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## European Technical Assessment

**ETA-13/0815**  
of 25.06.2018

General part

**Technical Assessment Body issuing the European Technical Assessment**

Österreichisches Institut für Bautechnik (OIB)  
Austrian Institute of Construction Engineering

**Trade name of the construction product**

DYWIDAG Strand

**Product family to which the construction product belongs**

Bonded post-tensioning kits for prestressing of structures with 3 to 55 strands

**Manufacturer**

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**This European Technical Assessment contains**

58 pages including Annexes 1 to 31, which form an integral part of this assessment.

**This European Technical Assessment is issued in accordance with Regulation (EU) № 305/2011, on the basis of**

EAD 160004-00-0301, European Assessment Document for Post-Tensioning Kits for Prestressing of Structures.

**This European Technical Assessment replaces**

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## Remarks

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## Specific parts

### 1 Technical description of the product

#### 1.1 General

The European Technical Assessment<sup>1</sup> – ETA – applies to a kit, the bonded PT system

#### **DYWIDAG Strand,**

comprising the following components.

– Tendon

Bonded tendon with 3 to 55 tensile elements

– Tensile element

7-wire prestressing steel strand with nominal diameters and nominal tensile strengths as given in Table 1

**Table 1** Tensile elements

Nominal diameter		Designation according to prEN 10138-3 <sup>2</sup>	Nominal tensile strength
mm	inch	—	N/mm <sup>2</sup>
15.3	0.6	Y1770S7	1 770
15.3	0.6	Y1860S7	1 860
15.7	0.62	Y1770S7	1 770
15.7	0.62	Y1860S7	1 860

NOTE 1 N/mm<sup>2</sup> = 1 MPa

– Anchorage

Prestressing steel strand anchored by either 3-piece wedge or bond head

Stressing (active) and fixed (passive) anchor with wedges, wedge plate, and multi-plane anchor body MA for tendons with 3 to 55 prestressing steel strands

<sup>1</sup> ETA-13/0815 was firstly issued in 2013 as European technical approval with validity from 28.06.2013 and converted 2018 to European Technical Assessment ETA-13/0815 of 25.06.2018.

<sup>2</sup> Standards and other documents referred to in the European Technical Assessment are listed in Annex 30 and Annex 31.

Stressing (active) and fixed (passive) anchor with wedges and anchor plate SD for tendons with 3 to 9 prestressing steel strands

Fixed (passive) anchor with bond anchorage H for tendons with 3 to 22 prestressing steel strands

- Coupler

Prestressing steel strand anchored by 3-piece wedge

Fixed coupler with wedges, coupler plate R, and multi-plane anchor body MA for tendons with 5 to 37 prestressing steel strands

Movable coupler with wedges and single strand couplers D for tendons with 3 to 37 prestressing steel strands

- Helix and additional reinforcement or only additional reinforcement without helix in the anchorage zone

- Ducts

- Permanent corrosion protection for tensile elements, anchors, and couplers

## PT system

### 1.2 Designation and range of anchorages and couplers

#### 1.2.1 Designation

Anchorages and couplers are designated by their function in the structure, the nominal diameter of the prestressing steel strands and the maximum number of the prestressing steel strands. The first number indicates the nominal diameter of the prestressing steel strand, “68” = 15.3 mm (0.6 ") or 15.7 mm (0.62 "), followed by the maximum number of prestressing steel strands per unit “n”, 68 n. The available anchorages and couplers are shown in Annex 1 and Annex 2, and are listed in Table 2.

**Table 2** Anchorages and Couplers

Component	Number of strands <sup>1)</sup>
Anchorage	
Wedge plate with anchor body MA	5 7 9 12 15 19 22 27 31 37 43 49 55
Anchor plate SD	3 4 5 6 7 8 9
Bond anchorage H	3 4 5 7 9 12 15 19 22
Coupler	
Fixed coupler with coupler plate R and anchor body MA	5 7 9 12 15 19 22 27 31 37
Movable coupler D	3 4 5 7 9 12 15 19 22 27 31 37

<sup>1)</sup> One or more prestressing steel strands may be omitted to install tendons with numbers of prestressing steel strands between the numbers given.

“Multi-plane anchor body MA” and “anchor body MA” are synonyms.



## 1.2.2 Tendon range

The available tendons sizes are listed in Table 2. The characteristic values of maximum force of tendons are given in Annex 27.

Anchorage and coupler may be provided with less prestressing steel strands than the maximum number, resulting in a continuous tendon row. Thereby the prestressing steel strands are omitted as much as possible radial symmetrically. For all omitted prestressing steel strands, the respective bores in wedge plate or coupler plate do not need to be drilled. Alternatively, at wedge plate and coupler plate R a short length of prestressing steel strand with a wedge is pressed in. For coupler plate R the bores in the projecting collar may be equally redistributed. However, overall dimensions of wedge plate and coupler plate are unchanged in any case.

Moreover, each anchorage and coupler may be installed with virtually any meaningful number of prestressing steel strands smaller or equal to the complete number of prestressing steel strands for the respective size. However, the resulting prestressing force is exactly axial with regard to anchorage and coupler. This is obtained by an appropriate arrangement of the prestressing steel strands in wedge plate and coupler plate.

Anchorage and couplers with omitted strands are in any case installed with unchanged dimensions and unchanged reinforcement compared to anchorages and couplers with complete number of prestressing steel strands.

## 1.2.3 Anchorage

### 1.2.3.1 General

The stressing anchor arranges the prestressing steel strands for the stressing operation and subsequently anchors the stressed prestressing steel strands by means of wedges. Each prestressing steel strand is individually anchored within a conical bore of the wedge plate or anchor plate SD by means of a 3-piece wedge, see Annex 9. All prestressing steel strands of the bundle tendon are stressed at the same time.

At the fixed anchor, the prestressing steel strands are anchored by means of wedges in wedge plate or in anchor plate SD, or by bond and bond heads within bond anchorage H.

The same principles of anchorage apply from the smallest to the largest tendon.

### 1.2.3.2 Stressing and fixed anchor with wedge plate and anchor body MA

The stressing anchor comprises wedges, wedge plate, and multi-plane anchor body MA, see Annex 10 to Annex 13. The trumpet is arranged between anchor body MA and duct. Anchorage with anchor body MA can be installed without or with helix. The helix, if present, is centrally aligned to the anchor body MA and fastened in its position. If required, the free end of the helix is fastened to the additional reinforcement. The duct is inserted into the trumpet or screwed thereon. The wedge plate is slipped over the prestressing steel strands before stressing.

Anchorage with anchor body MA can be installed with a flat duct, see Annex 4.

The stressing anchor can also be used as a fixed anchor. In that case, access is given to the fixed anchor during stressing. If the fixed anchor is not accessible and embedded in concrete, the wedges are secured by a wedge keeper plate, see Annex 10.

### 1.2.3.3 Stressing and fixed anchor with anchor plate SD

The stressing anchor comprises wedges and anchor plate SD, see Annex 15 and Annex 16. The trumpet is fastened at the formwork, optionally with a connection tube. Duct and trumpet are joined by inserting the duct into the trumpet or the duct is screwed on the trumpet. The helix, if present, is centrally aligned to the trumpet and fastened in its position. If required, the free end of the helix is fastened to the additional reinforcement. The anchor plate SD is slipped over the strands before stressing.

Anchorage with anchor plate SD can be installed with a flat duct, see Annex 4.

The stressing anchor can also be used as a fixed anchor. In that case, access is given to the fixed anchor during stressing. If the fixed anchor is not accessible and embedded in concrete, the complete anchorage, comprising anchor plate SD, connection tube, trumpet, and helix is mounted at once and the wedges are secured in the anchor plate SD by means of a wedge keeper plate, see Annex 15.

#### 1.2.3.4 Fixed anchor with bond anchorages H – HL and HR

At the fixed anchor with bond anchorage H, the prestressing steel strands are anchored by bond of the prestressing steel strands and in particular with bond heads to the structural concrete, see Annex 1, Annex 17, and Annex 18. Therefore, it can only be used as a fixed anchor, embedded in concrete. Beside bond heads, it comprises ring, helix, and spacers for creating the intended strand layout, see Annex 1 and Annex 17. The prestressing steel strands used in this anchorage are free of any surface treatment, i.e. free of temporary corrosion protection, neither applied at the manufacturing plant nor on site.

#### 1.2.4 Coupler

##### 1.2.4.1 General

In the coupler, the prestressing steel strands are anchored by means of wedges at both construction stages.

##### 1.2.4.2 Fixed coupler with coupler plate R

The fixed coupler comprises wedges, coupler plate R and anchor body MA, see Annex 21 and Annex 22. The fixed coupler connects a 2<sup>nd</sup> tendon with an already stressed 1<sup>st</sup> tendon. The already stressed 1<sup>st</sup> tendon is anchored in the same way as a stressing anchor with wedge plate. In addition, the coupler plate R provides a projecting ring collar with conical bores and pre-installed wedges that are secured by press-on-segments and springs. The prestressing steel strands of the 2<sup>nd</sup> tendon are pushed into the bores from bottom side and anchored with pre-installed wedges.

A 100 mm long and at least 4 mm thick PE-HD insert is installed at the deviating point at the end of the trumpet if the coupler can be subjected to significant fatigue actions. The insert is not required for a plastic trumpet, where the duct is screwed on an external thread of the plastic trumpet.

##### 1.2.4.3 Movable coupler D with single strand coupler

The movable coupler D comprises for each prestressing steel strand a single strand coupler. The single strand coupler is assembled of 2 wedges with 2 springs inside 2 barrel chucks, connected by the fitting bolt, see Annex 23. Movable couplers connect two tendons prior to stressing. The prestressing steel strands of both tendons are pushed into the single strand couplers and anchored with the pre-installed wedges. Springs between wedges and fitting bolt secure the wedge positions in the cones.

The group of single strand couplers are arranged staggered in up to 3 levels, see Annex 23 and Annex 24.

Prior to final assembly of the tube, and according to the stressing direction, the correct position of the coupler in the coupler tube is checked.

#### 1.2.5 Centre and edge distances, concrete cover

All centre and edge distances have been determined with regard to requirements on load-bearing capacity, depending on the actual mean compressive strength of concrete at time of stressing,  $f_{cm,0}$ . Distance of tendon anchorages conforms to the values specified in Annex 11, Annex 12, Annex 13, Annex 16, Annex 17, Annex 18, Annex 19, and Annex 20. However, these values for centre distance between anchorages may be reduced in one direction by 15 %, but not smaller than the outside diameter of the helix and the dimensions of anchor body MA or anchor plate SD,

and placing of additional reinforcement is still possible. In case of a reduction of the distances in one direction, the centre and edge distances in the perpendicular direction are increased by the same percentage in order to keep an equal concrete area in the anchorage zone.

The concrete cover of tendons is neither smaller than 20 mm nor smaller than the concrete cover of reinforcement installed in the same cross section. Concrete cover at the anchorage is at least 20 mm on the grout cap. Standards and regulations on concrete cover in force at the place of use are observed.

#### 1.2.6 Strength of concrete

Concrete according to EN 206 is used.

At the time of transmission of the prestressing force to the structural concrete, the actual mean cube compressive strength of concrete,  $f_{cm,0,cube}$ , or the actual mean cylinder compressive strength of concrete,  $f_{cm,0,cyl}$ , is at least as given in Annex 11, Annex 12, Annex 13, Annex 16, Annex 17, Annex 18, Annex 19, and Annex 20. The actual mean compressive strength,  $f_{cm,0,cube}$  or  $f_{cm,0,cyl}$ , is verified by means of at least three specimens, cube of size 150 mm or cylinder with diameter of 150 mm and height of 300 mm, which are cured under the same conditions as the structure.

For partial prestressing with 30 % of the full prestressing force the actual mean concrete compressive strength is at least  $0.5 \cdot f_{cm,0,cube}$  or  $0.5 \cdot f_{cm,0,cyl}$ . Intermediate values may be interpolated linearly according to Eurocode 2.

#### 1.2.7 Reinforcement in the anchorage zone

In any case, steel grades and dimensions of helix and additional reinforcement specified in Annex 11, Annex 12, Annex 13, Annex 16, Annex 17, Annex 18, Annex 19, Annex 20, and Annex 25 are conformed to.

The centric position of the helix, if present, is secured by welding the end ring onto the multi-plane anchor body MA or onto the anchor plate SD or by means of holding devices that are braced against the tendon.

If required for a specific project design, the reinforcement given in Annex 11, Annex 12, Annex 13, Annex 16, Annex 17, Annex 18, Annex 19, and Annex 20 may be modified in accordance with the respective regulations in force at the place of use as well as with the relevant approval of the local authority and of the ETA holder to provide equivalent performance.

### 1.3 Designation and range of tendons

#### 1.3.1 Designation

The tendon is designated by the nominal diameter of the prestressing steel strand and the number of prestressing steel strands with 68n. The first two digits indicate the nominal diameter of the prestressing steel strand "68" = 15.3 mm (0.6 ") or 15.7 mm (0.62 "), followed by two digits as the number "n" of prestressing steel strands, e.g. 6804.

#### 1.3.2 Range of tendons

The PT system includes tendons, see Table 2, with 3 to 55 prestressing steel strands. Only 7-wire prestressing steel strands with nominal diameters of 15.3 mm or 15.7 mm and tensile strengths of 1 770 N/mm<sup>2</sup> or 1 860 N/mm<sup>2</sup> are used. The dimensions and specifications of the prestressing steel strands are given in Table 1 and Annex 26.

Characteristic values of maximum force of the tendons are listed in Annex 27.

### 1.3.3 Maximum stressing forces

Prestressing and overstressing forces are specified in the respective standards and regulations in force at the place of use. Annex 5 and Annex 6 list the maximum prestressing and overstressing forces of the tendons according to Eurocode 2. I.e. the maximum prestressing force applied to a tendon is not exceeding  $P_{0, \max} = 0.90 \cdot A_p \cdot f_{p0.1}$ . Overstressing with up to  $0.95 \cdot A_p \cdot f_{p0.1}$  is only permitted if the force in the prestressing jack can be measured to an accuracy of  $\pm 5\%$  of the final value of the overstressing force.

Initial prestressing force,  $P_{m0}$ , immediately after stressing and anchoring does not exceed the forces as specified in Eurocode 2.

Where

- $A_p$  .....  $\text{mm}^2$  ..... Cross-sectional area of prestressing steel of tendon, i.e.  $A_p = n \cdot S_0$
- $f_{p0.1}$  .....  $\text{N/mm}^2$  ..... Characteristic 0.1 % proof stress of prestressing steel, i.e.  $F_{p0.1} = f_{p0.1} \cdot S_0$
- $n$  ..... — ..... Number of prestressing steel strands, i.e.  $n = 1$  to 55
- $S_0$  .....  $\text{mm}^2$  ..... Nominal cross-sectional area of one single prestressing steel strand, see Annex 26
- $F_{p0.1}$  .....  $\text{kN}$  ..... Characteristic value of 0.1 % proof force of one single prestressing steel strand, see Annex 26
- $P_{0, \max}$  .....  $\text{kN}$  ..... Maximum prestressing force
- $P_{m0}$  .....  $\text{kN}$  ..... Initial prestressing force immediately after stressing and anchoring

### 1.4 Slip at anchorage and coupler

Slip at anchorage and coupler is taken into consideration in design and for determining tendon elongation. In Annex 14 slip and the required locking measure of wedges are specified.

### 1.5 Friction losses

The tendon layout should not feature abrupt changes of the tendon axis, since this may lead to significant additional friction losses. For calculation of losses of prestressing forces due to friction, Coulomb's friction law applies. Calculation of friction loss is by the equation

$$P_x = P_0 \cdot e^{-\mu \cdot (\alpha + k \cdot x)}$$

Where

- $P_x$  .....  $\text{kN}$  ..... Prestressing force at distance  $x$  from the stressing anchor along the tendon
- $P_0$  .....  $\text{kN}$  ..... Prestressing force at the distance  $x = 0$  m
- $\mu$  .....  $\text{rad}^{-1}$  ..... Friction coefficient, see Table 3
- $\alpha$  .....  $\text{rad}$  ..... Sum of angular deviations over a distance  $x$ , irrespective of direction and sign
- $k$  .....  $\text{rad/m}$  ..... Wobble coefficient, see Table 3
- $x$  .....  $\text{m}$  ..... Distance along the tendon from the point where the prestressing force is equal to  $P_0$

NOTE 1  $\text{rad} = 1 \text{ m/m} = 1$

**Table 3** Friction coefficient  $\mu$  and wobble coefficient  $k$

—		Circular steel duct		Circular plastic duct	
		Duct I	Duct II	Range	Recommended value
$\mu$	rad <sup>-1</sup>	0.20	0.19	0.10 to 0.14	0.14
$k$	rad/m	0.005	0.005	—	0.005
	°/m	(0.3) <sup>1)</sup>	(0.3) <sup>1)</sup>		(0.3) <sup>1)</sup>

NOTE

<sup>1)</sup> For information only

For flat steel duct see Annex 4.

Information on friction losses in anchorages and couplers is included in Annex 3.

