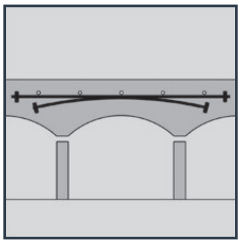
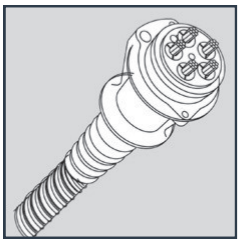
DYWIDAG-SYSTEMS INTERNATIONAL

European Technical Assessment
Post-Tensioning Systems

SUSPA SYSTEMS





Bonded Post-Tensioning Kit for Prestressing of Structures with 1 to 22 Strands

ETA-13/0839

European Organisation for Technical Approvals
Europäische Organisation für Technische Zulassungen
Organisation Européenne pour l'Agrément Technique

11 December 2017

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Designated according to Article 29 of Regulation (EU) No 305/2011

Member of EOTA
www.eota.eu

European Technical Assessment

ETA-13/0839 of 11.12.2017

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	SUSPA Strand DW
Product family to which the construction product belongs	Bonded post-tensioning kit for prestressing of structures with 1 to 22 strands
Manufacturer	DYWIDAG-Systems International GmbH Destouchesstraße 68 80796 Munich Germany
Manufacturing plant	DYWIDAG-Systems International GmbH Max-Planck-Ring 1 40764 Langenfeld Germany
This European Technical Assessment contains	70 pages including Annexes 1 to 39, which form an integral part of this assessment.
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	ETAG 013, Guideline for European technical approval for Post-Tensioning Kits for Prestressing of Structures, edition June 2002, used according to Article 66 (3) of Regulation (EU) № 305/2011 as European Assessment Document.
This European Technical Assessment replaces	European technical approval ETA-13/0839 with validity from 25.06.2013 to 24.06.2018.

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Remarks

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Specific parts

1 Technical description of the product

1.1 General

The European Technical Assessment[1] – ETA – applies to a kit, the bonded PT system

SUSPA Strand DW,

comprising the following components.

- Tendon

  Bonded tendon with 1 to 22 tensile elements

- Tensile element

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

Table 1 Tensile elements

Nominal diameter		Designation according to prEN 10138-3 [2]	Nominal tensile strength
mm	inch	—	N/mm^2
15.7	0.62	Y1770S7	1 770
15.7	0.62	Y1860S7	1 860

NOTE 1 N/mm^2 = 1 MPa

- Anchorage

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

  Stressing (active) and fixed (passive) anchor with wedges, anchor head E, and multi-plane anchor body MA for tendons with 5 to 22 prestressing steel strands

  Stressing (active) and fixed (passive) anchor with wedges, anchor head E, and anchor plate E for tendons with 3 to 22 prestressing steel strands

[1] ETA-13/0839 was firstly issued in 2013 as European technical approval with validity from 25.06.2013 and converted 2017 to European Technical Assessment ETA-13/0839 of 11.12.2017.

[2] Standards, guidelines, and other documents referred to in the European Technical Assessment are listed in Annex 38 and Annex 39.

Stressing (active) and fixed (passive) anchor with wedges, anchor head E, and anchor plate E for electrically isolated tendons with 3 to 22 prestressing steel strands

Fixed (passive) anchor with compression fittings, anchor head EP, and multi-plane anchor body MA for tendons with 5 to 22 prestressing steel strands

Fixed (passive) anchor with compression fittings, anchor head EP, and anchor plate E for tendons with 3 to 22 prestressing steel strands

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

Stressing (active) and fixed (passive) anchor with wedges, and anchor SK6 for tendons with one single prestressing steel strand

– Coupler

Prestressing steel strand anchored by either 3-piece wedge or compression fitting

Fixed coupler with wedges, compression fittings, coupler head K, and multi-plane anchor body MA for tendons with 7 to 22 prestressing steel strands

Fixed coupler with wedges, compression fittings, coupler head K, and anchor plate E for tendons with 3 to 22 prestressing steel strands

