mm²]**
30	25
37	30

For partial prestressing with 30% of the full prestressing force the actual mean value of the concrete compressive strength to be proved is 0.5 $f_{cmj,cube}$ or 0.5 $f_{cmj,cyl}$; intermediate values may be interpolated linearly.

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 less than the values given in the Annex 12 depending on the actual mean concrete strength.

The values of the centre or edge distances of the anchorages given in the Annex 12 may be reduced in one direction up to 15%, however, not to a lesser value than the minimal distance between the additional reinforcing bars or the external diameter of the helix plus 2cm. In this case the centre or edge distances of the anchorages in the other direction shall be increased for keeping the same concrete area in the anchorage zone. The dimensions of the additional reinforcement shall be adjusted accordingly.

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

The concrete cover may under no circumstances be less than 20 mm nor smaller than the concrete cover of the reinforcement installed in the same cross section. The concrete cover of the anchorage should be at least 20 mm. Standards and regulations on concrete cover valid in place of use shall be considered.

2.2.7 Reinforcement in the anchorage zone

The anchorages (including reinforcement according to Annex 12) for the transfer of the prestressing forces to the structural concrete are verified by means of tests. The resistance to the forces occurring in the structural concrete in the anchorage zones outside the helix and the additional reinforcement 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 shall not be taken into account as part of the statically required reinforcement. Existing reinforcement in a corresponding in excess to the reinforcement required by design may be taken into account for the additional reinforcement. The additional reinforcement shall consist of closed stirrups (stirrups closed by means of bends or hooks or an equivalent method) or of orthogonal reinforcement properly anchored. The stirrup locks (bends or hooks) shall be paced staggered.

In the anchorage zone vertically led gaps shall be provided for proper concreting and compacting. If in exceptional cases[13] - due to an increased amount of reinforcement - the helix or concrete cannot be properly placed, the helix can be replaced by different equivalent reinforcement.
Force transmission from the deviators into the structure must be statically verified.

2.2.8 Slip at the anchorages

The slip at the anchorages (see section 4.2.4) shall be taken into account in the static calculation and the determination of the tendon elongation.

13 This requires an individual investigation of the responsible project designer, or an approval for individual case according to the national regulations and administrative provisions.

2.2.9 Resistance to fatigue of the anchorages

With the fatigue test carried out in accordance with ETAG 013, the stress range of 80 N/mm² of the anchorages at the maximum load of 0,65 f_{pk} at $2x10^6$ load cycles was verified.

2.2.10 Inner sliding path on the deviation saddles

The inner sliding path (relative movement of the strands to sheath 1) on the deviation saddles (prestressing, restressing and possible releasing of the prestressing force) must not, in relation to the curvature radius, exceed the permissible values according to Annex 10, section 4.2. The minimum radii must not fall below the specification in Annex 10, section 4.2.1.

2.2.11 Guidance of Tendons through Construction

Where tendons are guided through the construction an appropriate size of the opening in the construction part, taking the production tolerance into account, must be provided to make sure that the tendons do not touch the construction part. When used as prevention of cross oscillation of the tendons as described in section 2.2.12, the guiding-through shall be carried out like a deviation saddle.

2.2.12 Prohibition of transversal oscillation of tendons

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

If at the place of the use no other regulation is valid for bridges of box sections a fixing distance of 35 m is recommended. Outside of box sections smaller fixing distance are necessary. The fixings shall be performed in such a manner that the tendon, especially sheath 2, shall not be damaged and the movement in longitudinal direction of the tendon is not limited.

2.2.13 Protection of the Tendons

The tendons may be protected against malfunction resulting from extraneous cause (e.g. vehicle impact, elevated temperature in case of fire, vandalism). The requirements must be individually investigated and rated according the project conditions. Tendons enclosed by a box girder are classified as sufficiently protected.

2.2.14 Lengths of Transitions Pipes and Overlapping of Protection Sheath 2

The required lengths of the transition pipes as well as the required overlapping of protection sheath 2 into the trumpets shall be specified under consideration of all possible influences, in particular temperature differences during construction, movements caused by prestressing and construction tolerances, in order to make sure that the minimum overlapping of both protection sheaths in the final state (see section 2.1.9 and Annexes 4 and 6) are reached. This specification must be approved by or in matching with the approval holder.

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[14] system 1+ of the attestation of conformity applies.

This system of attestation of conformity is defined as follows:

System 1+: Certification of the conformity of the product by an 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

14 Official Journal of the European Communities L 201/112 of 3 July 1998

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 kit manufacturer shall keep available an updated list of all components manufacturers. The list is provided to the Certification Body and to the Approval Body.
The kit manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the kit manufacturer shall be documented in a systematic manner in the form of written policies and procedures, including records of results performed. This production control system shall insure that the product is in conformity with this European Technical Approval.

The kit 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 March 2009 relating to the European Technical Approval ETA 10/0006 issued on 25 March 2010" 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 with Deutsches Institut für Bautechnik.[15]

The basic elements of the Control Plan comply with ETAG 013, Annex E1 (see Annex 14).

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
- Results of controls and tests and, where specified, comparison with the requirements
- Name and signature of person responsible for the factory production control

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

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

---

15 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.

The kit manufacturer shall make a declaration of conformity, stating that the construction product is in conformity with the provisions of the European Technical Approval ETA-10/0006 issued on 25 March 2010.

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

At least once a year, each components manufacturer shall be audited by the kit manufacturer (see ETAG 013, 8.2.1.1).

3.2.2 Tasks for approved bodies

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 March 2010 relating to the European Technical Approval ETA-10/0006 issued on 25 March 2010".

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 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 Deutsches Institut für Bautechnik without delay.

3.2.2.2 Initial 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 be 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 twice a year. Each factory of the components listed in Annex 14 shall be audited at least once in five years. 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 kit manufacturer

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 15 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 15).

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 or identifying mark of the kit manufacturer and of the production plant (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)
- The nominal cross sectional area and the characteristic value of 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 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 Deutsches Institut für Bautechnik before the changes are introduced. Deutsches Institut für Bautechnik will decide whether or not such changes affect the approval and consequently the validity of the CE marking on the basis of the approval and if so whether further assessment or alterations to the approval shall be necessary.

The tendons may be manufactured on the site or in the manufacturing plant (prefabricated tendons).

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 this VBT post-tensioning system. 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. National standards and regulations valid on site shall be considered.

The ETA holder is responsible to inform anyone concerned about the use of this VBT post-tensioning system.

The tendons and the components shall be handled carefully.

4.2.2 Welding

Steel welding at the anchorages is only permitted at the following points:

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

b) For ensuring the central position the helix may be attached to the bearing plate or anchor body by welding

c) Welding on additional reinforcement, e.g. to close the stirrups

After placing the tendons no more welding works shall be performed at the anchorages.

4.2.3 Installation of tendon

The central position of the helix or stirrups shall be ensured by tack-welding to the bearing plate or the anchor body or other appropriate mountings. The bearing plate or anchor body and the anchor head shall be in direction perpendicular to the axis of the tendon.

4.2.4 Wedging force, slip at anchorages, wedge securing and corrosion protection compound

The wedges of all anchorages (fixed anchorages) which are no longer accessible during tensioning shall be secured by means of pre-wedging with 1.2 $P_{m0,max}$ during installation. In the case of pre-wedging no slip shall be taken into account for the determination of elongation.