### 1.6 Support of ducts

Tendons are installed with high accuracy. This is achieved by installation of duct supports exactly levelled with regard to their designated position. The supports are secured in their position and the ducts fastened thereto. Distance between duct supports for tendons with steel strip sheaths does not exceed 1.80 m. In sections with maximum tendon curvature the distance between duct supports is reduced to 0.60 to 0.75 m.

If the prestressing steel strands are installed after concreting (duct II), special attention is applied that the duct will not displace. For that, the duct is additionally fastened between the supports e.g. to the reinforcement of the structure. If tendons are installed in several layers, only the lowest layer can be firmly connected with the duct support. All other tendon layers are placed and fastened on subsequently installed supports.

### 1.7 Radii of curvature

The minimum radii of curvature of tendons with steel strip sheaths as specified in Annex 7 and Annex 8 are observed. They correspond to

- A maximum prestressing force of the tendon of  $P_{m0} = 0.85 \cdot F_{p0.1}$
- A nominal diameter of the prestressing steel strand of  $d = 15.7$  mm
- Prestressing steel strand with a maximum nominal tensile strength of 1 860 N/mm<sup>2</sup>
- A maximum pressure under the prestressing steel strands of  $p_{R, \max} = 140$  kN/m or 200 kN/m
- A minimum concrete compressive strength of  $f_{cm, 0, \text{cube}} = 25$  N/mm<sup>2</sup>

In case of different tendon parameters or a different pressure under the prestressing steel strands, the calculation of the minimum radius of curvature can be carried out by the equation

$$R_{\min} = \frac{2 \cdot P_{m0} \cdot d}{d_i \cdot p_{R, \max}} \geq 2.0 \text{ m}$$

Where

$R_{\min}$  ..... m ..... Minimum radius of curvature

$P_{m0}$  ..... kN ..... Prestressing force of the tendon

$d$  ..... mm ..... Nominal diameter of the prestressing steel strand

$d_i$  ..... mm ..... Inner duct diameter

$p_{R, \max}$  .. kN/m ..... Maximum pressure under the prestressing steel strands

The minimum radius of curvature should not be less than 2.0 m. For a reduction of the minimum radius of curvature, the effects of the radial deviation forces on the concrete and stresses resulting from the curvature in the prestressing steel require verification, or the stressing force is reduced accordingly. Standards and regulations on minimum radius of curvature or on the maximum pressure under the prestressing steel strands in force in the place of use are observed.

## Components

### 1.8 Specification of prestressing steel strand

7-wire prestressing steel strand with plain surfaces of the individual wires, a nominal diameter of 15.3 or 15.7 mm and tensile strengths of 1 770 N/mm<sup>2</sup> or 1 860 N/mm<sup>2</sup> is used. Dimensions and specifications of the prestressing steel strand are according to prEN 10138-3 and are given in Clause 1.1, Table 1, and Annex 26.

In the course of preparing the European Technical Assessment, no characteristic has been assessed for the prestressing steel strand. In execution, a suitable prestressing steel strand that conforms to Annex 26 and is according to the standards and regulations in force at the place of use is taken.

### 1.9 Anchorage and coupler components

#### 1.9.1 General

Specifications of anchorage and coupler components are given in the Annexes and the technical file<sup>3</sup> of the European Technical Assessment. Therein the components' dimensions, materials, material identification data with tolerances and the materials used in corrosion protection are specified.

For prestressing steel strands with nominal tensile strength of 1 860 N/mm<sup>2</sup> as well as 1 770 N/mm<sup>2</sup> the same anchorages and couplers are used.

#### 1.9.2 Wedge plate and anchor plate SD

Both, wedge plate and anchor plate SD are made of steel with a pattern of regular arranged bores for anchoring the prestressing steel strands, see Annex 9, Annex 11, Annex 12, Annex 13, Annex 16, and Annex 22. The bores are cylindrical with conical ends at one side for bearing the wedges and are identical for stressing and fixed anchors. All bores are countersunk and deburred. See Annex 9 for details on the conical bores.

The wedge plate is supported by anchor body MA for load transfer to the structural concrete. Anchor plate SD serves for both in one piece, anchoring the prestressing steel strands and load transfer to the structural concrete by one load transfer plane.

For installation the bores and cones are clean and free of damage or rust and are provided with corrosion protection oil.

#### 1.9.3 Coupler plate R

The coupler plate R for fixed couplers, see Annex 22, is made of steel with two patterns of regular arranged bores for anchoring the prestressing steel strands. In the inner part of the coupler plates, the pattern is identical with the pattern of the wedge plate, providing cylindrical bores with conical ends at one side for bearing the wedges of the 1<sup>st</sup> construction stage. On the outer ring collar of the coupler plate, the pattern of bores are concentric rings, providing cylindrical bores with conical ends at one side for bearing the wedges of the 2<sup>nd</sup> construction stage. All bores are countersunk and deburred. See Annex 9 for details on the conical bores.

<sup>3</sup> The technical file of the European Technical Assessment is deposited at Österreichisches Institut für Bautechnik.

At the 2<sup>nd</sup> construction stage the wedges are pre-installed in the conical bores and secured with springs. A grouting box with vent is attached to coupler plate R to facilitate grouting.

For installation the bores and cones are clean and free of damage or rust and are provided with corrosion protection oil.

#### 1.9.4 Multi-plane anchor body MA

Multi-plane anchor body MA, see Annex 11, Annex 12, and Annex 13 is made of cast iron and used together with wedge plate as stressing or fixed anchor and with coupler plates R as fixed coupler.

Anchor body MA is of circular shape and provides several load transfer planes for load transfer to concrete. A centric circular hole allows for passing through the tendon.

#### 1.9.5 Single strand coupler

The single strand coupler, see Annex 23, is made of steel and employed for movable coupler D. Single strand coupler comprises 2 barrel chucks with conical bore and inner thread, 2 wedges, and 2 springs. The barrel chucks are connected by screwing a fitting bolt in steel in the inner threads of both barrel chucks.

For installation, the prestressing steel strands of both tendons are pushed into the single strand coupler with pre-assembled wedges, locked with springs. Cones are clean and free of damage or rust and provided with corrosion protection oil.

#### 1.9.6 Bond head

The bulb shaped bond head at the end of the prestressing steel strand, see Annex 17, for bond anchorage H is made by means of a special jack.

#### 1.9.7 Ring

Steel ring is used for bond anchorage H, see Annex 17, Annex 19, and Annex 20.

#### 1.9.8 Wedges

Only 3-piece wedges according to Annex 9 are used. The wedges feature different lengths for the respective nominal diameters of the prestressing steel strand, see Annex 9.

#### 1.9.9 Wedge keeper plate

Wedge keeper plate is used for fixed anchor that is not accessible, either with wedge plate, see Annex 10, or with anchor plate SD, see Annex 15.

### 1.10 Helix and additional reinforcement

Steel grades and dimensions of helix and additional reinforcement conform to the specifications given in the Annexes and the technical file of the European Technical Assessment. Helix for anchorage with anchor bodies MA can be made of plain round steel wire or ribbed reinforcing steel. Helix for bond anchorage H is made of ribbed reinforcing steel. Generally, both ends of each helix are welded to closed rings. Welding of one end, the inner end, may be omitted. Details on welding of helix are given in Annex 11, Annex 12, and Annex 16.

### 1.11 Duct

Usually, a corrugated duct made of steel strips is used. As a general rule, ducts with a smaller inner diameter, duct I, are used for pre-fabricated tendons. Longer tendons are transported to the job site in coils or oblong loops. The minimum transport bending diameter D for tendons up to 6812 is 1.50 m and for larger tendons up to 6827 is 1.80 m.

For on-site fabrication of tendons, the prestressing steel strands are inserted into the ducts either before or after placing the concrete. In general, ducts with a larger inner diameter, duct II, are used

for that purpose. Either one or several prestressing steel strands are consecutively pushed or pulled into the respective duct or the entire tendon all at once.

In general, the ducts have circular cross section – so called “round” duct. Optionally, for tendons 6803 to 6805, ducts with oval cross sections – so called “flat” duct – are available. The ends of the ducts are connected with couplers. For length compensation, a short duct piece may be installed between duct and trumpet of an anchorage as a telescopic duct.

The circular duct conforms to EN 523. For the flat duct EN 523 applies analogously.

Alternatively, corrugated plastic ducts may be installed, if permitted at the place of use.

### **1.12 Permanent corrosion protection**

In the course of preparing the European Technical Assessment no characteristic has been assessed for components and materials of the corrosion protection system. In execution, all components and materials are selected according to the standards and regulations in force at the place of use.

Corrosion protection of tendon, anchorage, and coupler is provided by grout according to EN 447, special grout according to EAD 160027-00-0301, or ready-mixed grout with an adequate composition according to standards and regulations in force at the place of use.

### **1.13 Welding**

Welding is only permitted for the following components.

- Welding the helix end turn to a closed ring
- Welding the helix end ring to the anchor body MA or to the anchor plate SD or its connection tube to secure the centric position of the helix

During welding it is ensured that there is no contact to duct and to prestressing steel strand.

After assembly of the tendons, no welding operations are carried out any more. Welding operations close to tendons require precautionary measures to avoid damage.

### **1.14 Material specifications of the components**

Material specifications of the components are given in Annex 25.

## **2 Specification of the intended use in accordance with the applicable European Assessment Document (hereinafter EAD)**

### **2.1 Intended use**

The PT system DYWIDAG Strand is intended to be used for the prestressing of structures. The specific intended use is

- Internal bonded tendon for concrete and composite structures

### **2.2 Assumptions**

#### **2.2.1 General**

Concerning product packaging, transport, storage, maintenance, replacement, and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on transport, storage, maintenance, replacement, and repair of the product as he considers necessary.



## 2.2.2 Packaging, transport and storage

Tendons and anchorages may be assembled on site or at the factory, i.e. pre-assembled tendons.

The tendons are packed, stored, and transported in transport racks, pallets, and bobbins such that they do not fall short of the following curvature diameters  $D$ .

For tendons up to 6812 .....  $D \geq 1.50$  m

For larger tendons up to 6827 .....  $D \geq 1.80$  m

Advice on packaging, transport, and storage includes.

- Temporary protection of prestressing steels and components in order to prevent corrosion during transportation from the production site to the job site
- Transportation, storage, and handling of prestressing steel and other components in a manner as to avoid damage by mechanical or chemical impact
- Protection of tensile elements and other components from moisture
- Keeping tensile elements away from zones where welding operations are performed

## 2.2.3 Design

### 2.2.3.1 General

Advice on design includes the following items.

Design of the structure permits correct installation, stressing, and grouting of tendon and design and reinforcement of the anchorage zone permits correct placing and compacting of concrete.

Tendons arranged one on top of each other are separated by an appropriate thick concrete layer, as in case of tendon curvatures there is a risk of inner ducts being crushed as a result of deviation forces from the prestressed outer tendons.

Verification of transfer of prestressing forces to the structural concrete is not required, if centre and edge distances of the tendons, strength of concrete, as well as grade and dimensions of helix and additional reinforcement, see Clause 1.2.5, Clause 1.2.6, Clause 1.2.7, Annex 11, Annex 12, Annex 13, Annex 16, Annex 17, Annex 18, Annex 19, and Annex 20, are conformed to. The forces outside the area of helix and additional reinforcement are verified and, if necessary, covered by appropriate, in general transverse reinforcement. The reinforcement of the structure is not employed as additional reinforcement. Reinforcement exceeding the required reinforcement of the structure may be used as additional reinforcement if appropriate placing is possible.

If required for a specific project design, the reinforcement given in Annex 11, Annex 12, Annex 13, Annex 16, Annex 17, Annex 18, Annex 19, and Annex 20 may be modified in accordance with the respective regulations in force at the place of use as well as with the relevant approval of the local authority and of the ETA holder to provide equivalent performance.

The anchor recess is designed as to ensure a concrete cover of at least 20 mm at the grout caps in the final state.

The initial prestressing force applied to the stressing anchor will decrease especially as a result of slip, see Clause 1.4 and Annex 14, of friction along the tendon, see Clause 1.5, and of the elastic shortening of the structure, and in the course of time because of relaxation of the prestressing steel, and creep and shrinkage of concrete. The stressing instructions prepared by the ETA holder should be consulted.

#### 2.2.3.2 Bond anchorage

For calculation of elongations the free length of the tendon includes 50 % of the distance between ring and bond head. Full tendon force is applied after the ring only. Between ring and bond head the decrease of the tendon force can be assumed to be linear and zero at the beginning of the bond head.

#### 2.2.3.3 Increased losses of prestressing forces at fixed coupler

For verification of the limitation of crack widths and for verification of the stress range increased losses of prestressing forces at fixed couplers due to creep and shrinkage of the concrete are taken into consideration. The determined losses of prestressing forces of tendons without the influence of couplers are multiplied by the factor 1.5 in the areas of fixed couplers.

For movable couplers, increased losses of prestressing forces do not need to be taken into consideration.

#### 2.2.3.4 Fixed coupler

Under all possible load combinations, the prestressing force at the 2<sup>nd</sup> construction stage of the fixed coupler is at no time higher than at the 1<sup>st</sup> construction stage, neither during construction nor in the final state.

#### 2.2.3.5 Movable coupler

The length of the coupler tube and its position relative to the coupler ensures unimpeded movement of the coupler in the coupler tube along a length of  $\geq \max \begin{cases} 1.20 \cdot \Delta l \\ 120 \text{ mm} \end{cases}$ , with  $\Delta l$  in mm as the expected displacement of the coupler during stressing.

#### 2.2.3.6 Tendons in masonry structures

Post-tensioning kits are primarily used in structures made of concrete. They can, however, be used with other structural materials, e.g. in masonry structures. However, there is no particular assessment in EAD 160004-00-0301 for these applications. Hence, load transfer of stressing force from the anchorage to the masonry structure is via concrete or steel member, designed according to the European Technical Assessment, especially according to the Clauses 1.2.5, 1.2.6, 1.2.7, or Eurocode 3 respectively.

The concrete or steel members have such dimensions as to permit a force of  $1.1 \cdot F_{pk}$  being transferred into the masonry. The verification is performed according to Eurocode 6 as well as to the respective standards and regulations in force at the place of use.

### 2.2.4 Installation

#### 2.2.4.1 General

It is assumed that the product will be installed according to the manufacturer's instructions or – in absence of such instructions – according to the usual practice of the building professionals.

Assembly and installation of tendons are only carried out by qualified PT specialist companies with the required resources and experience in the use of bonded multi-strand post-tensioning systems, see CWA 14646. The company's PT site manager has a certificate, stating that she or he has been trained by the ETA holder and that she or he possesses the necessary qualification and experience with the PT system DYWIDAG Strand.

## 2.2.4.2 Anchorages

### 2.2.4.2.1 General

Stressing and fixed anchor with anchor body MA and wedge plate, fixed coupler with anchor body MA and coupler plate R, and stressing and fixed anchor with anchor plate SD are installed perpendicular to the tendon's axis. Adjacent to the trumpet, the tendon continues with a straight section over a length of at least 250 mm.

The centric position of the helix is secured by welding the end ring to anchor body MA or to the anchor plate SD or its connection tube or by means of spacers braced against the tendon. The additional reinforcement is fastened centrally to the trumpet by tying or by means of spacers.

### 2.2.4.2.2 Stressing anchor

Site assembly comprises the following working steps, see Annex 10 and Annex 15.

- Fastening the anchor body MA or trumpet or connection tube for anchor plate SD to the formwork.
- Installation of the trumpet between anchor body MA and duct or between connection tube for anchor plate SD and duct.
- If the helix is not already welded on to the anchor body MA or the connection tube for anchor plate SD in the manufacturing plant, the helix is placed, centred relative to the tendon axis and fastened to the reinforcement.
- Pushing the duct into the trumpet to approximately a length of  $d$ , with  $d$  as the duct diameter, or aligning trumpet and duct and connecting them by means of a duct coupler with a minimum length of  $2 \cdot d$ , or, in the case of appropriately shaped plastic trumpets, screwing the duct onto the trumpet.
- Sealing the joint trumpet to duct.
- Pushing the wedge plate or the anchor plate SD over the strands shortly before stressing.
- Tightening the prestressing steel strands with 3-piece wedges.

### 2.2.4.2.3 Fixed anchor

The anchorage with anchor body MA and wedge plate or with anchor plate SD is also used as fixed anchor. If the fixed anchor is accessible during stressing, the installation is the same as for the stressing anchor according to Clause 2.2.4.2.2 with an anchor body MA with wedge plate or an anchor plate SD.

If the fixed anchor is not accessible during stressing, site assembly comprises the following steps, see Annex 10 and Annex 15.

- Assembly and placing of multi-plane anchor body MA, helix, trumpet, and duct or of connection tube, trumpet, and duct at the formwork. Subsequently fastening of respective components to reinforcement and sealing of joints.
- Pushing or pulling of strands.
- Pushing the wedge plate or the anchor plate SD over the strands.
- Installation of wedges and pre-wedging with  $P_{0, \max}$  according to Annex 5 and Annex 6 and subsequently securing the wedges with a wedge keeper plate.
- Mounting of grout cap together with respective sealing and vent pipes.