Fixed coupler with wedges, compression fittings, coupler head K – EI, and anchor plate K – EI for electrically isolated tendons with 7 to 22 prestressing steel strands

Movable coupler with compression fittings and coupler head V for tendons with 3 to 22 prestressing steel strands

Movable coupler with compression fittings and anchor head V for electrically isolated tendons with 3 to 22 prestressing steel strands

Movable coupler with wedges and 2 coupler barrels K6 for tendons with one single prestressing steel strand

– Floating block anchorage Z with wedges and anchor head Z for tendons with 2 to 8 prestressing steel strands

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

– Steel sheaths or plastic ducts.

– Permanent corrosion protection for tensile elements, anchorages, 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 prestressing steel strands. The first number indicates the nominal diameter of the prestressing steel strand, “6” = 15.7 mm (0.62 "), followed by the maximum number of prestressing steel strands per unit “n”, 6-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 – Combinations of components for different use categories

Components	**Internal bonded [1)]**	**Internal bonded and electrically isolated**	**Number of strands [2)]**												
Anchorage															
Anchor head E with anchor body MA	+	—					5		7		9	12	15	19	22
Anchor head EP with anchor body MA	+	—					5		7		9	12	15	19	22
Anchor head E with anchor plate E	+	+			3	4	5		7		9	12	15	19	22
Anchor head EP with anchor plate E	+	—			3	4	5		7		9	12	15	19	22
Bond anchorage H	+	—			3	4	5		7		9	12	15	19	22
Anchor head SK 6	+	—	1												
Coupler															
Fixed coupler with coupler head K and anchor body MA	+	—							7		9	12	15	19	22
Fixed coupler with coupler head K and anchor plate E	+	—			3	4			7		9	12	15	19	22
Fixed coupler with coupler head K – EI and anchor plate K – EI	+	+							7		9	12	15	19	22
Movable coupler with coupler head V	+	+			3	4			7		9	12	15	19	22
Movable coupler K6-K6	+	—	1												
Floating block anchorage with anchor head Z	+	—		2		4		6		8					

KEY
+....... applicable
—..... not applicable

NOTES
1) All use categories, except electrically isolated tendons
2) Except for floating block anchorage one or more prestressing steel strands may be omitting 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 5 and Annex 6.

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 anchor head or coupler head do not need to be drilled. Alternatively, at anchor head E and coupler head K a short length of prestressing steel strand with a wedge is pressed in. The respective bores in anchor head EP and coupler head V may be left void. For coupler anchor heads K and V the slots of the projecting collar may be equally redistributed.

However, overall dimensions of anchor head and coupler anchor head are unchanged in any case.

Moreover, each anchor 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 anchor und coupler. This is obtained by an appropriate arrangement of the prestressing steel stands in anchor head and coupler head.

Anchorages 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 strands.

Omitting of prestressing steel strands in a tendon with floating block anchorage Z is impossible.

As indicated in Table 2, particular anchorages and couplers can be provided electrically isolated with tendons with plastic ducts. However, tendons with all anchorages and couplers can be installed with plastic ducts, even without electrically isolation.

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 tensioned prestressing steel strands by means of wedges. Each prestressing steel strand is individually anchored within a conical bore of the anchor head E or anchor SK6 by means of a 3-piece wedge. All prestressing steel strands of the bundle tendon are stressed at the same time.

In the fixed anchor, the prestressing steel strands are anchored by means of wedges in anchor head E and anchor SK6, or by means of compression fittings in anchor head EP, 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 anchor head E

The stressing anchor comprises wedges, an anchor head E, and an anchor body MA or an anchor plate E, see Annex 1, Annex 10, Annex 11, Annex 23, and Annex 24. The trumpet is arranged between anchor body MA or anchor plate E and the duct, and in general is surrounded by a helix. The helix, if present, is centrically aligned to anchor body MA or anchor plate E and fastened in its position. If required, the free end of the helix is fastened to the additional reinforcement. Anchor with anchor body MA can be installed without or with helix, while anchor with anchor plate E is always with helix. The duct is inserted into the trumpet or screwed thereon. The anchor head E is slipped over the prestressing steel strands before stressing.