Pre-wedging is not necessary if wedges of fixed anchorages are secured by retainer discs. In this case a slip within the fixed anchorage of 6 mm shall be taken into account for the determination of elongation.

At stressing anchorage the slip of wedge is 6 mm and shall be taken into account for the determination of elongation. The slip is measured by the strand placed measuring marks behind the anchorage. The slip of the wedges is 1 mm smaller as the slip of the strand. During installation of wedges into the cones all relevant surfaces and clearances shall be protected against corrosion by grease. The material specifications of these greases are deposited at Deutsches Institut für Bautechnik.

4.2.5 Tensioning and stressing records

4.2.5.1 Tensioning

At time of stressing the minimum mean concrete strength shall comply with the values given in section 2.2.5.

Once 30% of the prestressing force has been reached tendons at all deviation saddles shall be labelled, so that the movement of the protection sheath 2 on each band in respect to the deviation saddle can be clearly determined when the prestressing is being continued.

The inner sliding path is the difference between the calculated elongation of the tendon on the saddle and the measured movement of the protection sheath 2 at the deviator (outer sliding path). The value of inner sliding (prestressing, restressing and possible releasing of the prestressing force) must not exceed the maximum permissible value in dependence of radius of curvature (see Annex 10, 4.2.2) of each deviator. The measured movement shall be recorded for each tendon and deviation saddle.

The strain of the protection sheath 2 shall be less then 1.5 % over the whole length of the tendon. Therefore it is sufficient to verify for every straight part of the tendon that the average strain does not exceed this value. As a function of the kind of limitation of the straight part of the tendon the average strain arises as follows:

1.) the straight part of the tendon is limited by two deviation saddles:
ratio between the difference of outer sliding at the two deviation saddles and the length of the straight part of the tendon

2.) the straight part of the tendon is limited by a deviation saddle and a stressing anchor:
ratio between the difference of outer sliding at the deviation saddle and the stressing anchor and the length of the straight part of the tendon

3.) the straight part of the tendon is limited by a deviation saddle and a fixed anchor:
ratio between the outer sliding at the deviation saddle and the length of the straight part of the tendon

The labelling and testing procedure can be renounced if the total elongation of the tendon at any deviation saddle does not exceed the maximum value of inner sliding given in Annex 10, section 4.2.2 and in no straight part of the tendon the average strain of 1.5% is crossed. As a function of the kind of limitation of the straight part of the tendon the average strain arises as follows:

1.) the straight part of the tendon is limited by two deviation saddles:
ratio between the total elongation of the tendon at the deviation saddle which is closer to the stressing anchor and the length of the straight part of the tendon

2.) the straight part of the tendon is limited by a deviation saddle and a stressing anchor:
ratio between the total elongation of the tendon at the stressing anchor and the length of the straight part of the tendon

3.) the straight part of the tendon is limited by a deviation saddle and a fixed anchor:
ratio between the total elongation of the tendon at the deviation saddle and the length of the straight part of the tendon

The minimum straight length for tensioning behind the anchorages (strand protrusion see Annex 7) depends on the jack which is used on site (appropriate information are available at the ETA holder). All strands of a tendon should be stressed simultaneously. This can be done by centrally controlled individual jacks, single band jacks or by a bundle jack. If simultaneously stressing is not possible the inner sliding of any band shall not exceed the values given in Annex 10, section 4.2.2 (appropriate information of special measures to fulfil this condition are available at the ETA holder).

4.2.5.2 Stressing record

All stressing operations shall be recorded for each tendon. In general, the required prestressing force shall be achieved. The elongation is measured and compared with the calculated value.

If during tensioning the difference between measured and calculated elongation or tensioning force is more than 5% for the sum of all tendons at the cross or 10% for a single tendon of the calculated value then the engineer shall be informed and the causes shall be found.

Local standards and national regulations valid in place of use shall be considered.

4.2.5.3 Restressing

It is admissible to restress the tendons by releasing and re-using the wedges. After restressing and anchoring, wedge marks on strands resulting from first stressing shall be moved to the outside by at least 15 mm. For restressing a minimal overlength of the strands is necessary (see Annex 7).

4.2.5.4 Prestressing jacks and space requirements, safety-at-work

For stressing works hydraulic jacks are used. Information about the stressing equipment has been submitted to Deutsches Institut für Bautechnik.

To stress the tendons, minimal clearance behind the anchorages according to the information of the system holder is necessary.

The safety-at-work and health protection regulations shall comply with.

4.2.6 Grouting of the wholes in the trumpet

After stressing either with grout for prestressing tendons according to EN 445:2007 or grease (see Annex 13 and Annex 14, page 2) can be used to grout the anchorages.

Grouting procedures with grout for prestressing tendons according to EN 445:2007 shall be carried out in accordance with EN 446:2007. The requirements of the quality management according to this standard shall be fulfilled. Local standards and national regulations valid in the place of use shall be considered.

4.2.7 Grouting of the cavities in the anchor blocks, between transition pipe and strand and in the protection cap

The cavities in the anchor block and between transition pipes and strands are filled with grease (see Annex 13 and Annex 14, page 2). Grouting occurs with a special fat press from the external side of the anchor blocks. It should be taken care to completely fill the remaining space. This shall be controlled afterwards by comparing of the volume, sound control by knocking or other adequate methods.

After the fastening of the protection caps (see Annex 7) these are also grouted with grease.

5 Packing, transport and storage

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

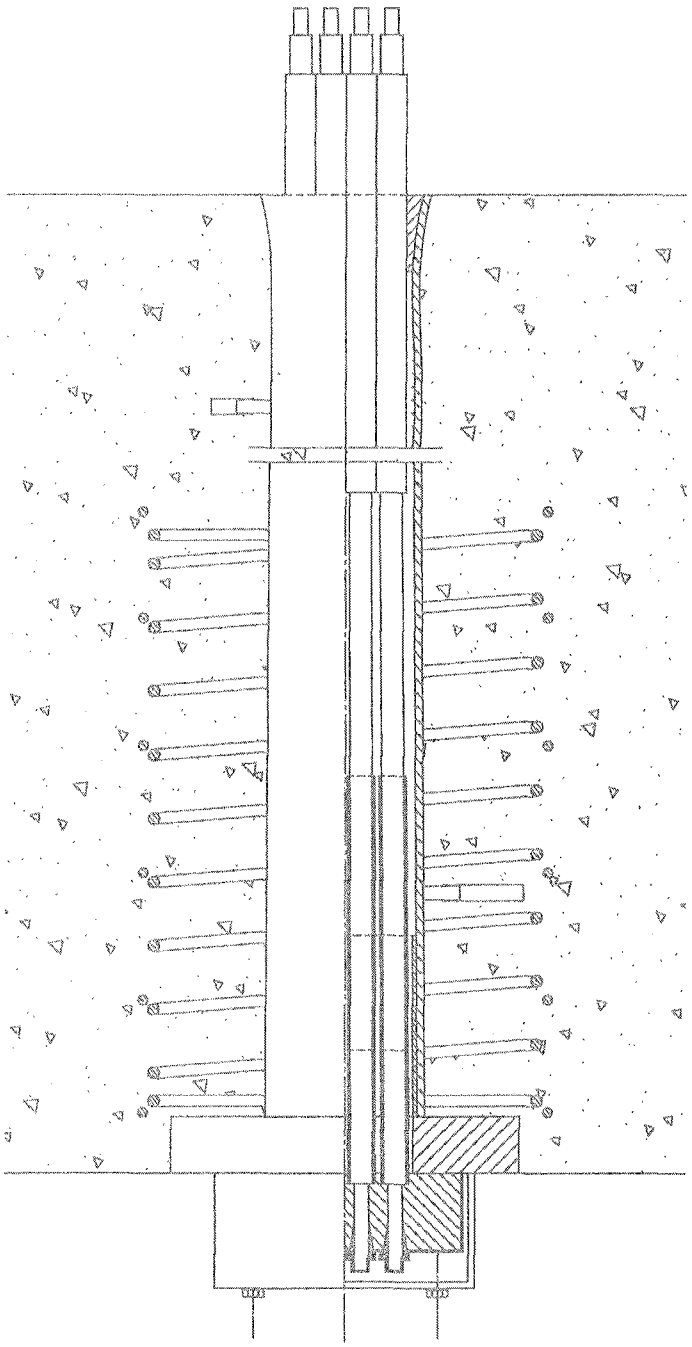
The tendons shall be kept away from areas where welding procedures are performed