### 2.2.4.2.4 Bond anchorage H – HL or HR

Before shaping the bond heads, ring, helix, and spacers are placed on the tendon. The bond heads are shaped in the manufacturing plant or on site by cold forming and all bond heads are arranged by means of spacers according to their designated position.

### 2.2.4.3 Couplers

#### 2.2.4.3.1 Fixed coupler with coupler plate R

The fixed coupler R joints a 2<sup>nd</sup> tendon with an already stressed 1<sup>st</sup> tendon. The anchorage of the prestressing steel strands in the already stressed 1<sup>st</sup> tendon in coupler plate R is equivalent to the stressing anchor with wedge plate and anchor body MA. The coupler with coupler plate R and anchor body MA are installed perpendicular to the tendon's axis with the same procedure as the stressing anchor. Adjacent to the trumpet, the tendon continues with a straight section over a length of at least 250 mm.

Site assembly of the 2<sup>nd</sup> tendon comprises the following steps, see Annex 21 and Annex 22.

- Assembly and positioning of end trumpet, duct sleeve, and duct in the formwork, subsequently fastening of respective components to reinforcement and sealing of the joints. End trumpet and duct sleeve are mounted with distance  $L_t$  from coupler plate R, where  $L_t$  as the total length of the end trumpet.
- Pushing or pulling of strands.
- Jointing the 2<sup>nd</sup> tendon with the 1<sup>st</sup> tendon by inserting the strands into the cylindrical bores of the outer ring collar of coupler plate R. The strands are locked by the pre-installed wedges, springs and press-on-segments at the rear conical ends of the cylindrical bores. Proper seating of the strand ends with regard to sufficient insertion length is checked with colour markings. The section behind the conical ends of the outer ring collar is covered with an also pre-installed protection cap.
- Installing end trumpet and duct sleeve in final position.
- Arranging grout or vent pipes on end trumpet and on protection cap for grouting.

#### 2.2.4.3.2 Movable coupler with single strand couplers D

The movable coupler joints two tendons prior to stressing by single strand couplers. The strands of both tendons are anchored by means of wedges. The single strand couplers consist of 2 coupler barrel chucks each with cone and thread, which are connected by a steel fitting bolt. Springs between wedges and fitting bolt secure the wedge positions in the cones.

Site assembly of the coupler D comprises the following working steps, see Annex 23 and Annex 24.

- Assembly and positioning of duct, sleeve tubes, trumpets, and coupler tube at the formwork. Subsequently, fastening of duct to reinforcement and sealing of the joints. Coupler tube, trumpets and sleeve tubes remain pushed back on duct, to provide space for installation of strand couplers.
- Pushing or pulling of strands.
- Cutting to length of strand with regard to staggered position of single strand couplers.
- Connecting the strands with strand couplers D by inserting the strand into the bores of the single strand couplers. The proper seating of the two strand ends with regard to sufficient insertion length is checked with colour markings.
- Before final assembly of coupler tube, trumpets, and sleeve tubes, checking the correct position of single strand couplers in the coupler tube with regard to the direction of stressing.
- Installing of coupler tube, trumpets and sleeve tube and sealing the joints.
- Arranging a vent pipe at both ends of the coupler tube.



ungrouted for a longer time, appropriate corrosion protection measures are implemented after acceptance of the ETA holder.

The anchor recesses are concreted once stressing and grouting are completed, to establish a complete corrosion protection of the tendon.

### 2.3 Assumed working life

The European Technical Assessment is based on an assumed working life of DYWIDAG Strand of 100 years, provided that DYWIDAG Strand is subject to appropriate installation, use, and maintenance, see Clause 2.2. These provisions are based upon the current state of the art and the available knowledge and experience.

In normal use conditions, the real working life may be considerably longer without major degradation affecting the basic requirements for construction works<sup>4</sup>.

The indications given as to the working life of the construction product cannot be interpreted as a guarantee, neither given by the product manufacturer or his representative nor by EOTA nor by the Technical Assessment Body, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

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

### 3.1 Essential characteristics

The performances of DYWIDAG Strand for the essential characteristics are given in Table 4.

**Table 4** Essential characteristics and performances of the product

No	Essential characteristic	Product performance
Basic requirement for construction works 1: Mechanical resistance and stability		
1	Resistance to static load	See Clause 3.2.1.1.
2	Resistance to fatigue	See Clause 3.2.1.2.
3	Load transfer to the structure	See Clause 3.2.1.3.
4	Friction coefficient	See Clause 3.2.1.4.
5	Deviation, deflection (limits) for internal bonded and internal unbonded tendon	See Clause 3.2.1.5.
6	Assessment of assembly	See Clause 3.2.1.6.
7	Corrosion protection	See Clause 3.2.1.7.
Basic requirement for construction works 2: Safety in case of fire		
8	Reaction to fire	See Clause 3.2.2.1.

<sup>4</sup> The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works are subject, as well as on the particular conditions of design, execution, use, and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than the assumed working life.

No	Essential characteristic	Product performance
Basic requirement for construction works 3: Hygiene, health, and the environment		
9	Content, emission, and/or release of dangerous substances	See Clause 3.2.3.1.
Basic requirement for construction works 4: Safety and accessibility in use		
—	Not relevant. No characteristic assessed.	—
Basic requirement for construction works 5: Protection against noise		
—	Not relevant. No characteristic assessed.	—
Basic requirement for construction works 6: Energy economy and heat retention		
—	Not relevant. No characteristic assessed.	—
Basic requirement for construction works 7: Sustainable use of natural resources		
—	No characteristic assessed.	—

## 3.2 Product performance

### 3.2.1 Mechanical resistance and stability

#### 3.2.1.1 Resistance to static load

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.1. The characteristic values of maximum force,  $F_{pk}$ , of the tendon with prestressing steel strands according to Annex 26 are listed in Annex 27.

#### 3.2.1.2 Resistance to fatigue

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.2. The characteristic values of maximum force,  $F_{pk}$ , of the tendon with prestressing steel strands according to Annex 26 are listed in Annex 27.

Fatigue resistance of anchorages and couplers was tested and verified with an upper force of  $0.65 \cdot F_{pk}$ , a fatigue stress range of  $80 \text{ N/mm}^2$ , and  $2 \cdot 10^6$  load cycles.

#### 3.2.1.3 Load transfer to the structure

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.3. The characteristic values of maximum force,  $F_{pk}$ , of the tendon with prestressing steel strands according to Annex 26 are listed in Annex 27.

Conformity with the stabilisation and crack width criteria specified for the load transfer test was verified to a force level of  $0.80 \cdot F_{pk}$ .

#### 3.2.1.4 Friction coefficient

For friction losses including friction coefficient see Clause 1.5.

#### 3.2.1.5 Deviation, deflection (limits) for internal bonded and internal unbonded tendon

For minimum radii of curvature see Clause 1.7.

#### 3.2.1.6 Assessment of assembly

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.7.

#### 3.2.1.7 Corrosion protection

The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.13.

#### 3.2.2 Safety in case of fire

##### 3.2.2.1 Reaction to fire

The performance of components made of steel or cast iron is Class A1 without testing.

The performance of components of other materials has not been assessed.

#### 3.2.3 Hygiene, health, and the environment

##### 3.2.3.1 Content, emission and/or release of dangerous substances

According to the manufacturer's declaration, the PT system does not contain dangerous substances.

- SVOC and VOC

The performance of components made of steel or cast iron that are free of coating with organic material is no emission of SVOC and VOC.

The performance of components of other materials has not been assessed.

- Leachable substances

The product is not intended to be in direct contact to soil, ground water, and surface water.

### 3.3 Assessment methods

The assessment of the essential characteristics in Clause 3.1 of DYWIDAG Strand, for the intended use, and in relation to the requirements for mechanical resistance and stability, safety in case of fire, and for hygiene, health and the environment, in the sense of the basic requirements for construction works № 1, 2, and 3 of Regulation (EU) № 305/2011, has been made in accordance with Annex A of EAD 160004-00-0301, Post-tensioning kits for prestressing of structures, for Item 1, Internal bonded tendon.

### 3.4 Identification

The European Technical Assessment for DYWIDAG Strand is issued on the basis of agreed data that identify the assessed product<sup>5</sup>. Changes to materials, to composition, or to characteristics of the product, or to the production process could result in these deposited data being incorrect. Österreichisches Institut für Bautechnik should be notified before the changes are introduced, as an amendment of the European Technical Assessment is possibly necessary.

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<sup>5</sup> The technical file of the European Technical Assessment is deposited at Österreichisches Institut für Bautechnik.



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

### **4.1 System of assessment and verification of constancy of performance**

According to Commission Decision 98/456/EC, the system of assessment and verification of constancy of performance to be applied to DYWIDAG Strand is System 1+. System 1+ is detailed in Commission Delegated Regulation (EU) № 568/2014 of 18 February 2014, Annex, point 1.1., and provides for the following items.

- (a) The manufacturer shall carry out
  - (i) factory production control;
  - (ii) further testing of samples taken at the manufacturing plant by the manufacturer in accordance with the prescribed test plan<sup>6</sup>.
- (b) The notified product certification body shall decide on the issuing, restriction, suspension, or withdrawal of the certificate of constancy of performance of the construction product on the basis of the outcome of the following assessments and verifications carried out by that body
  - (i) an assessment of the performance of the construction product carried out on the basis of testing (including sampling), calculation, tabulated values, or descriptive documentation of the product;
  - (ii) initial inspection of the manufacturing plant and of factory production control;
  - (iii) continuing surveillance, assessment, and evaluation of factory production control;
  - (iv) audit-testing of samples taken by the notified product certification body at the manufacturing plant or at the manufacturer's storage facilities.

### **4.2 AVCP for construction products for which a European Technical Assessment has been issued**

Notified bodies undertaking tasks under System 1+ shall consider the European Technical Assessment issued for the construction product in question as the assessment of the performance of that product. Notified bodies shall therefore not undertake the tasks referred to in Clause 4.1, point (b) (i).

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

### **5.1 Tasks for the manufacturer**

#### **5.1.1 Factory production control**

The kit manufacturer exercises permanent internal control of the production. All the elements, procedures, and specifications adopted by the kit manufacturer are documented in a systematic manner in the form of written policies and procedures.

- Control of the incoming materials

The manufacturer checks the incoming materials to establish conformity with their specifications.

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<sup>6</sup> The prescribed test plan has been deposited with Österreichisches Institut für Bautechnik and is handed over only to the notified product certification body involved in the procedure for the assessment and verification of constancy of performance. The prescribed test plan is also referred to as control plan.

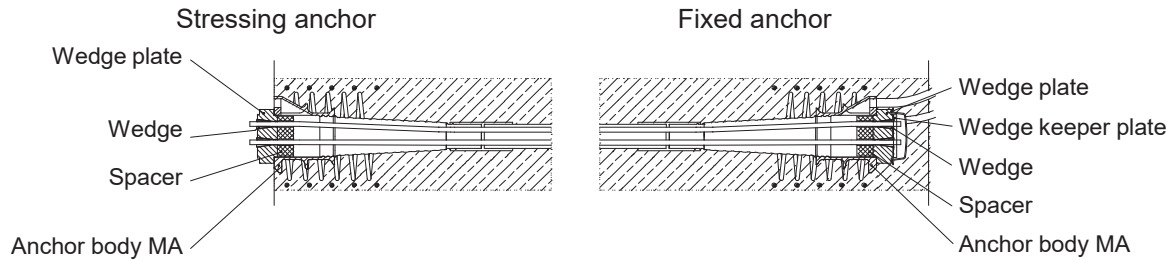




## Anchorages

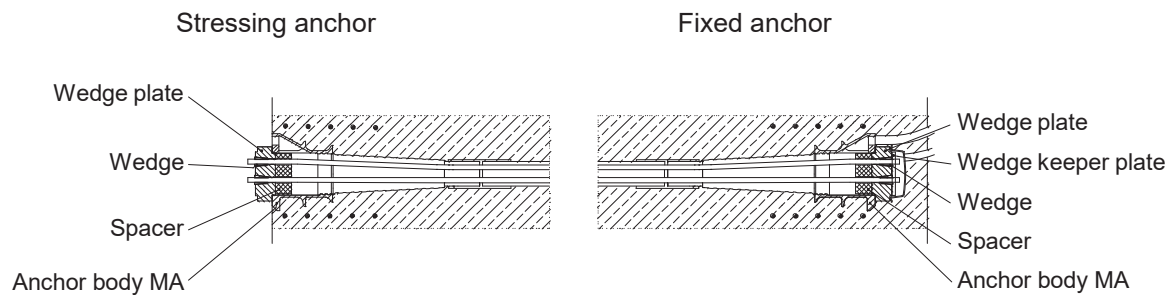
Anchor with wedge plate and multi-plane anchor body MA with helix

5–55 strands



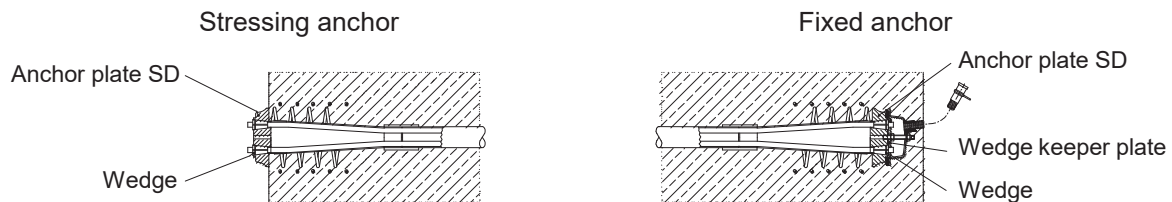
Anchor with wedge plate and multi-plane anchor body MA without helix

5–22 strands



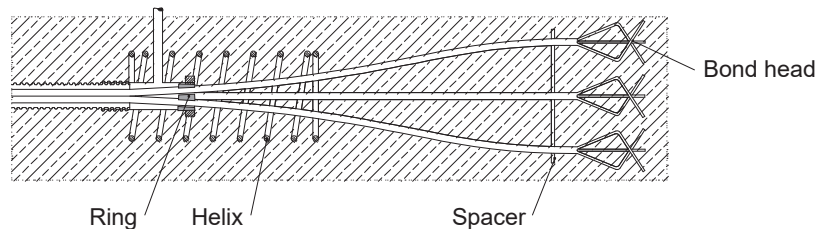
Anchor with anchor plate SD

3–9 strands



Bond anchorage H, HL and HR

3–22 strands



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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Overview on anchorages

**Annex 1**  
 of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

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Technical data for tendons 6803 to 6855 with round steel duct

Tendon	6803	6804	6805	6806	6807	6808	6809	6812	6815	
Number of strands	3	4	5	6	7	8	9	12	15	
Cross-sectional area of prestressing steel	$\varnothing$ 15.3 mm mm <sup>2</sup>	420	560	700	840	980	1 120	1 260	1 680	2 100
	$\varnothing$ 15.7 mm mm <sup>2</sup>	450	600	750	900	1 050	1 200	1 350	1 800	2 250
Nominal mass of prestressing steel	$\varnothing$ 15.3 mm kg/m	3.28	4.37	5.47	6.56	7.65	8.74	9.84	13.12	16.40
	$\varnothing$ 15.7 mm kg/m	3.52	4.69	5.86	7.03	8.20	9.37	10.55	14.06	17.58
Modulus of elasticity	N/mm <sup>2</sup>	195 000 (standard value)								
<b>Round steel duct</b> <sup>1)</sup>										
Duct I	$\varnothing$ d <sub>i</sub> /d <sub>a</sub> mm	40/47	45/52	50/57	55/62	55/62	65/72	65/72	75/82	80/87
Eccentricity	mm	3	6	7	7	6	10	9	10	10
Duct II	$\varnothing$ d <sub>i</sub> /d <sub>a</sub> mm	45/52	50/57	55/62	60/67	60/67	70/77	70/77	80/87	85/92
Eccentricity	mm	5	9	10	11	9	14	12	14	13
Distance of tendon support	m	0.60–1.80 m with stiffening, e.g. with strand bundle or PE tube 0.60–1.00 m with strengthened duct In tendon section with minimum radius of curvature a distance of 0.60 to 0.80 m applies.								
Friction coefficient	$\mu$ rad <sup>-1</sup>	0.19								
Wobble coefficient	k	0.005 rad/m $\triangleq$ 0.30 °/m								
Friction loss in stressing anchor	%	1.0	1.0	1.0	0.8	0.8	0.7	0.7	0.5	0.5

Tendon	6819	6822	6827	6831	6837	6843	6849	6855	
Number of strands	19	22	27	31	37	43	49	55	
Cross-sectional area of prestressing steel	$\varnothing$ 15.3 mm mm <sup>2</sup>	2 660	3 080	3 780	4 340	5 180	6 020	6 860	7 700
	$\varnothing$ 15.7 mm mm <sup>2</sup>	2 850	3 300	4 050	4 650	5 550	6 450	7 350	8 250
Nominal mass of prestressing steel	$\varnothing$ 15.3 mm kg/m	20.77	24.05	29.51	33.88	40.44	47.00	53.56	60.12
	$\varnothing$ 15.7 mm kg/m	22.27	25.78	31.64	36.33	43.36	50.40	57.43	64.46
Modulus of elasticity	N/mm <sup>2</sup>	195 000 (standard value)							
<b>Round steel duct</b> <sup>1)</sup>									
Duct I	$\varnothing$ d <sub>i</sub> /d <sub>a</sub> mm	90/97	95/102	105/112	115/122	—	—	—	—
Eccentricity	mm	10	10	11	15	—	—	—	—
Duct II	$\varnothing$ d <sub>i</sub> /d <sub>a</sub> mm	95/102	105/112	115/122	120/127	130/137	140/147	150/157	160/167
Eccentricity	mm	14	18	18	17	17	19	21	23
Distance of tendon support	m	1.00–1.80 m with stiffening, e.g. with PE tube 0.80–1.50 m with strengthened duct In tendon section with minimum radius of curvature a distance of 0.80 to 1.20 m applies.							
Friction coefficient	$\mu$ rad <sup>-1</sup>	0.19							
Wobble coefficient	k	0.005 rad/m $\triangleq$ 0.30 °/m							
Friction loss in stressing anchor	%	0.5							

<sup>1)</sup> Friction and wobble coefficients for round plastic duct see Clause 1.5.