Both anchorages, anchor with anchor body MA and anchor with anchor plate E can be installed with 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 anchorage during stressing.

For electrically isolated anchorages, an isolation plate, accompanied by a load distributing steel plate, is installed between anchor head E and anchor plate E, see Annex 25.

1.2.3.3 Fixed anchor with anchor head EP

The fixed anchor comprises compression fittings, a retainer plate, an anchor head EP and an anchor body MA or an anchor plate E, see Annex 1, Annex 9, and Annex 21. The assembly corresponds to the stressing anchor with anchor head E but instead of wedges, the prestressing steel strands are anchored by compression fittings. The compression fittings are locked by means of a retainer plate. For this type of anchorage, access does not need to be provided during stressing, therefore, it can be embedded in concrete.

Same as for the stressing anchor, the fixed anchor with anchor body MA can be installed without or with helix and fixed anchor with anchor plate E is always with helix.

For electrically isolated anchorage, a stressing anchor according to Clause 1.2.3.2 is installed as fixed anchor with isolation plate, accompanied by a load distributing steel plate, between anchor head E and anchor plate E.

1.2.3.4 Anchorage with anchor body MA

Anchor body MA transfers the tendon force by several load transfer planes – multi-plane anchor body MA – into the structural concrete, see Annex 9, Annex 10, and Annex 11.

The anchor heads E and EP and the coupler head K, see Annex 12, with corresponding wedges and compression fittings can be used with anchor body MA. The anchor body MA is used within a stressing anchor as well as a fixed anchor. Anchorage with multi-plane anchor body MA can be installed even without helix, see Annex 10.

1.2.3.5 Anchorage with anchor plate E

Different to anchor body MA there is only one single load transfer plane with anchor plate E. Anchor plate E always is accompanied by a helix, see Annex 21, Annex 23, and Annex 24. Applications with anchor plate E require preceding consultations of the ETA holder to confirm availability.

Anchor heads E and EP and coupler head K, see Annex 12 and Annex 26, with corresponding wedges and compression fittings can be used with anchor plate E. Anchor plate E is used within a stressing anchor as well as a fixed anchor.

Anchorage and fixed coupler with anchor plate E and anchor plate K – EI can be installed electrically isolated.

1.2.3.6 Bond anchorages H – HL and HR

The bond anchorage H anchors the prestressing steel strands by bond of the prestressing steel strands and in particular with bond heads to the structural concrete. Therefore it can only be used as a fixed anchor, embedded in concrete. Beside bond heads it comprises a ring, a helix and spacers for creating the intended strand layout, see Annex 1 and Annex 13. The prestressing steel strands used in this anchorage do not receive any surface treatment, including no temporary corrosion protection, neither from the manufacturing plant nor on site.

1.2.3.7 Stressing and fixed single prestressing steel strand anchor SK6

The single prestressing steel strand anchor SK6 comprises a wedge and anchor SK6, see Annex 1, Annex 17, and Annex 18. With this anchorage only one single prestressing steel strand is anchored. The stressing anchor is fastened to the formwork on site and connected to the prestressing steel strand. The fixed anchor does not need access during stressing, therefore it can be embedded in concrete. In this case it is installed with a spring and locked by a venting cap to secure the wedge seating. A PE-sleeve connects the anchor to the duct. The additional reinforcement is aligned and fastened centrically to anchor SK6, PE-sleeve and duct.

Anchor SK6 serves for both in one piece, anchoring the prestressing steel strand and load transfer to the structural concrete.

1.2.4 Coupler

1.2.4.1 General

The fixed coupler connects a 2nd tendon with an already stressed 1st tendon and the movable coupler connects two untensioned tendons prior to stressing both tendons at once. A 100 mm long and at least 4 mm thick PE-HD insert should be installed at the deviating point at the end of the trumpet, if the coupler may be subjected to significant fatigue actions. The insert is not required for plastic trumpet, where the duct is screwed on an external thread of the plastic trumpet.