During transport the smallest admissible diameter of curvature of tendons is 1.10 m.

Dipl.-Ing. Georg Feistel
Head of Division Construction Engineering
of Deutsches Institut für Bautechnik
Berlin, 25 March 2010

beglaubigt
Dr.-Ing. Alex

FIXED AND STRESSING ANCHORAGE



External Bondless
Post-Tensioning System
VBT-BE

VBT systems

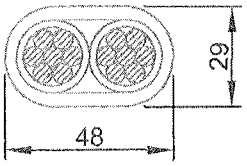
ANNEX 1

of European
Technical Approval
ETA-10/0006

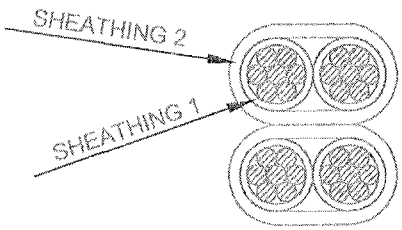
Overview

VBT-BE 1-150

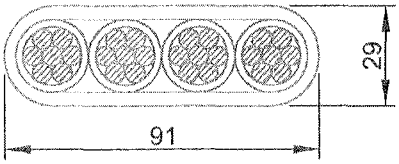
VBT-BE 2-150



VBT-BE 2x2-150

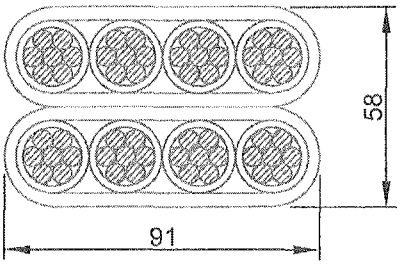


VBT-BE 4-150

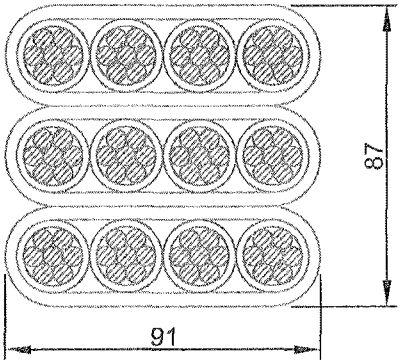


ALL MEASURES IN [mm]

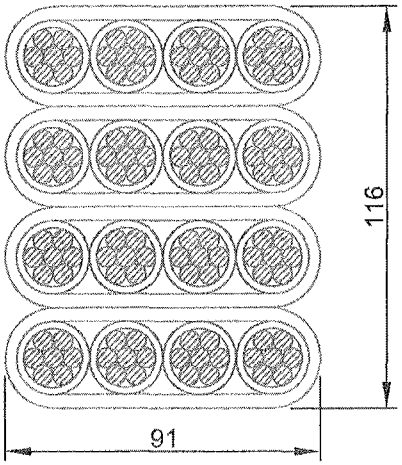
VBT-BE 2x4-150



VBT-BE 3x4-150



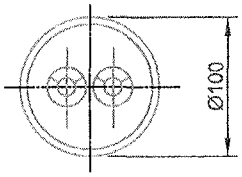
VBT-BE 4x4-150



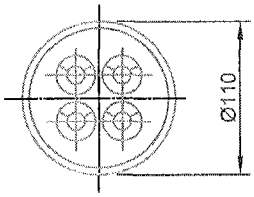
External Bondless Post-Tensioning System VBT-BE	VBT systems	ANNEX 2
Tendons, Types of Bands		of European Technical Approval ETA-10/0006