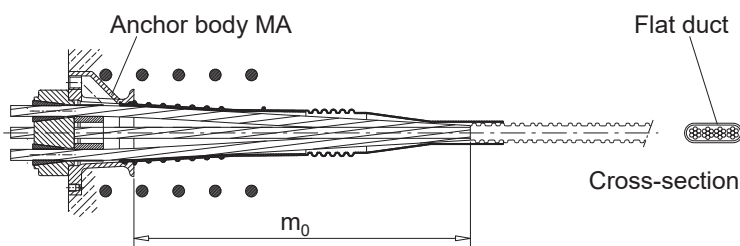


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**Bonded prestressing system**  
**DYWIDAG – Strand**  
Technical data  
Tendons 6803 to 6855 with round steel duct

**Annex 3**  
of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

Technical data for tendons 6803 to 6805 with flat steel duct



Tendon		6803	6804	6805
Number of strands		3	4	5
Cross-sectional area of prestressing steel	∅ 15.3 mm mm <sup>2</sup>	420	560	700
	∅ 15.7 mm mm <sup>2</sup>	450	600	750
Nominal mass of prestressing steel	∅ 15.3 mm kg/m	3.28	4.37	5.47
	∅ 15.7 mm kg/m	3.52	4.69	5.86
Modulus of elasticity N/mm <sup>2</sup>		195 000 (standard value)		
<b>Flat steel duct <sup>1)</sup></b>				
Dimensions	d <sub>i</sub> mm	55 × 21	70 × 21	85 × 21
	d <sub>a</sub> mm	60 × 25	75 × 25	90 × 25
Trumpet length	m <sub>o</sub> mm	350	350	500
Distance of tendon support	m	0.50–1.00		
Wobble coefficient	k	0.010 rad/m △ 0.60 °/m		
Bending around weak axis, Minimum radius of curvature	R <sub>min</sub> m	2.5		
Friction coefficient	μ rad <sup>-1</sup>	0.15		
Bending around strong axis, Minimum radius of curvature	R <sub>min</sub> m	5.0		
Friction coefficient	μ rad <sup>-1</sup>	0.23	0.26	0.32

<sup>1)</sup> Friction and wobble coefficients for flat plastic duct see Clause 1.5.



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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Technical data  
 Tendons 6803 to 6805 with flat steel duct

**Annex 4**  
 of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

Maximum prestressing and overstressing forces for strand 140 mm<sup>2</sup>

Number of strands <sup>1)</sup>	Mass of strands	Cross-sectional area of strands	$f_{pk} = 1\,770\text{ N/mm}^2$		$f_{pk} = 1\,860\text{ N/mm}^2$	
			Maximum prestressing force <sup>2), 4)</sup>	Maximum overstressing force <sup>2), 3), 4)</sup>	Maximum prestressing force <sup>2), 4)</sup>	Maximum overstressing force <sup>2), 3), 4)</sup>
			$A_p$	$0.90 \cdot F_{p0.1}^{5)}$	$0.95 \cdot F_{p0.1}$	$0.90 \cdot F_{p0.1}^{5)}$
—	kg/m	mm <sup>2</sup>	kN	kN	kN	kN
1	1.09	140	197	208	207	218
3	3.28	420	590	622	620	654
4	4.37	560	786	830	827	872
5	5.47	700	983	1037	1 033	1 091
6	6.56	840	1 179	1 245	1 240	1 309
7	7.65	980	1 376	1 452	1 446	1 527
8	8.74	1 120	1 572	1 660	1 653	1 745
9	9.84	1 260	1 769	1 867	1 860	1 963
12	13.12	1 680	2 359	2 490	2 480	2 617
15	16.40	2 100	2 948	3 112	3 100	3 272
19	20.77	2 660	3 735	3 942	3 926	4 144
22	24.05	3 080	4 324	4 565	4 546	4 799
27	29.51	3 780	5 307	5 602	5 579	5 889
31	33.88	4 340	6 093	6 432	6 406	6 762
37	40.44	5 180	7 273	7 677	7 646	8 070
43	47.00	6 020	8 452	8 922	8 886	9 379
49	53.56	6 860	9 631	10 167	10 125	10 688
55	60.12	7 700	10 811	11 411	11 365	11 997

- 1) By omitting strands, tendons with number of strands between the numbers given may be installed. The respective prestressing force is reduced per omitted strand as specified for one strand.
- 2) The given values are maximum values according to Eurocode 2. The actual values are taken from the standards and regulations in force at the place of use.
- 3) Overstressing is permitted if the force in the prestressing jack can be measured to an accuracy of  $\pm 5\%$  of the final value of the overstressing force.
- 4) For prestressing steel strands according to prEN 10138-3, 09.2000, the values are multiplied by 0.98.
- 5) Maximum prestressing force  $P_{0, \max}$

Where

$f_{pk}$  .....Characteristic tensile strength of prestressing steel strand  
 $F_{p0.1}$  .....Characteristic value of 0.1 % proof force of tendon,  $F_{p0.1} = A_p \cdot f_{p0.1}$   
 For  $F_{p0.1}$  of one single prestressing steel strand see Annex 26.



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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Maximum prestressing and overstressing forces  
 for prestressing steel strand 140 mm<sup>2</sup>

**Annex 5**  
 of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

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Maximum prestressing and overstressing forces for strand 150 mm<sup>2</sup>

Number of strands <sup>1)</sup>	Mass of strands	Cross-sectional area of strands	$f_{pk} = 1\,770\text{ N/mm}^2$		$f_{pk} = 1\,860\text{ N/mm}^2$	
			Maximum prestressing force <sup>2), 4)</sup>	Maximum overstressing force <sup>2), 3), 4)</sup>	Maximum prestressing force <sup>2), 4)</sup>	Maximum overstressing force <sup>2), 3), 4)</sup>
		$A_p$	$0.90 \cdot F_{p0.1}^{5)}$	$0.95 \cdot F_{p0.1}$	$0.90 \cdot F_{p0.1}^{5)}$	$0.95 \cdot F_{p0.1}$
—	kg/m	mm <sup>2</sup>	kN	kN	kN	kN
1	1.17	150	211	222	221	234
3	3.52	450	632	667	664	701
4	4.69	600	842	889	886	935
5	5.86	750	1 053	1 112	1 107	1 169
6	7.03	900	1 264	1 334	1 328	1 402
7	8.20	1 050	1 474	1 556	1 550	1 636
8	9.38	1 200	1 685	1 778	1 771	1 870
9	10.55	1 350	1 895	2 001	1 993	2 103
12	14.06	1 800	2 527	2 668	2 657	2 804
15	17.58	2 250	3 159	3 335	3 321	3 506
19	22.27	2 850	4 001	4 224	4 207	4 440
22	25.78	3 300	4 633	4 891	4 871	5 141
27	31.64	4 050	5 686	6 002	5 978	6 310
31	36.33	4 650	6 529	6 891	6 863	7 245
37	43.36	5 550	7 792	8 225	8 192	8 647
43	50.40	6 450	9 056	9 559	9 520	10 049
49	57.43	7 350	10 319	10 893	10 849	11 451
55	64.46	8 250	11 583	12 227	12 177	12 854

- 1) By omitting strands, tendons with number of strands between the numbers given may be installed. The respective prestressing force is reduced per omitted strand as specified for one strand.
- 2) The given values are maximum values according to Eurocode 2. The actual values are taken from the standards and regulations in force at the place of use.
- 3) Overstressing is permitted if the force in the prestressing jack can be measured to an accuracy of  $\pm 5\%$  of the final value of the overstressing force.
- 4) For prestressing steel strands according to prEN 10138-3, 09.2000, the values are multiplied by 0.98.
- 5) Maximum prestressing force  $P_{0, \max}$

Where

$f_{pk}$  .....Characteristic tensile strength of prestressing steel strand  
 $F_{p0.1}$  .....Characteristic value of 0.1 % proof force of tendon,  $F_{p0.1} = A_p \cdot f_{p0.1}$   
 For  $F_{p0.1}$  of one single prestressing steel strand see Annex 26.



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**Bonded prestressing system  
 DYWIDAG – Strand**

Maximum prestressing and overstressing forces  
 for prestressing steel strand 150 mm<sup>2</sup>

**Annex 6**

of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

Minimum radii of curvature for  $p_{R, \max} = 140 \text{ kN/m}$ , prestressing steel strand Y1860S7 <sup>1)</sup>  
 with use of corrugated steel ducts according to EN 523

Strand Y1860S7, $A_p = 140 \text{ mm}^2$					Strand Y1860S7, $A_p = 150 \text{ mm}^2$				
Number of strands	Duct I	Minimum radius of curvature	Duct II	Minimum radius of curvature	Number of strands	Duct I	Minimum radius of curvature	Duct II	Minimum radius of curvature
n	$\varnothing d_i$	$R_{\min}$	$\varnothing d_i$	$R_{\min}$	n	$\varnothing d_i$	$R_{\min}$	$\varnothing d_i$	$R_{\min}$
—	mm	m	mm	m	—	mm	m	mm	m
1	20	2.0	25	2.0	1	20	2.0	25	2.0
3	40	3.7	45	3.0	3	40	4.0	45	3.2
4	45	3.8	50	3.4	4	45	4.1	50	3.8
5	50	4.3	55	3.9	5	50	4.7	55	4.3
6	55	4.7	60	4.3	6	55	5.1	60	4.7
7	55	5.4	60	5.0	7	55	6.0	60	5.5
8	65	5.3	70	4.9	8	65	5.8	70	5.4
9	65	5.9	70	5.5	9	65	6.5	70	6.0
12	75	6.8	80	6.4	12	75	7.5	80	7.0
15	80	8.0	85	7.5	15	80	8.8	85	8.3
19	90	9.0	95	8.5	19	90	9.9	95	9.4
22	95	9.9	105	8.9	22	95	10.9	105	9.8
27	105	11.0	115	10.0	27	105	12.1	115	11.0
31	115	11.5	120	11.0	31	115	12.6	120	12.1
37	—	—	130	12.1	37	—	—	130	13.3
43	—	—	140	13.1	43	—	—	140	14.4
49	—	—	150	13.9	49	—	—	150	15.3
55	—	—	160	14.7	55	—	—	160	16.1

<sup>1)</sup> Minimum radii of curvature for prestressing steel strand Y1770S7 can be calculated with the equation in Clause 1.7.



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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Minimum radii of curvature –  $p_R = 140 \text{ kN/m}$

**Annex 7**  
 of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

Minimum radii of curvature for  $p_{R, \max} = 200 \text{ kN/m}$ , prestressing steel strand Y1860S7 <sup>1)</sup>  
 with use of corrugated steel ducts according to EN 523

Strand Y1860S7, $A_p = 140 \text{ mm}^2$					Strand Y1860S7, $A_p = 150 \text{ mm}^2$				
Number of strands	Duct I	Minimum radius of curvature	Duct II	Minimum radius of curvature	Number of strands	Duct I	Minimum radius of curvature	Duct II	Minimum radius of curvature
n	$\varnothing d_i$	$R_{\min}$	$\varnothing d_i$	$R_{\min}$	n	$\varnothing d_i$	$R_{\min}$	$\varnothing d_i$	$R_{\min}$
—	mm	m	mm	M	—	mm	m	mm	m
1	20	2.0	25	2.0	1	20	2.0	25	2.0
3	40	2.6	45	2.2	3	40	2.8	45	2.3
4	45	2.7	50	2.4	4	45	2.8	50	2.6
5	50	3.0	55	2.7	5	50	3.3	55	3.0
6	55	3.3	60	3.0	6	55	3.6	60	3.3
7	55	3.8	60	3.5	7	55	4.2	60	3.8
8	65	3.7	70	3.4	8	65	4.0	70	3.8
9	65	4.1	70	3.8	9	65	4.5	70	4.2
12	75	4.8	80	4.5	12	75	5.3	80	4.9
15	80	5.6	85	5.3	15	80	6.2	85	5.8
19	90	6.3	95	6.0	19	90	6.9	95	6.6
22	95	6.9	105	6.3	22	95	7.6	105	6.9
27	105	7.7	115	7.0	27	105	8.4	115	7.7
31	115	8.0	120	7.7	31	115	8.8	120	8.5
37	—	—	130	8.5	37	—	—	130	9.3
43	—	—	140	9.2	43	—	—	140	10.1
49	—	—	150	9.8	49	—	—	150	10.7
55	—	—	160	10.3	55	—	—	160	11.3

<sup>1)</sup> Minimum radii of curvature for prestressing steel strand Y1860S7 can be calculated with the equation in Clause 1.7.



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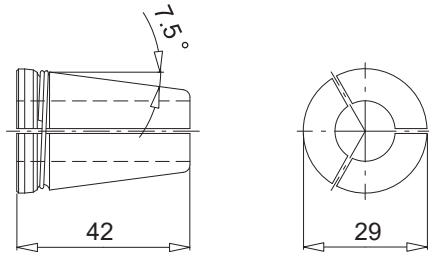
**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Minimum radii of curvature –  $p_R = 200 \text{ kN/m}$

**Annex 8**  
 of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

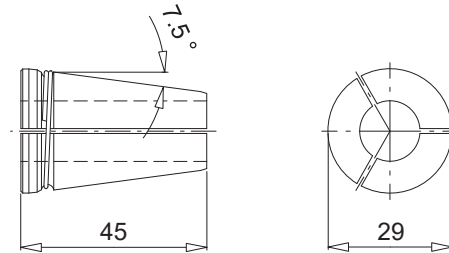
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Wedge and cone geometry

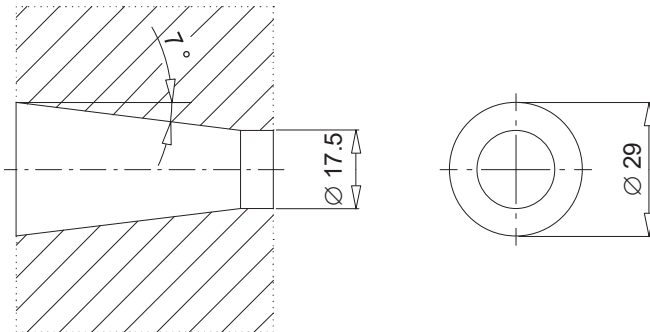
Prestressing steel strand 140 mm<sup>2</sup> (0.6")



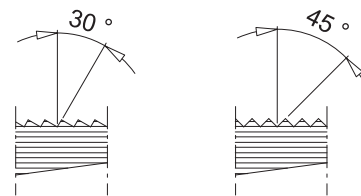
Prestressing steel strand 150 mm<sup>2</sup> (0.62")