1.2.4.2 Fixed coupler with coupler head K

The fixed coupler comprises wedges, compression fittings, coupler head K, anchor body MA or anchor plate E, and a ring, see Annex 2, Annex 12, and Annex 26. The fixed coupler connects a 2nd tendon with an already stressed 1st tendon. The already stressed 1st tendon is anchored in the same way as with an anchor head E of a stressing anchor. In addition, the coupler head K provides a projecting ring collar with slots. The prestressing steel strands of the 2nd tendon to be joined, provided with compression fittings, are placed in the slots and secured with a tensioning belt.

Fixed coupler with coupler head K – EI and anchor plate K – EI can be installed electrically isolated.

1.2.4.3 Movable coupler with coupler head V

The movable coupler comprises compression fittings, retainer plates, coupler head V, and a ring, see Annex 2, Annex 12, and Annex 26. Movable coupler connects two tendons prior to stressing. The prestressing steel strands of both tendons are anchored by means of compression fittings. The compression fittings of tendon 1 are secured by a retainer plate and the compression fittings of tendon 2 are locked by a retainer ring plate and a tensioning belt. The coupling principle is identical to the one of the fixed coupler with coupler head K.

Movable coupler with coupler head V can be installed electrically isolated.

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

1.2.4.4 Movable coupler K6-K6

The movable coupler comprises wedges and 2 coupler barrels K6, connected by the coupler bushing, see Annex 2 and Annex 20. With this type of coupler only one single prestressing steel strand is coupled. The prestressing steel strands of both tendons are anchored by means of wedges. A locking pin inside the coupler bushing prevents the prestressing steel strands from being pushed too far into the coupler bushing. Springs between wedges and coupler bushing secure the wedge positions in the cones.

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

1.2.5 Floating block anchorage Z

The floating block anchorage Z comprises wedges, an anchor head Z, retainer plates, and two rings, see Annex 2 and Annex 30. Floating block anchorage Z is normally used to stress a ring tendon e.g. in storage facilities or tanks. Both tendon ends, end 1 and end 2, of the ring tendon overlap in the floating block anchorage Z.

For stressing, the strand protrusion of tendon end 1 is guided out of the stressing recess by means of a deviation chair. To compensate the strand friction within the deviation chair, a higher force is applied by the prestressing jack for stressing.

The floating block anchorage Z can also be applied as intermediate stressing anchor between two fixed anchors, e.g. if these anchors are not accessible for prestressing jacks.

During stressing, the anchor head Z is displaced by the value E, with E as the sum of elongation and a slip of 6 mm of tendon end 2. When the prestressing force is transferred from prestressing jack to anchorage, the prestressing steel strands of tendon end 1 slip by approximately 6 mm. As a result of the slip, the force within the tendon at the end of stressing is lower than during stressing.

After stressing, the anchor recess is concreted and subsequently the tendon injected with cement grout.

1.2.6 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 10, Annex 11, Annex 13, Annex 15, Annex 16, Annex 19, Annex 23, and Annex 24. However, these values for centre distance between anchorages may be reduced in one direction by 15 %, but are not smaller than the outside diameter of the helix and the dimensions of anchor body MA or anchor plate E. 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 protection caps and venting caps. Standards and regulations on concrete cover in force at the place of use are observed.

1.2.7 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 10, Annex 11, Annex 13, Annex 15, Annex 16, Annex 19, Annex 23, and Annex 24. 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.

1.2.8 Reinforcement in the anchorage zone

In any case, steel grades and dimensions of helix and additional reinforcement specified in the Annex 10, Annex 11, Annex 13, Annex 14, Annex 15, Annex 16, Annex 19, Annex 23, and Annex 24 are conformed to.