VBT-BE 1-150

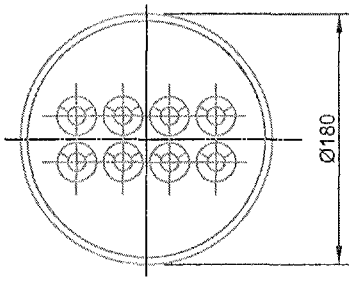
VBT-BE 2-150



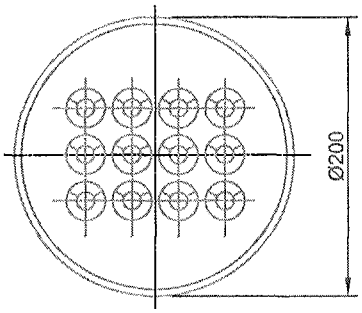
VBT-BE 4-150
VBT-BE 2x2-150



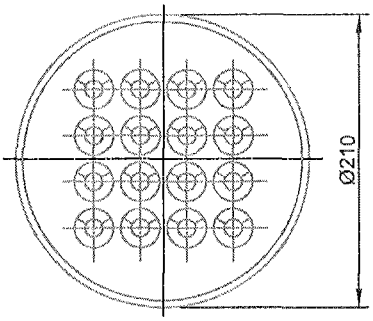
VBT-BE 2x4-150
VBT-BE 4x2-150



VBT-BE 3x4-150

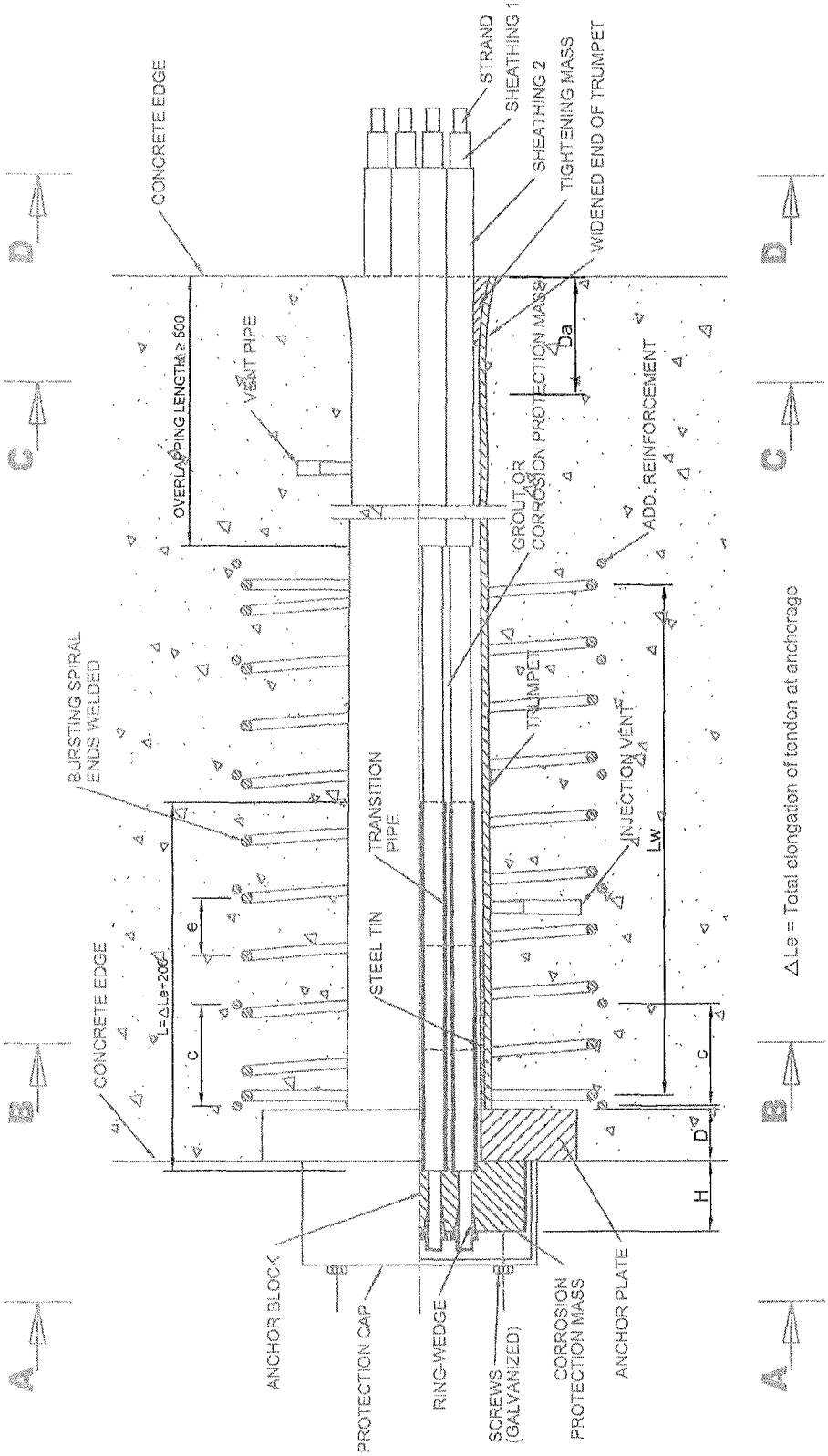


VBT-BE 4x4-150



External Bondless Post-Tensioning System VBT-BE	VBT systems	ANNEX 3
Types of Anchor-Blocks		of European Technical Approval ETA-10/0006

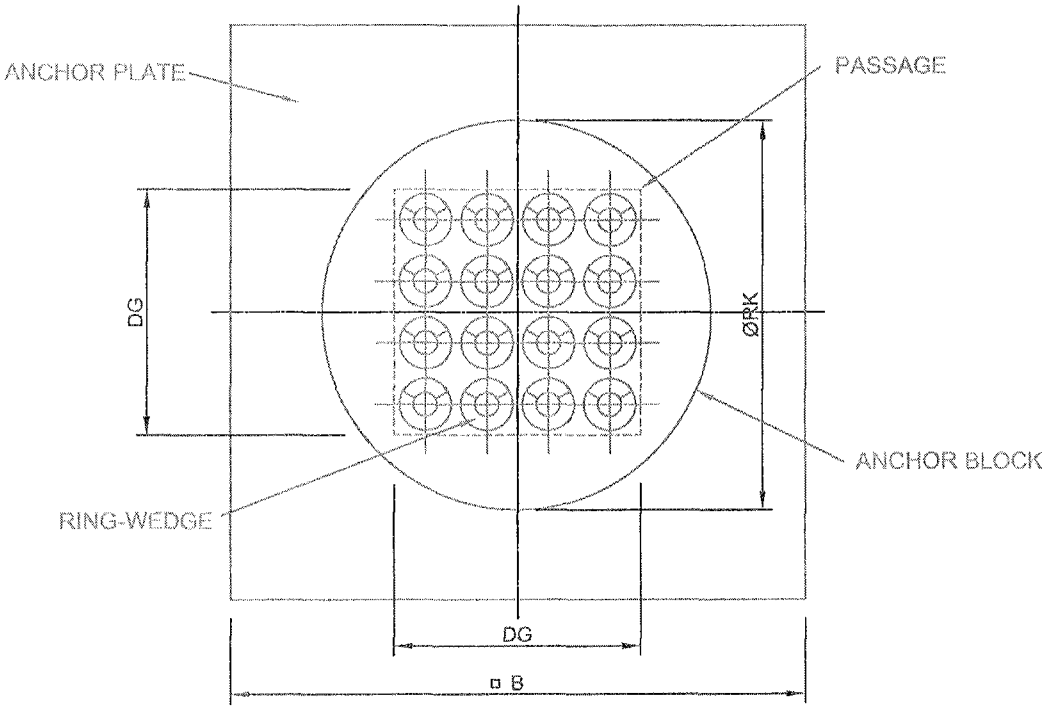
LONGITUDINAL SECTION
EXPOSITION WITH PLASTIC TRUMPET
(TRUMPET ALTERNATIVELY MADE OF STEEL)



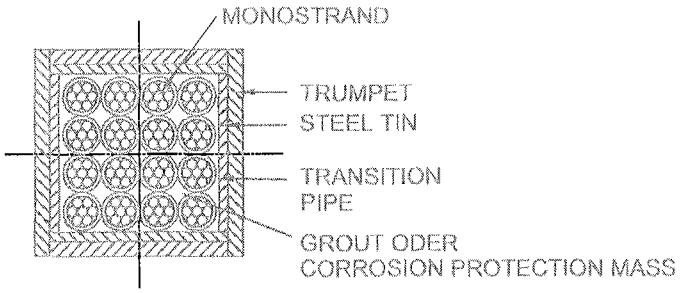
External Bondless Post-Tensioning System VBT-BE	ANNEX 4
Longitudinal Section Anchorage	of European Technical Approval ETA-10/0006

A-A

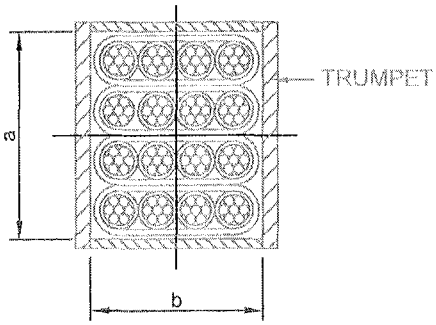
(VIEW WITHOUT PROTECTION CAP)