Cone, for both wedge sizes

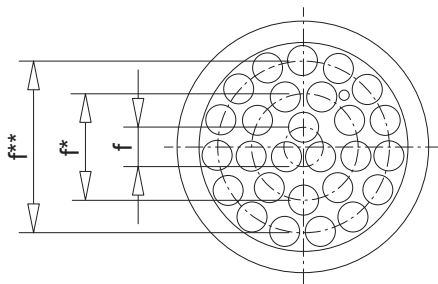


Wedge tooth geometry, for both wedge sizes

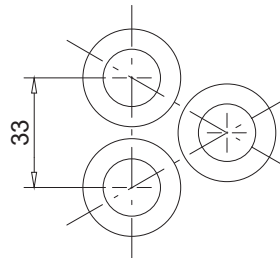


Geometry of wedge plate and anchor plate SD

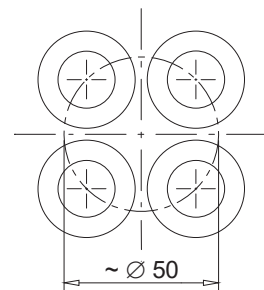
Tendon 6803 to 6837



Tendon 6843 to 6855

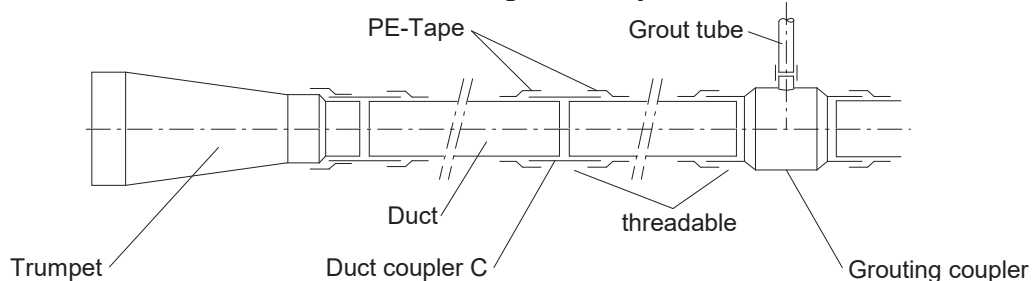


Tendon 6804



f, f\*, and f\*\* according to Annex 16 and Annex 22

Sheathing assembly



Dimensions in mm



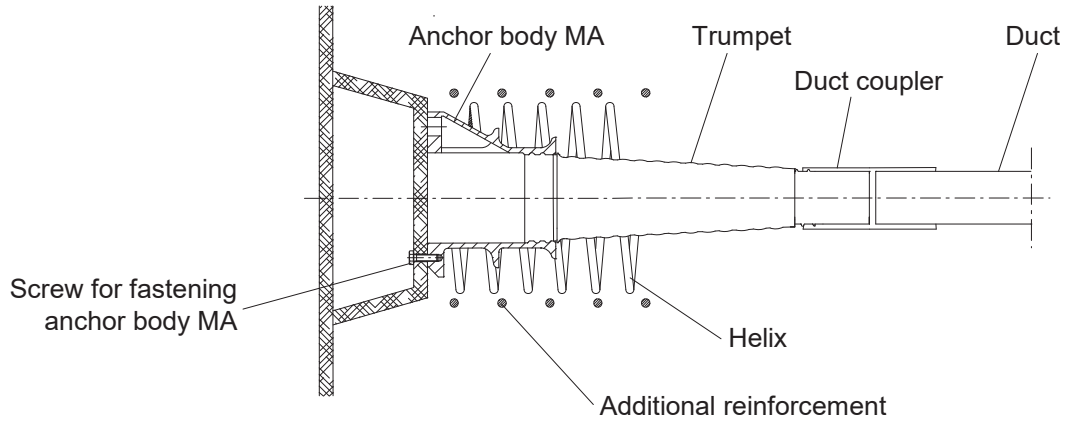
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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Basic components

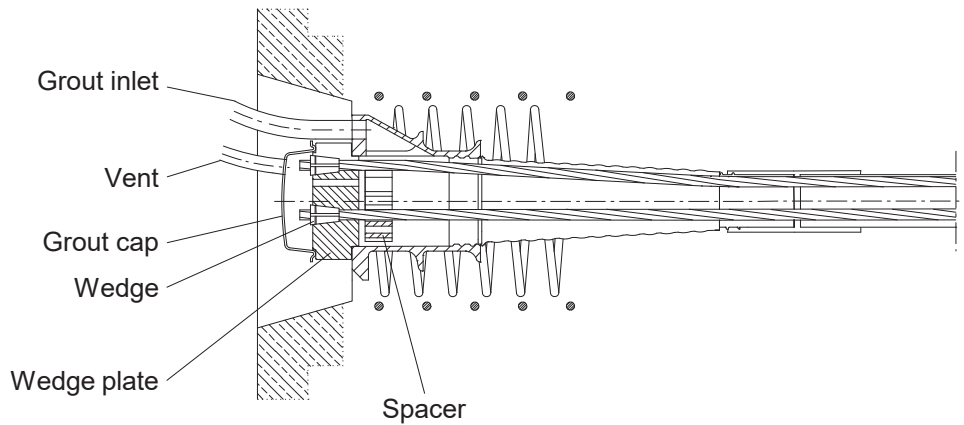
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Stressing anchor with wedge plate and anchor body MA

Installation of anchor body, trumpet, duct, and reinforcement

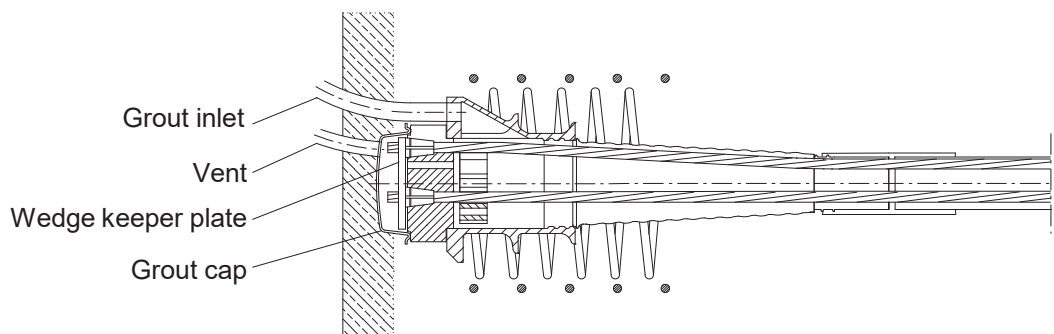


After installation and stressing of tendon



Fixed anchor with wedge plate and anchor body MA

Not accessible



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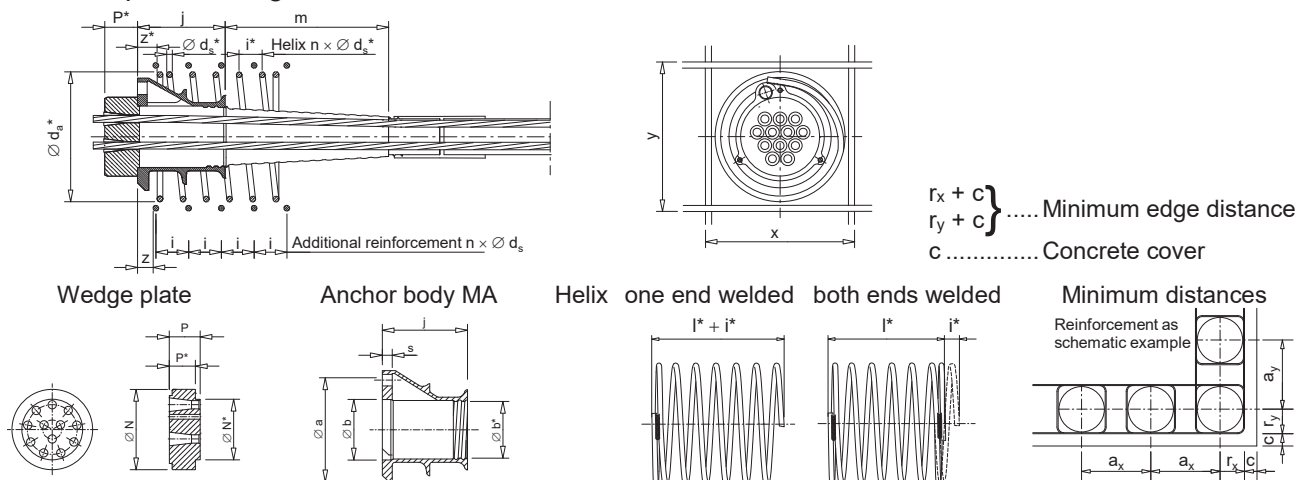
**Bonded prestressing system  
 DYWIDAG – Strand**

Assembly of anchorage with  
 multi-plane anchor body MA

**Annex 10**  
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Multi-plane anchor body MA with additional reinforcement and with helix and with minimum centre distances, prestressing steel strand Y1770S7 15.3, Y1770S7 15.7, Y1860S7 15.3, and Y1860S7 15.7



Tendon		6805	6807	6809	6812	6815	6819	6822
Number of strands		5	7	9	12	15	19	22
Strand arrangement								
Wedge plate	$\varnothing N$	117	130	145	170	190	210	220
	$\varnothing N^*$	88	96	112	128	148	159	176
thickness	P	55	60	60	65	70	80	85
depth	P*	47	52	52	55	60	68	73
Anchor body MA	$\varnothing a$	150	170	190	220	250	280	305
	$\varnothing b$	90	98	114	130	150	162	179
	$\varnothing b^*$	80	90	100	120	130	145	161
height	j	90	100	125	180	200	220	220
thickness	s	18	18	15	17	19	23	26.5
Trumpet length	m	240	210	280	350	390	430	550

Minimum concrete compressive strength at time of stressing																								
$f_{cm, 0, \text{cube}}$ N/mm <sup>2</sup>	25	34	45	25	34	45	25	34	45	25	34	45	25	34	45	25	34	45	25	34	45			
$f_{cm, 0, \text{cyl}}$ N/mm <sup>2</sup>	20	28	36	20	28	36	20	28	36	20	28	36	20	28	36	20	28	36	20	28	36	20	28	36
Centre distance $a_x, a_y$	270	235	220	320	280	245	345	305	270	400	350	310	445	390	345	500	435	380	540	470	410			
Edge distance (plus c) <sup>1)</sup> $r_x, r_y$	125	110	100	150	130	115	165	145	125	190	165	145	215	185	165	240	210	180	260	225	195			

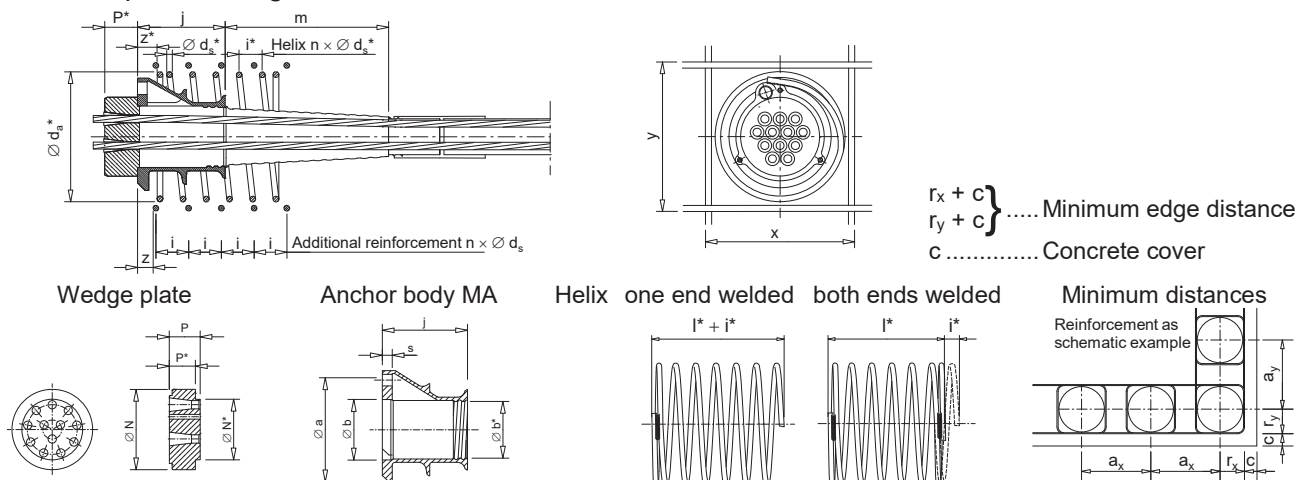
Helix																						
Minimum number of turns $n^*$	5.5	5	5	5	5	5	6.5	6	6	6	7	7	8	8	7	8.5	8	7.5	9	8.5	8	
Minimum wire diameter $\varnothing d_s^*$	12	12	12	14	14	14	14	14	14	14	14	14	16	14	14	16	16	16	16	16	16	16
Maximum distance $z^*$	40	40	40	40	40	40	40	40	40	45	45	45	50	50	50	50	50	50	55	55	55	
Min. external diameter $\varnothing d_a^*$	205	185	180	240	220	200	270	250	220	320	265	255	345	310	285	420	375	310	465	370	340	
max. $i^*$	45	40	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	
min. $l^*$	235	195	235	240	240	240	315	290	290	290	340	340	395	390	340	420	395	370	445	420	395	

Additional reinforcement, ribbed reinforcing steel $R_e \geq 500$ N/mm <sup>2</sup>																					
Minimum numbers of layers $n$	5	5	5	6	6	6	7	7	7	7	8	8	8	8	8	8	8	8	8	8	8
Minimum bar diameter $\varnothing d_s$	12	12	12	12	12	12	14	14	14	14	14	14	16	16	16	16	16	16	16	16	16
Maximum distance $z$	40	40	40	40	40	40	40	40	40	45	45	45	50	50	50	50	50	50	55	55	55
Maximum spacing $i$	50	45	50	55	50	50	55	55	55	55	50	55	65	60	60	65	65	65	60	55	55
External dimensions $x, y$	250	215	200	300	260	225	325	285	250	380	330	290	425	370	325	480	415	360	520	450	390

<sup>1)</sup> c ... concrete cover Dimensions in mm

 DYWIDAG-Systems International GmbH www.dywidad-systems.com	<b>Bonded prestressing system</b> <b>DYWIDAG – Strand</b> Anchorage with multi-plane anchor body MA with additional reinforcement and with helix Data sheet for tendons 6805 to 6822	<b>Annex 11</b> of European Technical Assessment <b>ETA-13/0815</b> of 25.06.2018
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Multi-plane anchor body MA with additional reinforcement and with helix and with minimum centre distances, prestressing steel strand Y1770S7 15.3, Y1770S7 15.7, Y1860S7 15.3, and Y1860S7 15.7

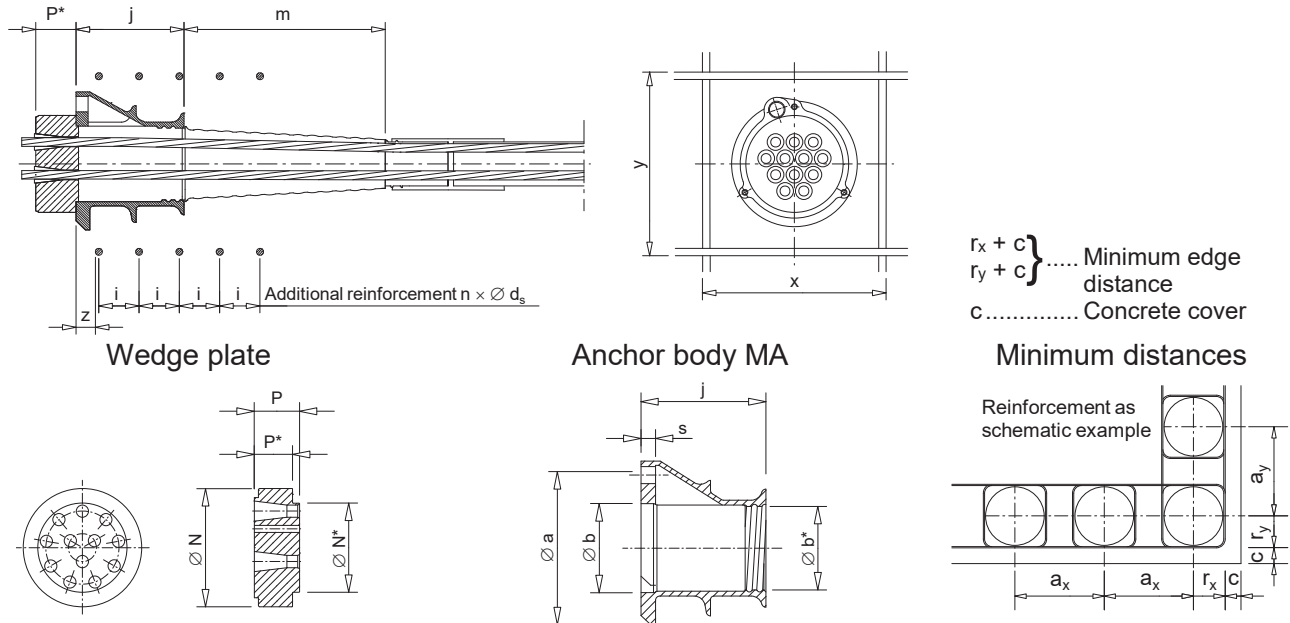


Tendon		6827	6831	6837	6843	6849	6855										
Number of strands		27	31	37	43	49	55										
Strand arrangement																	
Wedge plate	$\varnothing N$	240	270	270	320	340	340										
	$\varnothing N^*$	188	214	214	251	262	262										
	thickness P	95	100	115	130	140	140										
	depth $P^*$	80	80	95	110	120	120										
Anchor body MA	$\varnothing a$	330	385	420	465	510	510										
	$\varnothing b$	190	217	217	254	266	266										
	$\varnothing b^*$	161	196	196	252	252	252										
	height j	240	350	350	380	420	420										
thickness s	30	40	50	50	50	50											
Trumpet length m		550	570	570	950	780	780										
<b>Minimum concrete compressive strength at time of stressing</b>																	
$f_{cm, 0, \text{cube}}$	N/mm <sup>2</sup>	25	34	45	28	40	53	53	53	53							
$f_{cm, 0, \text{cyl}}$	N/mm <sup>2</sup>	20	28	36	23	33	43	43	43	43							
Centre distance $a_x, a_y$		600	520	460	690	590	535	760	650	600	640	680	710				
Edge distance (plus c) <sup>1)</sup> $r_x, r_y$		290	250	220	335	285	260	370	315	290	310	330	345				
<b>Helix</b>																	
Minimum number of turns	n*	10	9	8.5	10	9	8	11	9	8	10	10	11				
Minimum wire diameter	$\varnothing d_s^*$	16	16	16	20	20	20	20	20	20	20	20	20				
Maximum distance	$z^*$	55	55	55	60	60	60	70	70	70	70	70	70				
Min. external diameter	$\varnothing d_a^*$	510	430	370	620	530	480	660	570	520	530	550	580				
	max. $i^*$	50	50	50	55	60	65	50	60	65	55	60	55				
	min. $l^*$	495	445	420	555	540	515	560	540	515	555	600	610				
<b>Additional reinforcement, ribbed reinforcing steel <math>R_e \geq 500</math> N/mm<sup>2</sup></b>																	
Minimum numbers of layers	n	10	10	10	6	6	6	7	7	7	7	8	8	8	8	8	8
Minimum bar diameter	$\varnothing d_s$	20	20	20	12	12	12	14	14	14	14	14	14	16	16	16	16
Maximum distance	z	55	55	55	40	40	40	40	40	40	45	45	45	50	50	50	50
Maximum spacing	i	65	60	60	55	50	50	55	55	55	55	50	55	65	60	60	65
External dimensions	x, y	580	500	440	300	260	225	325	285	250	380	330	290	425	370	325	480