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

If required for a specific project design, the reinforcement given in Annex 10, Annex 11, Annex 13, Annex 14, Annex 15, Annex 16, Annex 19, Annex 23, and Annex 24 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 6-n. The first number indicates the nominal diameter of the prestressing steel strand 6 = 15.7 mm (0.62 "), followed by the number "n" of prestressing steel strands.

1.3.2 Range of tendons

The PT system includes tendons, see Table 2, with 1 to 22 prestressing steel strands. Only 7-wire prestressing steel strands with a nominal diameter of 15.7 mm and tensile strengths of 1 770 MPa or 1 860 MPa are used. The dimensions and specifications of the prestressing steel strands are given in Table 1 and Annex 33.

Characteristic values of maximum force of the tendons are listed in Annex 5 and Annex 6.

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 lists 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 $0.90 \cdot A_p \cdot f_{p0.1}$. 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 ± 5 % of the final value of the overstressing force.

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

Where

A_p .... mm^2 .... Cross-sectional area of prestressing steel of tendon, i.e. $A_p = n \cdot S_0$

$f_{p0.1}$...... MPa .... 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 22

S_0 .... mm^2 .... Nominal cross-sectional area of one single prestressing steel strand, see Annex 33

$F_{p0.1}$ ...... kN .... Characteristic value of 0.1 % proof force of one single prestressing steel strand, see Annex 33

P_{m0}........ kN .... Initial prestressing force immediately after tensioning 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 Table 3 slip and the required locking measure of wedges and compression fittings are specified.

Table 3 Slip values and locking of wedges and compression fittings

Anchorage or coupler		Slip	Locking measures
—		mm	—
Stressing anchor	E6-n	6 1), 2)	—
	SK6	5 1)	—
Fixed coupler – 1st construction stage	K6-n	6 1), 2)	—
Fixed anchor	E6-n	6	— 3)
	EP6-n	0	Retainer plate
	SK6	5	Spring, Venting cap
Bond anchorage	H6-n	0	—
Fixed coupler – 2nd construction stage	K6-n	0	Tensioning belt
Movable coupler	V6-n	0	Retainer plate, Retainer ring plate, Tensioning belt
Movable coupler	K6-K6	10	Spring
Floating block anchorage Z	Z6-n	6 4)	Retainer plate

NOTES
1) Slip occurs by transfer of prestressing force from jack to anchorage.
2) Slip is 3 mm with power-seating of ~ 20 kN per strand. This requires a special prestressing jack, its availability is coordinated with the ETA holder.
3) Anchorage is accessible during stressing.
4) See Clause 1.2.5.

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 .... kN .... Prestressing force at distance x from the stressing anchor along the tendon

P_0 .... kN .... Prestressing force at the distance x = 0 m

μ .... rad^{-1} .... Friction coefficient, see Table 4

α .... rad .... Sum of angular deviations over a distance x, irrespective of direction or sign

k .... rad/m .... Wobble coefficient, see Table 4

x .... m .... Distance along the tendon from the point where the prestressing force is equal to P_0

NOTE 1 rad = 1 m/m = 1

Table 4 Friction coefficient μ and wobble coefficient k

—		Circular metal duct		Circular plastic duct	
		Duct I	Duct II	Range	Recommended value
μ	rad^{-1}	0.20	0.19	0.10 to 0.14	0.14
k	rad/m	0.005	0.005	—	0.005
	°/m	(0.3) [1)]	(0.3) [1)]		(0.3) [1)]

NOTE

[1)] For information only

For flat metal duct see Annex 4 and for flat plastic duct see Annex 28.

More information on friction coefficients and wobble coefficients is given in Annex 27 and Annex 28. Information on friction losses in anchorages and couplers is included in Annex 4, Annex 19, Annex 20, and Annex 30.

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 1.8 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.

For corrugated plastic ducts, spacing of supports should be 0.6 to 1.0 m for sizes 50 to 85 mm, and 0.60 to 0.75 m as stated above, and up to 1.4 m for size 100 mm, see also Annex 27 and Annex 28.