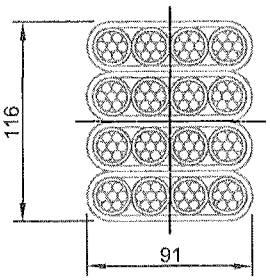
B-B



C-C

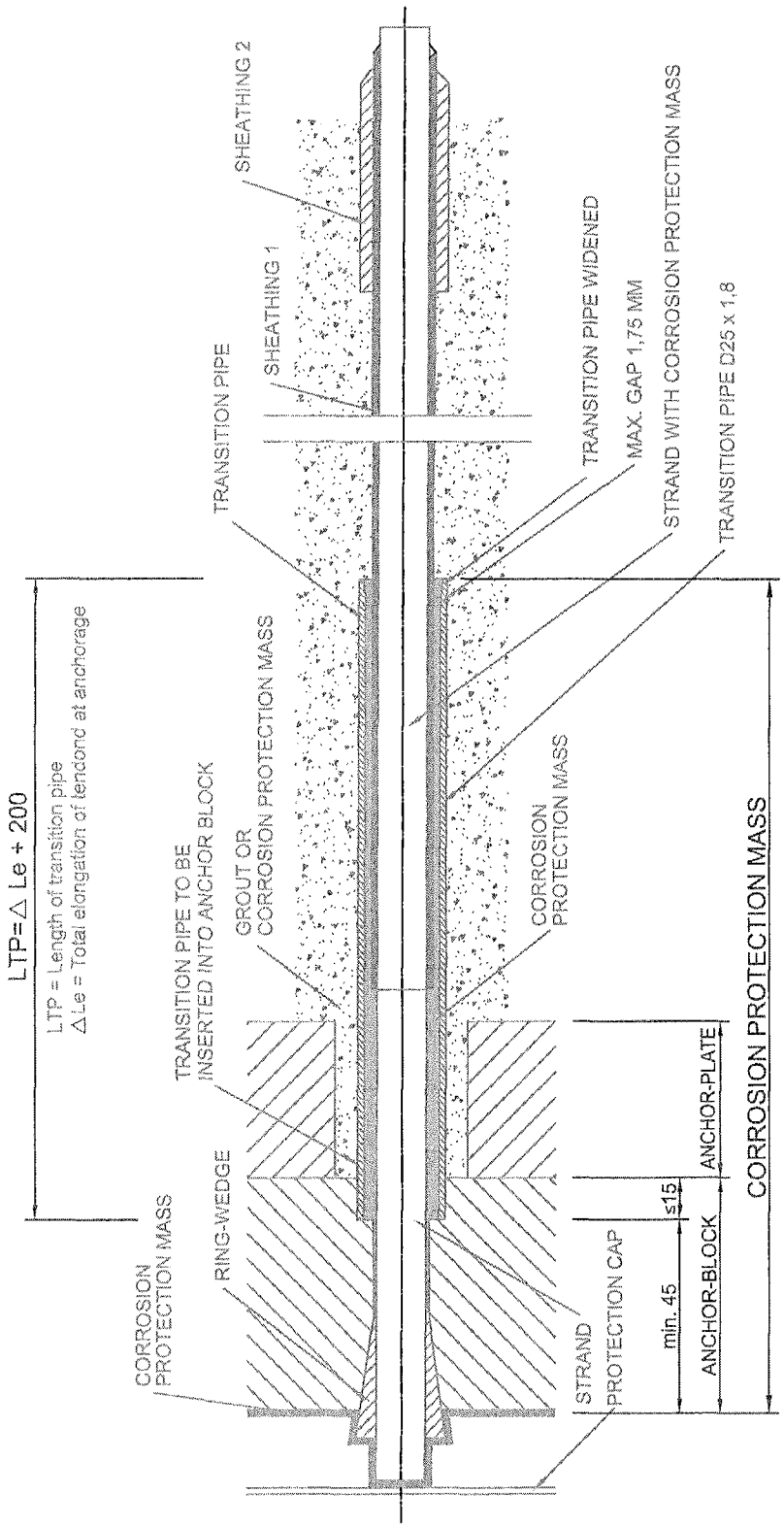


D-D



External Bondless Post-Tensioning System VBT-BE	VBT systems	ANNEX 5
Cross Section Anchorage		of European Technical Approval ETA-10/0006

MEASURES OF CORROSION PROTECTION IN THE AREA OF MONOSTRANDS-TRANSITION PIPES



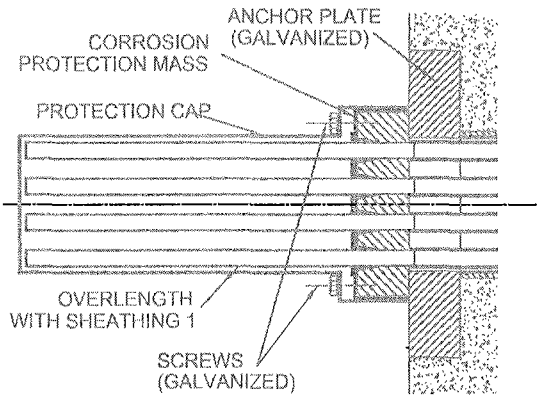
External Bondless Post-Tensioning System VBT-BE	VBT systems	ANNEX 6
Measures of Corrosion Protection in the Area of Monostrand-Transition Pipe		of European Technical Approval ETA-10/0006

RESTRESSABLE ANCHORAGES

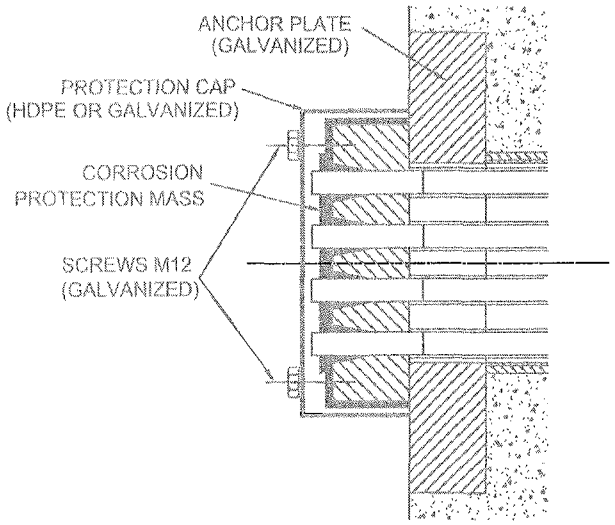
OVERLENGTH FOR RESTRESSING

TENDON TYPE	OVERLENGTH*
1-150	65cm
2-150 bis 4x4-150	65cm
2x4-150 bis 4x4-150	38cm**

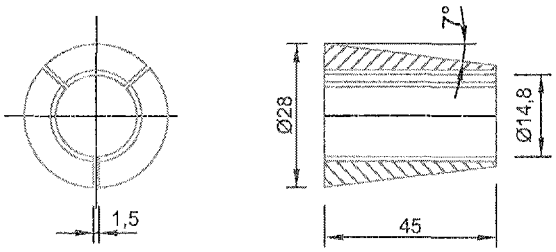
* THE OVERLENGTH IS RELATED TO THE TYPE OF THE JACK AND NEEDS TO BE COORDINATED WITH THE MANUFACTURER OF THE TENDON SYSTEM
\pt4.038;** WITH SPECIAL JACK