<sup>1)</sup> c ... concrete cover Dimensions in mm

 DYWIDAG-Systems International GmbH www.dywidadg-systems.com	<b>Bonded prestressing system</b> <b>DYWIDAG – Strand</b> Anchorage with multi-plane anchor body MA with additional reinforcement and with helix Data sheet for tendons 6827 to 6855	<b>Annex 12</b> of European Technical Assessment <b>ETA-13/0815</b> of 25.06.2018
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Multi-plane anchor body MA with additional reinforcement and without helix,  
 prestressing steel strand Y1770S7 15.3, Y1770S7 15.7, Y1860S7 15.3, and Y1860S7 15.7



Tendon		6805	6807	6809	6812	6815	6819	6822
Number of strands		5	7	9	12	15	19	22
Strand arrangement								
Wedge plate	Ø N	117	130	145	170	190	210	220
	Ø N*	88	96	112	128	148	159	176
	thickness P	55	60	60	65	70	80	85
	depth P*	47	52	52	55	60	68	73
Anchor body MA	Ø a	150	170	190	220	250	280	305
	Ø b	90	98	114	130	150	162	179
	Ø b*	80	90	100	120	130	145	161
	height j	90	100	125	180	200	220	220
	thickness s	18	18	15	17	19	23	26.5
Trumpet length	m	240	210	280	350	390	430	550
<b>Minimum concrete compressive strength at time of stressing</b>								
f <sub>cm,0, cube</sub>	N/mm <sup>2</sup>	34 44 54	34 44 54	34 44 54	34 44 54	34 44 54	34 44 54	34 44 54
f <sub>cm,0, cyl</sub>	N/mm <sup>2</sup>	28 35 43	28 35 43	28 35 43	28 35 43	28 35 43	28 35 43	28 35 43
Centre distance	a <sub>x</sub> , a <sub>y</sub>	255 225 205	300 265 240	335 300 275	380 340 310	425 375 345	475 420 385	510 450 410
Edge distance (plus c) <sup>1)</sup>	r <sub>x</sub> , r <sub>y</sub>	120 105 95	140 125 110	160 140 130	180 160 145	205 180 165	230 200 185	245 215 195
<b>Additional reinforcement, ribbed reinforcing steel R<sub>e</sub> ≥ 500 N/mm<sup>2</sup></b>								
Minimum numbers of layers	n	5 5 5	6 5 6	6 6 6	8 8 7	8 8 8	8 8 9	10 9 8
Minimum bar diameter	Ø d <sub>s</sub>	16 16 16	16 16 16	16 16 16	16 16 16	20 16 16	20 20 20	20 20 20
Maximum spacing	Z	40 40 40	40 40 40	40 40 40	40 40 40	40 40 40	40 40 40	40 40 40
Maximum spacing	l	50 50 50	50 50 50	50 50 50	45 50 50	55 45 45	55 55 50	50 50 50
External dimensions <sup>2)</sup>	x, y	240 205 175	280 235 195	305 260 225	320 295 260	380 335 300	410 370 350	430 390 360

<sup>1)</sup> c ... concrete cover

<sup>2)</sup> The external dimensions x, y have to be met exactly.

Dimensions in mm



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**Bonded prestressing system  
 DYWIDAG – Strand**

Anchorage with multi-plane anchor body MA  
 with additional reinforcement and without helix  
 Data sheet for tendons 6805 to 6822

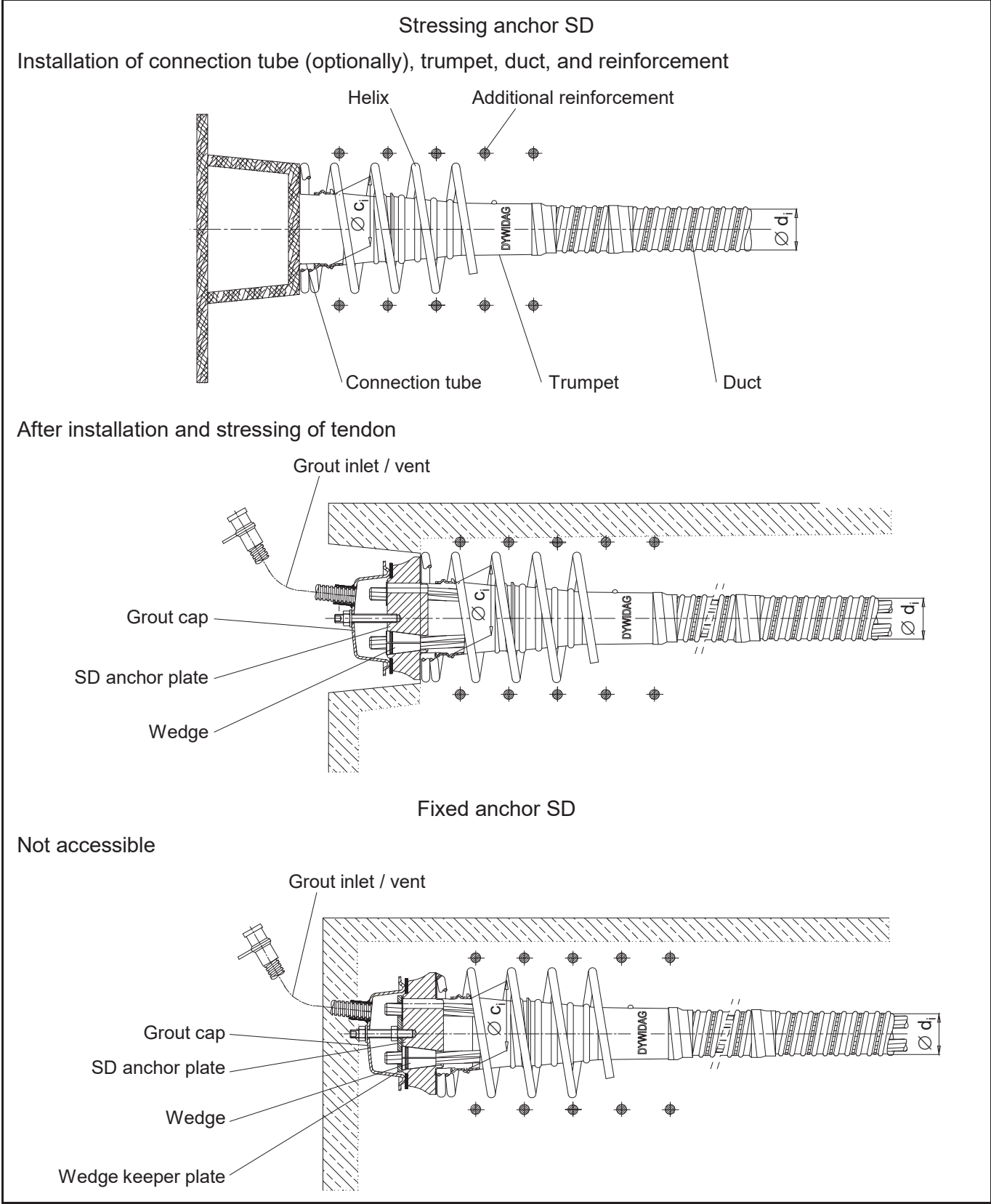
**Annex 13**

of European Technical Assessment  
**ETA-13/0815** of 25.06.2018





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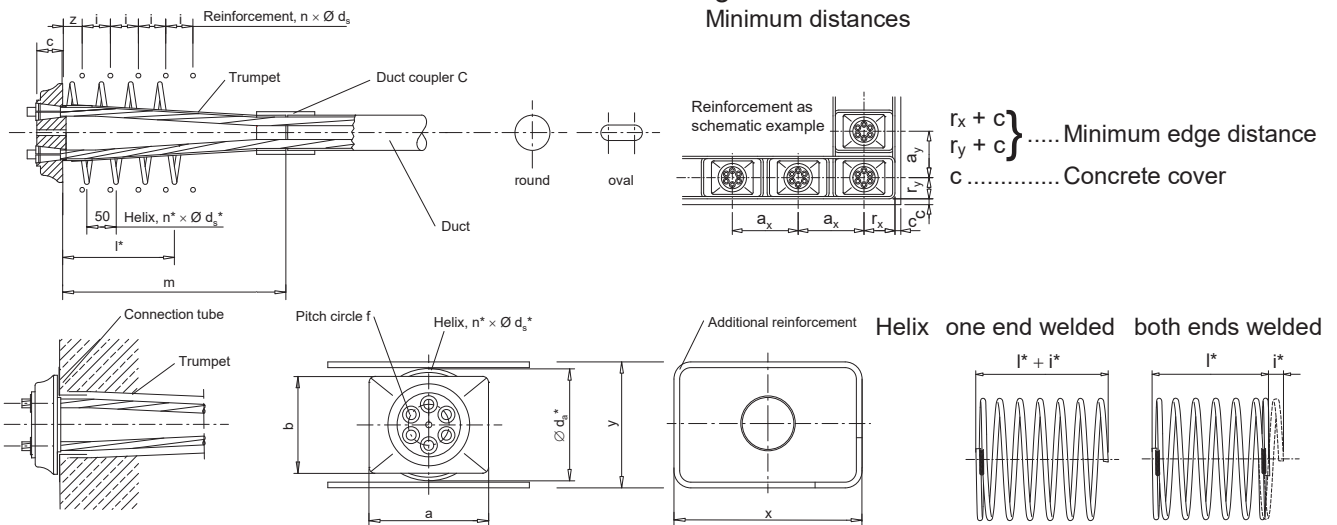

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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Assembly of anchorage with anchor plate SD

**Annex 15**  
 of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

**Plate anchorage SD**

Minimum distances



Tendon		6803	6804	6805	6806	6807	6808	6809
Number of strands		3	4	5	6	7	8	9
Strand arrangement								
Pitch circle	f	44	50	60	70	70	86	86
Anchor plate SD	a	140	160	180	215	215	245	245
	b	125	135	150	170	170	190	190
	c	50	50	50	50	50	55	55
Connecting tube	$\varnothing c_i$	65	75	85	95	95	110	110
Trumpet length	m	300	300	400	350	350	400	400
<b>Minimum concrete compressive strength at time of stressing</b>								
	$f_{cm, 0, \text{cube}}$ N/mm <sup>2</sup>	30	30	30	30	30	30	30
	$f_{cm, 0, \text{cyl}}$ N/mm <sup>2</sup>	24	24	24	24	24	24	24
Centre distance	$a_x, a_y$	250/170	290/190	320/215	340/240	370/250	400/270	420/280
Edge distance (plus c) <sup>1)</sup>	$r_x, r_y$	115/75	135/85	150/100	160/110	175/115	190/125	200/130
<b>Helix</b>								
Minimum number of turns	$n^*$			6	6	6	6	6
Minimum wire diameter	$\varnothing d_s^*$			12	12	14	14	14
Min. external diameter	$\varnothing d_a^*$	—	—	160	180	190	210	220
	max. $i^*$			50	50	50	50	50
	min. $l^*$			285	285	290	290	290
<b>Additional reinforcement, ribbed reinforcing steel <math>R_e \geq 500</math> N/mm<sup>2</sup></b>								
Minimum numbers of layers	n	6	6	7	7	7	7	7
Minimum bar diameter	$\varnothing d_s$	12	12	12	12	12	12	12
Maximum distance	z	35	35	40	40	40	40	40
Maximum spacing	i	50	50	50	50	50	55	55
External dimensions <sup>2)</sup>	x, y	230/150	270/170	300/195	320/22	350/230	380/250	400/260

<sup>1)</sup> c ... concrete cover

<sup>2)</sup> The external dimensions x, y have to be met exactly.

Dimensions in mm



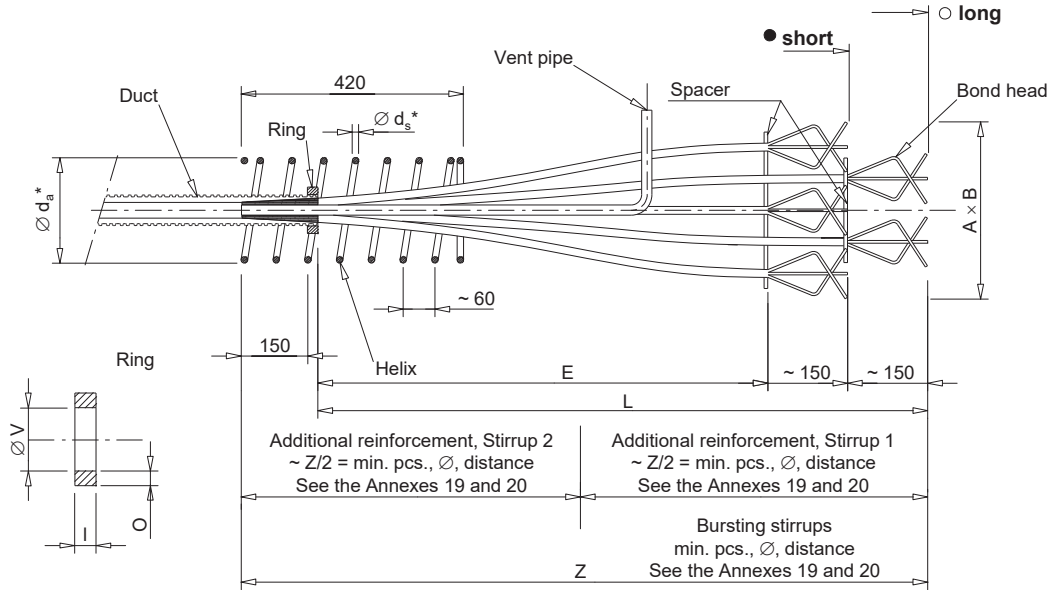
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**Bonded prestressing system**  
**DYWIDAG – Strand**  
Plate anchorage SD  
Data sheet for tendons 6803 to 6809

**Annex 16**  
of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

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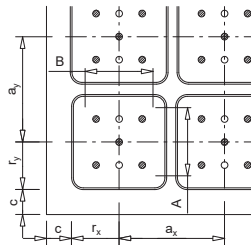
**Bond anchorage H 6803 to 6822**  
 for  $f_{cm, 0, \text{cube}} \geq 34 \text{ N/mm}^2$  or  $f_{cm, 0, \text{cyl}} \geq 28 \text{ N/mm}^2$



Tendon	6803	6804		6805		6807		6809	
Format	HL	HL	HR	HL	HR	HL	HR	HL	HR
Elevation anchorage									

Tendon	6812		6815		6819		6822	
Format	HL	HL	HL	HR	HL	HR	HL	HR
Elevation anchorage								

- Key**
- ..... Position long
  - ..... Position short
  - ⊙..... 3<sup>rd</sup> position <sup>1)</sup>
  - $r_x + c$  } ..... Minimum edge distance
  - $r_y + c$  }
  - c..... Concrete cover



1) 3<sup>rd</sup> position see Annex 18

Reinforcement as schematic example

Dimensions in mm



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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Bond anchorage H  
 Strand arrangement – Helix

**Annex 17**  
 of European Technical Assessment  
**ETA-13/0815** of 25.06.2018



Bond anchorage H 6803 to 6809 for  $f_{cm, 0, cube} \geq 34 \text{ N/mm}^2$  or  $f_{cm, 0, cyl} \geq 28 \text{ N/mm}^2$   
strand Y1770S7 15.3, Y1770S7 15.7, strand Y1860S7 15.3, and strand Y1860S7 15.7

For layout see the Annexes 17 and 18.

Tendon		6803	6804		6805		6807		6809		
Number of strands		3	4		5		7		9		
Format		HL	HL	HR	HL	HR	HL	HR	HL	HR	
Dimensions	A	290	390	210	330	210	450	250	390	290	
	B	90	90	190	90	210	90	250	210	290	
	Z	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	
	E	950	950	950	950	950	950	950	950	950	
	L	1 250	1 250	1 250	1 250	1 250	1 250	1 250	1 250	1 250	
Helix	$\varnothing d_a^*$	—	—	—	160	160	180	180	230	230	
	$\varnothing d_s^*$	—	—	—	12	12	12	12	14	14	
Ring	$\varnothing V$	Duct outer diameter + ~ 3 mm									
	O	11	14	14	14	14	14	14	14	14	
Minimum centre and edge distance	l	20	20	20	20	20	30	30	30	30	
	$a_x$	180	190	285	210	305	230	340	280	375	
	$a_y$	380	430	285	440	305	500	340	500	375	
	$r_x$	80	85	135	95	145	105	160	130	180	
Bursting stirrups <sup>1)</sup>	$r_y$	180	205	135	210	145	240	160	240	180	
	a	100	100	—	100	—	100	—	100	100	
	b	80	80	—	80	—	83	—	90	100	
	$n_0$	6	6	—	6	—	6	—	6	5	
Width Height	$\varnothing$	10	10	—	10	—	10	—	12	14	
	Width	160	170	—	190	—	210	—	260	355	
	Height	150	180	—	180	—	180	—	200	120	
	Stirrup 1	c	115	115	115	115	105	115	105	120	120
d		80	80	80	80	80	83	85	90	100	
$n_1$		8	8	7	8	7	8	7	8	6	
$\varnothing$		12	12	12	12	12	12	12	14	14	
Width Height	Width	160	170	265	190	285	210	320	260	355	
	Height	360	410	265	420	285	480	320	480	355	
	Stirrup 2	e	850	850	785	850	785	850	785	900	810
		f	166	166	170	166	170	166	170	200	185
$n_2$		5	5	5	5	5	5	5	4	5	
$\varnothing$		12	12	12	12	12	12	12	14	14	
Width Height	Width	160	170	265	190	285	210	320	260	355	
	Height	360	410	265	420	285	480	320	480	355	

<sup>1)</sup> Crosswise installation of bursting reinforcement for fixed anchor HR according to Annex 18

Dimensions in mm



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**Bonded prestressing system**  
**DYWIDAG – Strand**  
Bond anchorage H  
Data sheet for tendons 6803 to 6809

**Annex 19**  
of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

Bond anchorage H 6812 to 6822 for  $f_{cm, 0, cube} \geq 34 \text{ N/mm}^2$  or  $f_{cm, 0, cyl} \geq 28 \text{ N/mm}^2$   
strand Y1770S7 15.3, Y1770S7 15.7, strand Y1860S7 15.3, and strand Y1860S7 15.7

For layout see the Annexes 17 and 18.

Tendon		6812		6815		6819		6822	
Number of strands		12		15		19		22	
Format		HL	HR	HL	HR	HL	HR	HL	HR
Dimensions	A	480	390	480	410	610	490	730	490
	B	250	330	250	350	250	390	250	450
	Z	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400
	E	950	950	950	950	950	950	800 2)	950
	L	1 250	1 250	1 250	1 250	1 250	1 250	1 250	1 250
Helix	$\varnothing d_a^*$	250	250	295	295	330	330	360	360
	$\varnothing d_s^*$	14	14	16	16	16	16	16	16
Ring	$\varnothing V$	Duct outer diameter + ~ 3 mm							
	O	20	20	20	20	20	20	20	20
	I	30	30	30	30	30	30	30	30
Minimum centre and edge distance	$a_x$	300	390	350	460	390	525	410	570
	$a_y$	570	440	630	475	715	525	780	560
	$r_x$	140	185	165	220	185	255	195	275
	$r_y$	275	210	305	230	350	255	380	270
Bursting stirrups 1)	A	100	100	100	100	110	110	110	120
	B	100	100	100	100	110	110	110	120
	$n_0$	6	5	6	6	6	5	6	5
	$\varnothing$	12	12	14	14	14	14	14	14
	Width	280	420	330	455	370	505	390	550
	Height	200	150	220	230	220	230	260	280
Stirrup 1	c	120	120	120	120	130	130	130	140
	d	100	100	100	100	110	110	110	120
	$n_1$	8	6	8	6	7	6	6	5
	$\varnothing$	14	14	14	14	14	14	14	14
	Width	280	370	330	440	370	505	390	550
	Height	550	420	610	455	695	505	760	540
Stirrup 2	e	1 020	820	1 020	900	1 120	1 000	1 120	1 060
	f	200	200	150	150	110	120	110	120
	$n_2$	3	4	5	5	5	6	5	6
	$\varnothing$	14	14	14	14	14	14	14	14
	Width	280	370	330	440	370	505	390	550
	Height	550	420	610	455	695	505	760	540

1) Crosswise installation of bursting reinforcement for fixed anchor HR according to Annex 18

2) Bond head in 3<sup>rd</sup> position

Dimensions in mm



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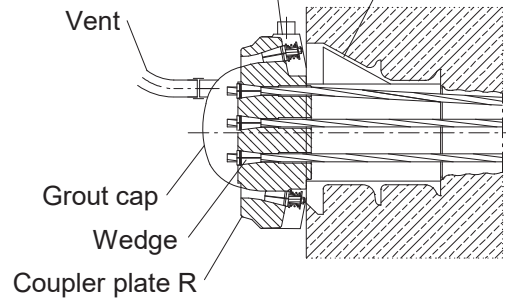
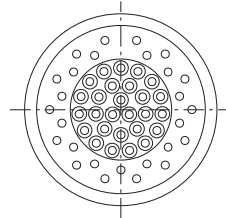
**Bonded prestressing system**  
**DYWIDAG – Strand**  
Bond anchorage H  
Data sheet for tendons 6812 to 6822

**Annex 20**  
of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

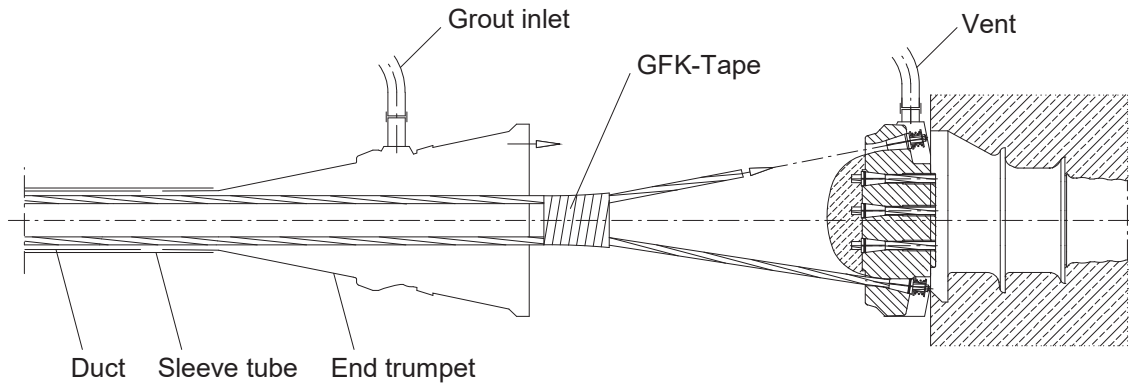
### Installation of 1<sup>st</sup> construction stage

Installation of anchor body and other components identical to stressing anchor with wedge plate and anchor body MA

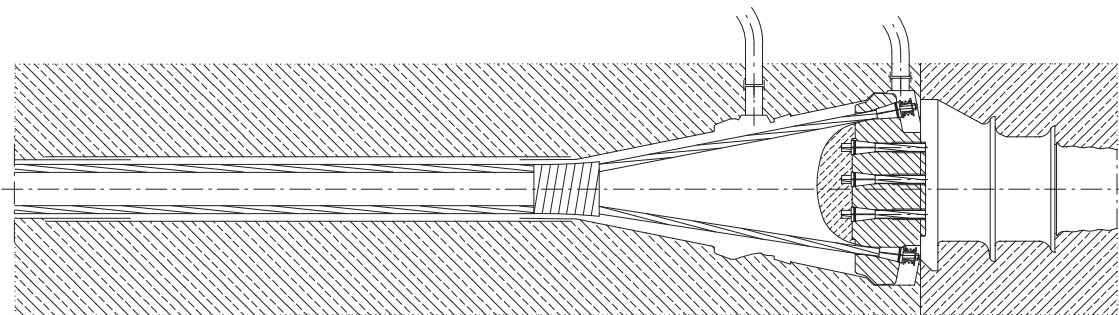
Pre-assembly of wedges, springs, wedge keeper plates and protection cap for coupling of 2<sup>nd</sup> construction stage



### Coupler assembly



### Pouring of concrete, stressing 2<sup>nd</sup> construction stage



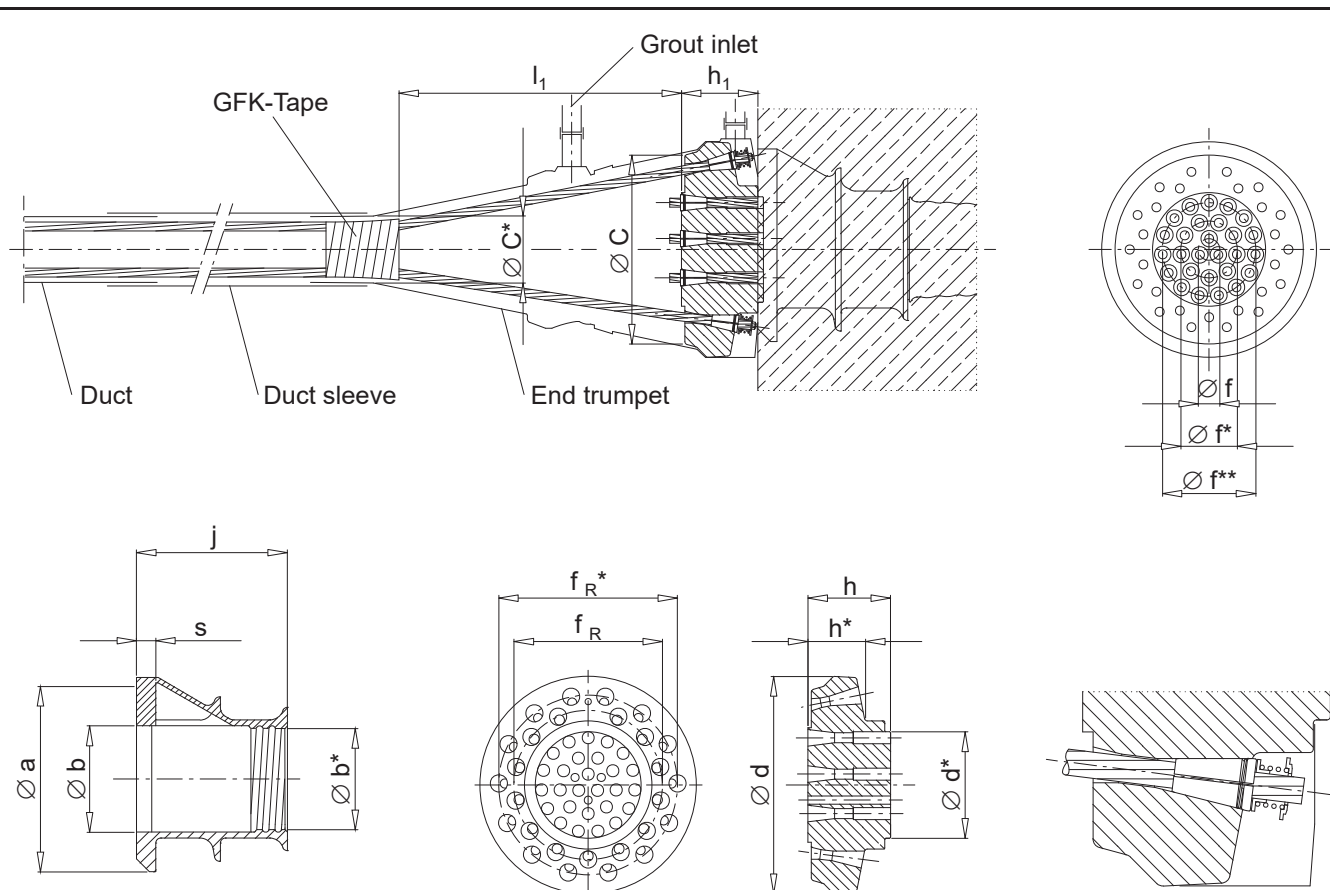
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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Assembly of fixed coupler R

**Annex 21**  
 of European Technical Assessment  
**ETA-13/0815** of 25.06.2018

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Tendon		6805	6807	6809	6812	6815	6819	6822	6827	6831	6837
Number of strands		05	07	09	12	15	19	22	27	31	37
Anchor body MA	Ø a mm	150	170	190	220	250	280	305	330	385	420
	Ø b mm	90	98	114	130	150	162	179	190	217	217
	Ø b* mm	80	90	100	120	130	145	161	161	196	196
	j mm	90	100	125	180	200	220	220	240	350	350
	s mm	18	18	15	17	19	23	26.5	30	40	50
Coupler plate R	Ø d mm	207	207	224	246	264	289	340	380	435	435
	Ø d* mm	88	96	112	128	148	159	176	188	214	214
	h mm	115	115	115	115	120	130	135	145	170	170
	h* mm	75	75	75	75	76	85	90	100	120	120
	h1 mm	105	105	105	105	110	120	125	135	158	158
Pitch circles	central	—	⊙	⊙	—	—	⊙	—	—	⊙	⊙
	Ø f mm	60	70	86	40	60	70	86	38	—	65
	Ø f* mm	—	—	—	105	125	136	152	100	126	126
	Ø f** mm	—	—	—	—	—	—	—	165	190	190
	Ø fR mm	152	152	168	188	207	224	244	261	306	306
	Ø fR* mm	—	—	—	—	—	—	276	314	370	370
End trumpet	Length l1 mm	460	370	350	500	450	570	640	660	870	870
	Ø c mm	185	185	205	232	250	268	297	333	395	395
	Ø c* mm	75	75	85	90	100	105	120	120	137	137

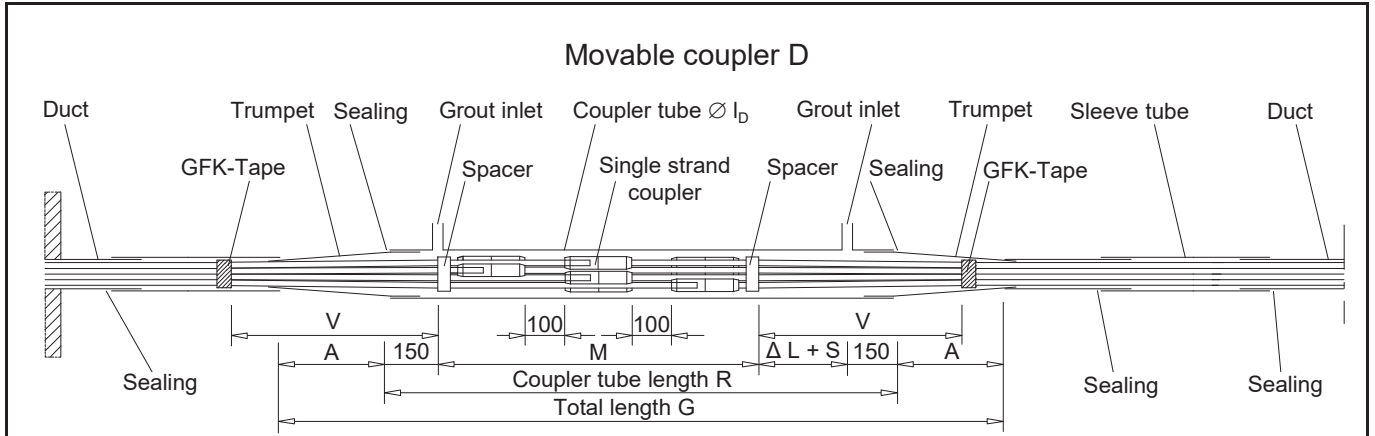


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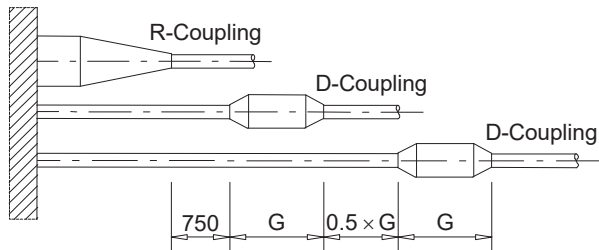
**Bonded prestressing system**  
**DYWIDAG – Strand**  
Fixed coupler R  
Data sheet for tendons 6805 to 6837

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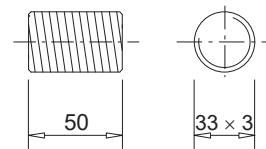
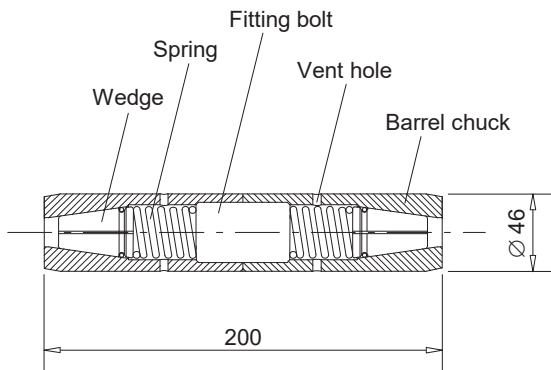


Schematic representation of staggering

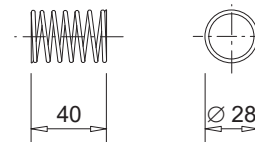


Key  
 $\Delta L$ ... Expected displacement during stressing  
 $S$ ..... Maximum  $\begin{cases} 0.2 \cdot \Delta L \\ 120 \text{ mm} \end{cases}$ , safety clearance  
 Coupler tube length  
 $R = \Delta L + S + M + 300 \text{ mm}$   
 Total length  
 $G = R + 2 \cdot A$

Single strand coupler



Fitting bolt with special thread  $33 \times 3$ ,  $l = 50 \text{ mm}$



Spring  $\varnothing 28 \text{ mm}$ ,  $l = 40 \text{ mm}$

NOTE  
 Outer dimensions are identical for both nominal diameters of the prestressing steel strand. For installation, refer to marking  
 - 060 for  $140 \text{ mm}^2$  or  
 - 062 for  $150 \text{ mm}^2$   
 prestressing steel strand respectively.