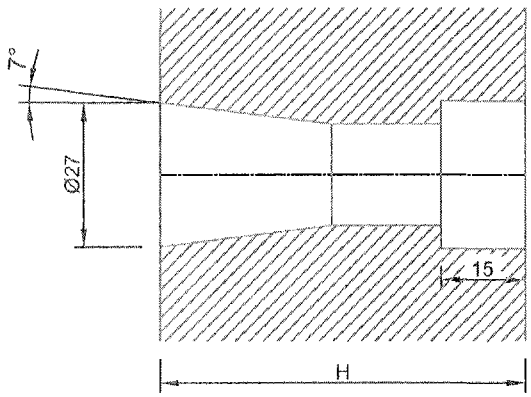
NON-RESTRESSABLE ANCHORAGES

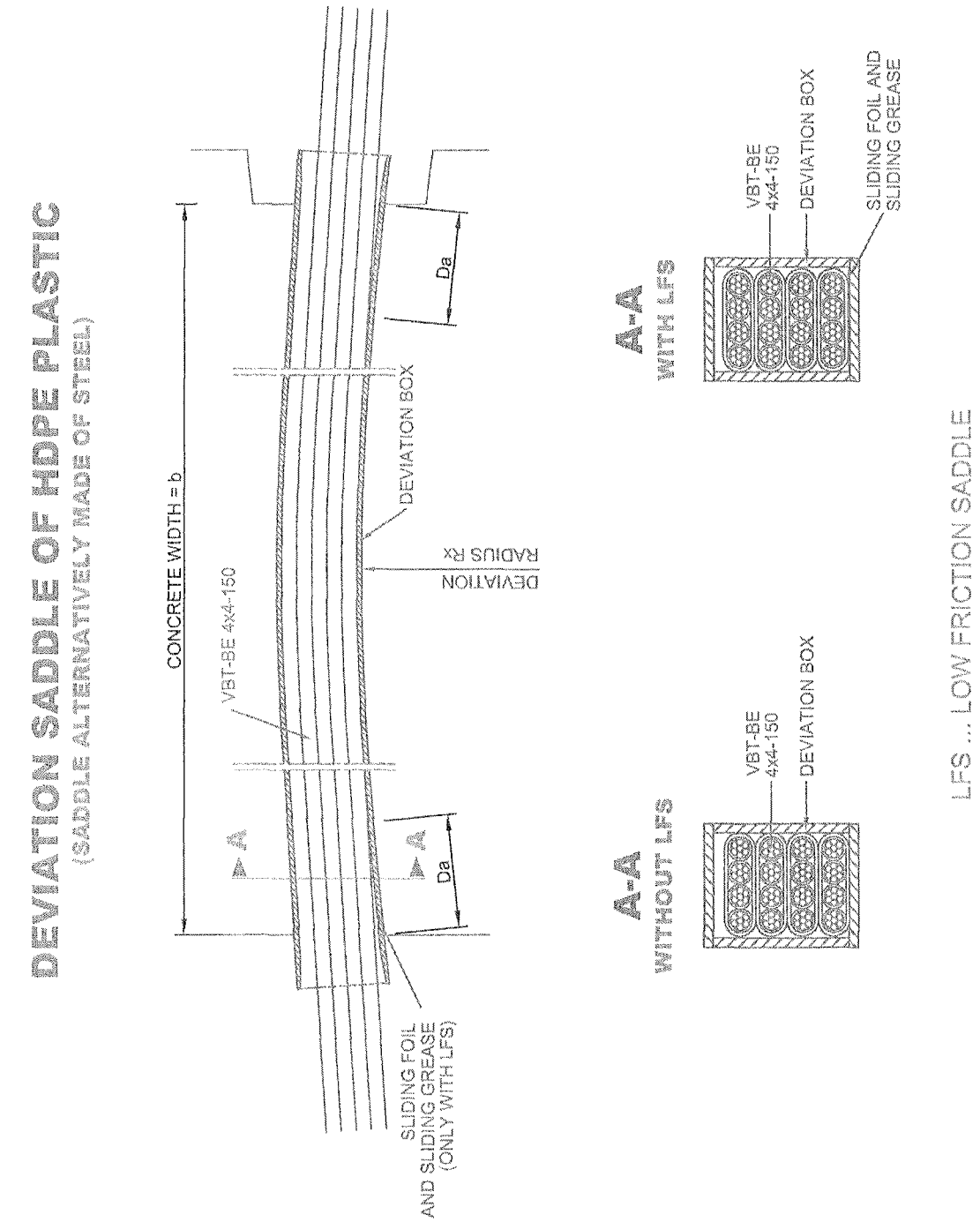


RING WEDGE



CONICAL DRILLING





External Bondless Post-Tensioning System VBT-BE	VBT systems	ANNEX 9
HDPE Deviation Saddle		of European Technical Approval ETA-10/0006

1 INTRODUCTION

This Annex gives details and regulations in the application of the prestressing system VBT-BE "Band external" in addition to the main part of this approval.

2 TENDONS

2.1 Description of tendons

The VBT-BE tendons are designed for external prestressing and consist either of a monostrand and a second sheath, or of bands of 2 to 4, side by side lying monostrands, which are factory protected against corrosion by a grease and sheath 1 of PE. The side by side lying monostrands are formed by a flat PE-pipe (sheat 2) with a rectangular section to stressing-bands.

2.2 Production of tendons

The side by side lying monostrands and the flat PE-pipe are put together in factory. The stressing-bands can be produced on drums in great single and multi lengths, or in length fitting for individual sites.

3 ANCHORAGES

3.1 Stressing anchor and fixed anchor

Anchoring is being performed by anchor-plates, anchor-blocks with conical drillings parallel to the axis of tendon and ring-wedges, which consist of 3 equal parts. The transition area between the bands and the anchorage will be as follows: at the inner side of the anchor-plate a rectangular galvanized pipe of steel is welded to it. At this pipe the PE trumpet is fastened. In the area of the trumpet-box sheath 2 of the stressing-bands are to be removed, by use of a special knife. The strands with sheath 1 will be inserted through the transition pipes into the conical drillings of the anchor-block and anchored. Transition pipes are fixed to the anchor-blocks by strong hitting (see Annex 6).

The ring gap between transition pipe and sheath 1 (monostrand) shall not exceed 1.75mm. If the ring gap is larger then special measures must be carried out in correspondence with the actual environmental situation. To secure, that sheath 1 can be inserted into the transition pipe without great resistance, the transition pipes can be widened at their ends.

When stressing is finished, the inner space of the trumpet will be grouted by grout for prestressing tendons according to EN 445:2007 or corrosion protection grease. Tightening at exit of trumpets between trumpet-box and bands will be done by tightening mass (e.g. PU foam).

At the non-restressable anchorages with short over-length a protection cap of PE or galvanized steel will be fastened by galvanized screws. The space inside the cap should be filled with corrosion protection grease (see Annex 7 below).

At the restressable anchorages with long over-length (see Annex 7 on top) a protection cap (minimum length in respect to the available stressing jack, e.g. 40 cm) will be fastened, made of PE or galvanized steel, by galvanized screws to the anchor-block. Anchor block and ring-wedges will be lubricated by corrosion protection grease. The strands (over-length) are covered by corrosion protection grease and additional transition pipes.

4 DEVIATIONS

4.1 Implementation of trumpets and deviation boxes

At the anchors and deviations the band tendons are guided in rectangular trumpets or deviation boxes. The surfaces of the trumpets and deviation boxes are adapted to geometry of cable layout. For avoiding any sharp bend of the tendons, the trumpets and deviation boxes are widened at their ends like a trumpet.