Dimensions in mm

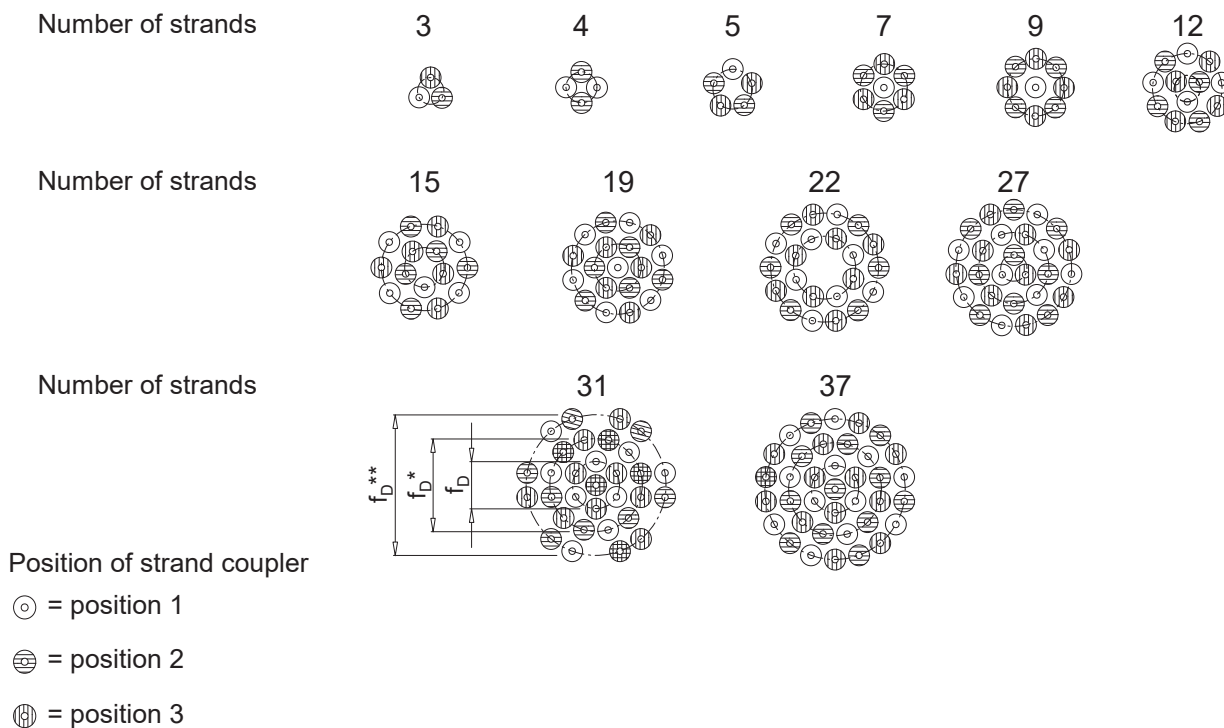


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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Assembly of movable coupler D

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Movable coupler D – Arrangement of single strand couplers



Tendon	6803	6804	6805	6807	6809	6812	6815	6819	6822	6827	6831	6837
Number of strands	03	04	05	07	09	12	15	19	22	27	31	37
Deviation length V mm	300	350	400	500	550	650	700	750	900	900	1 000	1 000
Transition length A mm	150	200	250	300	350	450	500	550	700	700	800	800
Length M mm	900	600	900	900	900	900	900	940	940	940	940	940
Pitch circles of spacer	—	—	—	⊙	⊙	—	—	⊙	—	—	⊙	⊙
$f_D$ mm	44	50	60	70	86	40	60	70	86	38	65	65
$f_D^*$ mm	—	—	—	—	—	105	125	136	152	100	126	126
$f_D^{**}$ mm	—	—	—	—	—	—	—	—	—	165	190	190
Coupler tube $l_D$ mm	100	110	120	125	140	160	180	200	225	225	250	250



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**Bonded prestressing system**  
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 Movable coupler D  
 Data sheet for tendons 6803 to 6837

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Designation	Specification	Material <sup>1)</sup>
Wedge	EN 10277-2	Steel
Wedge plate	EN 10083-2	Steel
Anchor plate SD	EN 10083-2	Steel
Coupler plate R	EN 10083-2	Steel
Coupler D barrel chuck	EN 10083-2	Steel
Coupler D fitting bolt	EN 10025-2	Steel
Anchor body MA	EN 1563	Ductile cast iron
Duct, Telescopic duct	EN 523	Steel
Coupler tube, Duct sleeve Sleeve tube	EN 523	Steel
	EN 10130	Steel
	EN ISO 17855-1	PE-HD
Trumpet	EN 10130	Steel
	EN ISO 17855-1	PE-HD
Helix	—	Ribbed reinforcing steel, $R_e \geq 500 \text{ N/mm}^2$
	EN 10025-2	Plain round steel
Additional reinforcement	—	Ribbed reinforcing steel, $R_e \geq 500 \text{ N/mm}^2$
Ring	EN 10025-2	Steel
Wedge keeper plate	EN 10025-2	Steel
Spacer	EN ISO 17855-1	PE-HD
Grout cap	EN 10130	Steel
Sealing	—	Synthetic caoutchouc

<sup>1)</sup> Detailed material specifications are deposited at Österreichisches Institut für Bautechnik



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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Material specifications

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Prestressing steel strand			Y1770S7		Y1860S7	
Characteristic tensile strength	$R_m$	N/mm <sup>2</sup>	1 770		1 860	
Nominal diameter of strand	D	mm	15.3	15.7	15.3	15.7
Nominal diameter of outer wire	$d_o$	mm	5.0	5.2	5.0	5.2
Diameter of core wire	$d'$	mm	$\geq 1.03 \cdot d_o$			
Nominal mass per metre	M	g/m	1 093	1 172	1 093	1 172
Nominal cross-sectional area	$A_p$	mm <sup>2</sup>	140	150	140	150
Characteristic value of maximum force	$F_m$	kN	248	266	260	279
Maximum value of maximum force	$F_{m, max}$	kN	285	306	299	321
Characteristic value of 0.1% proof force <sup>1)</sup>	$F_{p0.1}$	kN	218	234	229	246
Minimum elongation at maximum force, $L_0 \geq 500$ mm	$A_{gt}$	%	3.5			
Modulus of elasticity	E	N/mm <sup>2</sup>	195 000 <sup>2)</sup>			
Relaxation after 1 000 h, for an initial force of						
– $0.70 \cdot F_{ma}$	—	%	$\leq 2.5$			
– $0.80 \cdot F_{ma}$	—	%	$\leq 4.5$			

1) For prestressing steel strand according to prEN 10138-3, 09.2000, the value is multiplied by 0.98.

2) Standard value



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**Bonded prestressing system**  
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 Specification of the  
 7-wire prestressing steel strands

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Characteristic maximum force of tendon,  $F_{pk}$

Number of strands	Prestressing steel strand $A_p = 140 \text{ mm}^2$				Prestressing steel strand $A_p = 150 \text{ mm}^2$			
	$M^{1)}$	$A_p^{2)}$	Y1770S7	Y1860S7	$M^{1)}$	$A_p^{2)}$	Y1770S7	Y1860S7
			$F_{pk}^{3)}$	$F_{pk}^{3)}$			$F_{pk}^{3)}$	$F_{pk}^{3)}$
—	kg/m	$\text{mm}^2$	kN	kN	kg/m	$\text{mm}^2$	kN	kN
1	1.09	140	248	260	1.17	150	266	279
3	3.28	420	744	780	3.52	450	798	837
4	4.37	560	992	1 040	4.69	600	1 064	1 116
5	5.47	700	1 240	1 300	5.86	750	1 330	1 395
6	6.56	840	1 488	1 560	7.03	900	1 596	1 674
7	7.65	980	1 736	1 820	8.20	1 050	1 862	1 953
8	8.74	1 120	1 984	2 080	9.38	1 200	2 128	2 232
9	9.84	1 260	2 232	2 340	10.55	1 350	2 394	2 511
12	13.12	1 680	2 976	3 120	14.06	1 800	3 192	3 348
15	16.40	2 100	3 720	3 900	17.58	2 250	3 990	4 185
19	20.77	2 660	4 712	4 940	22.27	2 850	5 054	5 301
22	24.05	3 080	5 456	5 720	25.78	3 300	5 852	6 138
27	29.51	3 780	6 696	7 020	31.64	4 050	7 182	7 533
31	33.88	4 340	7 688	8 060	36.33	4 650	8 246	8 649
37	40.44	5 180	9 176	9 620	43.36	5 550	9 842	10 323
43	47.00	6 020	10 664	11 180	50.40	6 450	11 438	11 997
49	53.56	6 860	12 152	12 740	57.43	7 350	13 034	13 671
55	60.12	7 700	13 640	14 300	64.46	8 250	14 630	15 345

- 1) Nominal mass of tendon
- 2) Nominal cross-sectional area of tendon
- 3) Characteristic maximum force of tendon



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**Bonded prestressing system**  
**DYWIDAG – Strand**  
 Characteristic maximum force of tendon

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Subject / type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control	
Wedge plate, Anchor plate SD, Coupler plate R, Barrel chuck, Fitting bolt	Material	Checking <sup>1)</sup>	<sup>2)</sup>	100 %	continuous
	Detailed dimensions	Testing	<sup>2)</sup>	5%, ≥ 2 specimens	continuous
	Visual inspection <sup>3)</sup>	Checking	<sup>2)</sup>	100 %	continuous
	Traceability	full			
Anchor body MA	Material	Checking <sup>1)</sup>	<sup>2)</sup>	100 %	continuous
	Detailed dimensions	Testing	<sup>2)</sup>	3%, ≥ 2 specimens	continuous
	Visual inspection <sup>3)</sup>	Checking	<sup>2)</sup>	100 %	continuous
	Traceability	full			
Wedge	Material	Checking <sup>1)</sup>	<sup>2)</sup>	100 %	continuous
	Treatment, hardness	Testing	<sup>2)</sup>	0.5 %, ≥ 2 specimens	continuous
	Detailed dimensions	Testing	<sup>2)</sup>	5 %, ≥ 2 specimens	continuous
	Visual inspection <sup>3)</sup>	Checking	<sup>2)</sup>	100 %	continuous
	Traceability	full			
Prestressing steel strand	Material	Checking	<sup>2), 4)</sup>	100 %	continuous
	Diameter	Testing	<sup>2)</sup>	1 sample	each coil or every 7 tons <sup>5)</sup>
	Visual inspection	Checking	<sup>2)</sup>	1 sample	
Helix in plain round steel, EN 10025	Material	Checking <sup>6)</sup>	<sup>2)</sup>	100 %	continuous
	Visual inspection <sup>3)</sup>	Checking	<sup>2)</sup>	100 %	continuous
	Traceability	full			
Steel strip duct	Material	Checking <sup>7)</sup>	<sup>2)</sup>	100 %	continuous
	Dimension	Testing	<sup>2)</sup>	3 %, ≥ 2 specimens	continuous
	Traceability	full			
Cement, Admixtures, Additions of filling materials as per EN 447	Material	Checking <sup>7)</sup>	<sup>2)</sup>	100 %	continuous
	Traceability	full			

<sup>1)</sup> Checking by means of an inspection report 3.1 according to EN 10204.

<sup>2)</sup> Conformity with the specifications of the components

<sup>3)</sup> Successful visual inspection does not need to be documented.

<sup>4)</sup> Checking of relevant certificate, as long as the basis of "CE"-marking is not available.

<sup>5)</sup> Maximum between a coil and 7 tons is taken into account.

<sup>6)</sup> Checking by means of at least a test report 2.2 according to EN 10204.

<sup>7)</sup> Checking of relevant certificate, CE marking and declaration of performance or, if basis for CE marking is not available, certificate of supplier

Traceability full Full traceability of each component to its raw material.

Material Defined according to technical specification deposited by the supplier

Detailed dimension Measuring of all the dimensions and angles according to the specification given in the test plan

Visual inspection Main dimensions, correct marking and labelling, surface, corrosion, coating, etc.

Treatment, hardness Surface hardness, core hardness, and treatment depth



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 Contents of the prescribed test plan

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Subject / type of control		Test or control method	Criteria, if any	Minimum number of samples <sup>1)</sup>	Minimum frequency of control
Wedge plate, Anchor plate SD, Coupler plate R, Barrel chuck, Fitting bolt	Material	Checking and testing, hardness and chemical <sup>2)</sup>	<sup>3)</sup>	1	1/year
	Detailed dimensions	Testing	<sup>3)</sup>	1	1/year
	Visual inspection	Checking	<sup>3)</sup>	1	1/year
Anchor body MA	Material	Checking and testing, hardness and chemical <sup>2)</sup>	<sup>3)</sup>	1	1/year
	Detailed dimensions	Testing	<sup>3)</sup>	1	1/year
	Visual inspection	Checking	<sup>3)</sup>	1	1/year
Wedge	Material	Checking and testing, hardness and chemical <sup>2)</sup>	<sup>3)</sup>	2	1/year
	Treatment, hardness	Checking and testing, hardness profile	<sup>3)</sup>	2	1/year
	Detailed dimensions	Testing	<sup>3)</sup>	1	1/year
	Main dimensions, surface hardness	Testing	<sup>3)</sup>	5	1/year
	Visual inspection	Checking	<sup>3)</sup>	5	1/year
Single tensile element test		According to EAD 160004-00-0301, Annex C.7		9	1/year

<sup>1)</sup> If the kits comprise different kinds of anchor heads e.g. with different materials, different shape, different wedges, etc., then the number of samples is understood as per kind.

<sup>2)</sup> Testing of hardness and checking of chemical composition by means of an inspection report 3.1 according to EN 10204.


<sup>3)</sup> Conformity with the specifications of the components

Material Defined according to technical specification deposited by the ETA holder at the Notified body

Detailed dimension Measuring of all the dimensions and angles according to the specification given in the test plan

Visual inspection Main dimensions, correct marking and labelling, surface, corrosion, coating, etc.

Treatment, hardness Surface hardness, core hardness, and treatment depth

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## Reference documents

### European Assessment Documents

EAD 160004-00-0301	Post-Tensioning Kits for Prestressing of Structures
EAD 160027-00-0301	Special filling products for post-tensioning kits

### Eurocodes

Eurocode 2	Eurocode 2 – Design of concrete structures
Eurocode 3	Eurocode 3 – Design of steel structures
Eurocode 6	Eurocode 6 – Design of masonry structures

### Standards

EN 206+A1, 11.2016	Concrete – Specification, performance, production and conformity
EN 446, 10.2007	Grout for prestressing tendons – Grouting procedures
EN 447, 10.2007	Grout for prestressing tendons – Basic requirements
EN 523, 08.2003	Steel strip sheaths for prestressing tendons – Terminology, requirements, quality control
EN 1563, 12.2011	Founding – Spheroidal graphite cast irons
EN 10025-2, 11.2004	Hot rolled products of structural steels – Part 2: Technical delivery conditions for non-alloy structural steels
EN 10083-2, 08.2006	Steels for quenching and tempering – Part 2: Technical delivery conditions for non alloy steels
EN 10130, 12.2006	Cold-rolled low carbon steel flat products for cold forming – Technical delivery conditions
EN 10204, 10.2004	Metallic products – Types of inspection documents
EN 10277-2, 03.2008	Bright steel products – Technical delivery conditions – Part 2: Steels for general engineering purposes
EN ISO 17855-1, 10.2014	Plastics – Polyethylene (PE) moulding and extrusion materials – Part 1: Designation system and basis for specifications
prEN 10138-3, 09.2000	Prestressing steels – Part 3: Strand
prEN 10138-3, 08.2009	Prestressing steels – Part 3: Strand
CWA 14646, 01.2003	Requirements for the installation of post-tensioning kits for prestressing of structures and qualification of the specialist company and its personnel



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