Normally, material of the trumpets and deviation boxes is PE. Execution in corrosion protected steel is possible as well. The trumpets and deviation boxes of PE are fully embedded in concrete. or grout in the deviator area. If steel saddle boxes are used they can also be supported by a steel structure according the project requirements, instead to or in combination with grouting or concrete support.

PE:	Thickness ≥ 8mm
Corrosion protected steel	Thickness ≥ 3mm

Number of bands	1x1	1x2	2x2	1x4	2x4	3x4	4x4
min. width (inside) X	33	52	52	95	95	95	95
min. height (inside) Y	33	38	67	38	67	96	125
Wall Thickness	PE ≥ 8 mm / Steel ≥ 3 mm						

Table 1: Minimum section dimensions of deviation boxes

If the trumpets and deviation boxes are made of steel the initial minimum wall thickness of the monostrand need to be 2 mm, or a PE-insert with a minimum thickness of 8 mm has to be placed between the contact surfaces of the trumpet or deviation box and the tendon.
If trumpets and deviation boxes of steel with the above mentioned PE-insert or trumpets and deviation boxes of PE are used the initial wall thickness of the monostrands can be less than 2 mm according the dimensions and radii given in Chapter 4.2.

4.2 Radii of curvature and limits of inner sliding

4.2.1 Radii of curvature

The minimal curvature radii R_x along the broad side of the stacked bands are given in Table 2. In case of different stacking arrangements the minimal curvature radius is calculated in the following approach (e.g. three stacked bands, n=3):

$$R_{min}(d_{inside};n) \geq Min\left\{\begin{matrix} R_{min}(d_{inside};n) * n/4 \\ 1.9m \end{matrix}\right\}$$

d_{inside} minimum initial wall thickness of the monostrand
n number of stacked band layers
Example – Band Type 3x4 (d_{inside} ≥2.00 mm; n = 3)

$R_{min}(2,00;3) \geq 5.0\ m * 3 / 4 = 3,75\ m$ (see Table 2, column 2, row 3)

number of band layers	Initial wall thickness of sheath 1 [mm]					
	2	1.75	1.5	1.25	1 (restressable)	0.8 (restressable)
	Minimum deviation radius [m]					
4	5.00	5.60	6.50	10.50	∞	∞
3	3.75	4.20	4.88	7.88	∞	∞
2	2.50	2.80	3.25	5.25	∞	∞
1	1.90	1.90	1.90	2.63	∞	∞

Table 2: Minimum curvature radius using 40 cm or less inner sliding movement

The minimum curvature radius along the narrow side (R_y) is fixed to 10.00m for all type of bands.

Not to cross the tested angles of 2,9° of the strands at the exit from the anchor blocks the minimum length of the straight part of the trumpet in dependence to the used tendon given in Table 3 shall be kept.

	Minimum length of the straight part of the trumpet [mm]						
System VBT-BE	1-150 1-140	2-150 2-140	2x2-150 2x2-140	1x4-150 1x4-140	2x4-150 2x4-140	3x4-150 3x4-140	4x4-150 4x4-140
Minimum lenght (mm)	192	458	617	772	1156	1314	1502

Table 3: Minimum length of the straight part of the trumpet at anchorages

The minimum lengths given in Table 3 show extreme values with which is supposed that the tendon leaves the trumpet in the highest possible measure of eccentricity. Besides, the sheath 1 and 2 were credited only with half of her wall thickness (deformation in the tensioned state). If special measures are planned on site to reduce the eccentricity of the exit of the tendon from the trumpet (e.g. back plates of chuck) lower minimum lengths of the straight part of the trumpet are possible. Besides, is to be proved by calculation that the allowed corner of 2.9° in the escape of the strands from the anchor blocks is not crossed and the besides accepted geometry is to be checked on site in the tensioned state.

4.2.2 Permissible inner sliding on a deviation saddle

The resulting elongation can be separated into inner and outer sliding.

Inner sliding is the movement of the steel strand in the monostrand sheath.
Outer sliding is the movement of the complete tendon in the deviation saddle.

The maximum allowable value of inner sliding depends on the actual deviation radius. While deviating on minimum curvature radius the value of inner sliding must not exceed 40 cm. The maximum value of inner sliding may be increased by using deviators with higher radius of curvature than the minimum radiuses given in Table 2. The relationship to determine this maximum value of inner sliding at higher radiuses of deviation is:

$$\Delta l_i(R) = \Delta l_i(R_{min}) * \frac{4}{n_l} \frac{R}{R_{min}}$$ were

$\Delta l_i(R_{min})$ is the maximum value of inner sliding at minimum radius of curvature R_{min} and 4 layers of bands according to the first line of Table 2

R_{min} is the minimum radiuses of curvature according to the first line of Table 2,

Δl_i is the maximum value of inner sliding at the current radius of curvature R and the current numbers of band layers n_l,

R is the current radius of curvature at the deviator an shall at least be 1.9 m,

n_l current numbers of band layers at the deviator

The value of $\Delta l_i(R_{min})$ is 40 cm for the system VBT-BE.

The maximum allowable value of outer sliding is infinite. Outer sliding is allowed with no limitations. Typical values of outer sliding ratio are ranges from 50-90% without LFS (low friction saddle), and from 95-99% with LFS. The values with or without LFS can additional vary depending on cleanness of saddle surfaces and restriction to movements of the bands.

The real behaviour of the sliding conditions will in most cases be a mixture of inner and outer sliding. The distribution will depend on e.g. the cleanness of the deviation surfaces, grease application and optional of a low friction system.

5 CORROSION PROTECTION

5.1 Tendon in free length

The cables are protected against corrosion by the sheath 1 and sheath 2 as well as by a corrosion protection mass.
The minimum wall thickness of sheath 1 is related to the chosen deviation radius.
The initial minimum wall thickness of sheath 2 is $t \geq 3.00$ mm.

5.2 Anchorages

The inner space of the anchorage trumpet will be filled with grout or corrosion protection mass. The monostrands will be guided to the anchor block through PE transition pipes. The end of the trumpet to the free length of the bands will be tightened by sealing compound. The protection cap is made of PE or steel. All outside surfaces of steel elements must be protected against corrosion (see Annex 6).

DIMENSION OF BANDS AND FORCES [MM]

System VBT-BE	1-150	2-150	2x2-150	4-150	2x4-150	3x4-150	4x4-150

Band types	1x1	1x2	2x2	1x4	2x4	3x4	4x4
Number of strands [-]	1	2	4	4	8	12	16
Number of layers [-]	1	1	2	1	2	3	4
Weight per meter [kg]							
A_p=140mm² per Strand	1,09	2,19	4,37	4,37	8,74	13,12	17,49
A_p=150mm² per Strand	1,17	2,34	4,69	4,69	9,38	14,06	18,75
Nominal cross section [mm²]							
A_p=140mm² per Strand	140	280	560	560	1120	1680	2240
Ap=150mm² per Strand	150	300	600	600	1200	1800	2400

Permitted prestressing force [kN]														
Steel grade Y1770S7/Y1860S7	1770	1860	1770	1860	1770	1860	1770	1860	1770	1860	1770	1860	1770	1860
A_p=140mm²														
Ultimate Force F_{pk}	248	260	496	520	992	1040	992	1040	1984	2080	2976	3120	3968	4160
Max. Overstress Force 0.95 $F_{p0,1k}$	202	213	405	426	809	851	809	851	1619	1702	2428	2554	3238	3405
Max. Prestress Force 0.9 $F_{p0,1k}$	192	202	383	403	767	806	767	806	1534	1613	2300	2419	3067	3226
A_p=150mm²														
Ultimate Force F_{pk}	266	279	532	558	1064	1116	1064	1116	2128	2232	3192	3348	4256	4464
Max. Overstress Force 0.95 $F_{p0,1k}$	218	228	435	456	870	912	870	912	1740	1824	2611	2736	3481	3648
Max. Prestress Force 0.9 $F_{p0,1k}$	206	216	412	432	824	864	824	864	1649	1728	2473	2592	3298	3456

DIMENSION OF ANCHORAGES [MM]

System	VBT-BE	1-150	2-150	2x2-150	4-150	2x4-150	3x4-150	4x4-150
Dimension of bands								
a x b		Ø29	29x49	58x49	29x91	58x91	87x91	116x91
Anchor plate								
Length	BxB	100	120	170	170	230	280	310
Thickness	D	15	15	20	20	30	40	50
Passage	DG	34x34	34x64	64x64	64x64	64x128	98x128	128x128
Anchor block								
Diameter	ØRK	50	100	110	110	180	200	210
Height	H	60	60	60	60	60	60	70
Trumpet								
Wall thickness HDPE/S235JR		8/3	8/3	8/3	8/3	8/3	8/3	8/3
min. length	L	600	750	750	1000	1000	1000	1000
Protection cap								
inside diameter	ØSK	60	110	120	120	190	210	220

BURSTING SPIRALS UND ADDITIONAL REINFORCEMENT [MM]

Band type		1x1	1x2	2x2 and 1x4	2x4	3x4	4x4
Spiral Bst 500 S							
Wire	Ø min.	-	-	12	14	14	14 (16)
Distance of windings	e	-	-	50	50	50	45 (50)
Length	min. Lw	-	-	175	300	325	425
Outer	Ø min. a						
$f_{cm0,cube,150} \geq 30N/mm^2$ (*)		-	-	190	300	320	360
$f_{cm0,cube,150} \geq 37N/mm^2$ (*)		-	-	160	270	320	350
Additional Reinforcement BSt 500 S							
Diameter	Ø	5Ø10	5Ø10	5Ø12	6Ø14	7Ø14	8Ø14
Distance	c	40	40	40	50	50	50
bxb							
$f_{cm0,cube,150} \geq 30N/mm^2$ (*)		120	150	210	285	355	410
$f_{cm0,cube,150} \geq 37N/mm^2$ (*)		110	140	195	255	335	385

MINIMAL CENTRE AND EDGE DISTANCES OF ANCHORAGE [MM]

Band type	1x1	1x2	2x2 and 1x4	2x4	3x4	4x4
min. distance of anchorage (**)						
for $f_{cm0,cube,150} \geq 30N/mm^2$ (*)						
Distance of axis	140	170	230	325	395	450
Distand from edge (***)	90	105	135	185	220	245

min. distance of anchorage (**)						
for $f_{cm0,cube,150} \geq 37N/mm^2$ (*)						
Distance of axis	130	160	215	295	375	425
Distance from edge (***)	85	100	130	170	210	235

(*) Minimum actual concrete strength at stressing [N/mm²]
(**) The minmum centre and edge distances may be reduced up to 15% of the given values in one direction, if increased correspondingly in the other direction
(***) Concrete cover of spiral and additional reinforcement shall be taken into account

MATERIAL SPECIFICATIONS

Naming	Material-Code*	Annex	Standard
Anchor Block	Unalloyed Steel		EN 10 083-2:2006
Ring wedge	Bright Steel		EN 10 084:2008
Padding	Unalloyed Steel		EN 10 025-1:2004
Transition pipes	PE		EN ISO 1872-1:1999
Protection cap	PE		EN ISO 1872-1:1999
or	Unalloyed Steel		EN 10 025-1:2004
Anchor plate	Unalloyed Steel		EN 10 025-1:2004
Trumpet	PE		EN ISO 1872-1:1999
or	Unalloyed Steel		EN 10 025 (2005-02)
Deviation box	PE		EN ISO 1872-1:1999
or	Unalloyed Steel		EN 10 025-1:2004
or	Stainless Steel		EN 10 088-3:2005
Sliding tins	Stainless Steel		EN 10 088-3:2005
Sliding foil	PE		EN ISO 1872-1:1999
Corrosion protection mass (grease)	*		ETA based on ETAG 013, C.4.1 or according to national regulations valid at the place of use
Monostrands (inclusive sheath 1 and 2)	PE		ETA based on ETAG 013, C.1 or according to national regulations valid at the place of use
Corrosion protection for the outer surfaces, galvanized 80µm			EN ISO 1461:2009

* exact material definitions deposited at DIBt

CONTENT OF CONTROL PLAN

Component	Item	Test/ Check	Traceability[4]	Minimum frequency	Documen-tation
Anchor plate	material	check	bulk	100%	„2.2“[1]
	detailed dimensions[5]	test		3% ≥2 specimen	yes
	visual inspection[3]	check		100%	no
Anchor block	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
Monostrands[10], Annex C.1	Material	check	full	100%	„CE“
Sheath 2[11] Annex C.3	Material	check	full	100%	„CE“
Tensile element strand[8]					
	diameter	test		each coil/bundle	no
	visual inspection[3]	check		each coil/bundle	no

Continuation of Control Plan and footnotes see next page

Component	Item	Test/ Check	Traceability[4]	Minimum frequency	Documen-tation
Constituents of filling material as per EN 447	cement	check	bulk	100%	yes
	admixtures, additions	check		100%	yes
Helix	material	check	full	100%	yes
	visual inspection[3]	check		100%	no
Stirrups	material	check	full	100%	yes
	visual inspection[3]	check		100%	no
Corrosion protection mass (grease)	material[7]	check	full	100%	„CE“

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 inspection means e.g.: Main dimensions, gauge testing, correct marking or labeling, 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 ETA, chapter 2.1.3
7 Grease according to an ETA based on ETAG 013, C.4.1 or according to national regulations valid at the place of use .
8 As long as the basis for CE marking for prestressing steel is not available, an approval or certificate according to the respective rules in force at the place of use shall accompany each delivery.
9 Certificate or confirmation given by supplier
10 Monostrands according to an ETA based on ETAG 013, C.1 or according to national regulations valid at the place of use.
11 Sheath 2 according to an ETA based on ETAG 013, C.3 or according to national regulations valid at the place of use.

AUDIT TESTING

Component	Item	Test/ Check	Sampling[1] – Number of components per audit
Anchor block, coupling block, anchor plate, multi surface anchor	material according to specification	check/ test	1
	detailed dimensions	test	1
	visual inspection[2]	check	1
	treatment	test	
Wedge	material according to specification	check/ test	2
	treatment	test	2
	Detailed dimensions	test	1
	Main dimensions, surface hardness	test	5
	visual inspection[2]	check	5
Single tensile element test	ETAG 013, Annex E.3	test	1 series

[1] All samples shall be randomly selected and clearly identified.

[2] Visual inspection means e.g.: Main dimensions, gauge testing, correct marking or labelling, appropriate performance, surface, fins, kinks, smoothness, corrosion, etc.as given in the Control Plan.