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 MPa
- 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 $f_{cm,\,0,\,cube}$ = 25 MPa

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.

For corrugated plastic ducts minimum radii of curvature are given in Annex 28 and Annex 29.

Components

1.8 Specification of prestressing steel strand

7-wire prestressing steel strands with plain surfaces of the individual wires, a nominal diameter of 15.7 mm and tensile strengths of 1 770 MPa or 1 860 MPa are used. Dimensions and specifications of the prestressing steel strands are according to prEN 10138-3 and are given in Clause 1.1, Table 1, and Annex 33.

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 33 and is according to the standards and regulations in force at the place of use is taken.

1.9 Anchorage and coupling components

1.9.1 General

Specification of anchorage components are given in the Annexes and the technical file[3] 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 MPa as well as 1 770 MPa the same anchorages and couplers are used.

1.9.2 Anchor head

The anchor heads E and EP are made of steel with a pattern of regular arranged bores for anchoring the prestressing steel strands, see Annex 10, Annex 11, Annex 23, and Annex 24. Anchor head E for the stressing anchor provides cylindrical bores with conical ends at one side for bearing wedges. Anchor head EP for the fixed anchor provides only cylindrical bores for bearing compression fittings. All bores are countersunk and deburred. See Annex 3 for details on the conical and cylindrical bores.

The single prestressing steel strand anchor SK6, see Annex 17, is made of cast iron and contains a conical hole to bear one wedge. It is used with a wedge as stressing anchor as well as fixed anchor.

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 head

Coupler heads K, V, and K6 are made of steel with a pattern of regular arranged bores and slots for anchoring the prestressing steel strands. In the inner part of coupler heads K and V the bore pattern is identical with that of the anchor head. In addition, the outer ring collar of the coupler heads provide slots for anchoring prestressing steel strands by means of compression fittings.

Coupler head K, see Annex 12 and Annex 26, for fixed couplers provides in the inner part cylindrical bores with conical ends for stressing and bearing the wedges of the 1st construction stage like anchor head E. On the outer ring collar, the prestressing steel strands of 2nd construction stage are anchored in slots by means of compression fittings.

The coupler head V, see Annex 12, for movable couplers provides in the inner part cylindrical bores for bearing the compression fittings of the 1st tendon like anchor head EP. On the outer ring collar the prestressing steel strands of the 2nd tendon are anchored in slots by means of compression fittings.

The coupler K6-K6, see Annex 20, for movable single prestressing steel strand couplers comprises 2 coupler barrels K6 with cones and threads, which are connected by a steel bushing.

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

1.9.4 Anchor body MA and anchor plate E

Anchor body MA, see Annex 10 and Annex 11, and anchor plate E, see Annex 21, Annex 23, and Annex 24, are used together with anchor heads E and EP of the stressing and fixed anchorage and with coupler head K of the fixed coupler.

Applications with anchor plate E require preceding consultations of the ETA holder to confirm availability.

Cast iron anchor body MA is of circular shape and provide several load transfer planes for load transfer to the structural concrete. Steel anchor plate E is of circular shape as well, but with only

[3] The technical file of the European Technical Assessment is deposited at Österreichisches Institut für Bautechnik.

one load transfer plane. Anchor body MA and anchor plate E feature a centric circular hole for passing through the tendon.

1.9.5 Bond head

The bulb shaped bond head on the end of the prestressing steel strand, see Annex 13, for bond anchorage H is made by means of a special jack.

1.9.6 Anchor head Z

The anchor head Z, see Annex 30, is made of steel, of rectangular shape, and with two pattern of regular arranged bore for anchoring the prestressing steel strands. Anchor head Z is stressing and fixed anchor in one piece. All prestressing steel strands are anchored by means of wedges. The bores and cones for the stressing end are located in the centre of the anchor head Z. The bores for the fixed end are split. One half each is located adjacent to the centre holes on the outside ends of the anchor head Z, with cones arranged on the opposite side to the ones of the stressing end.

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

1.9.7 Rings

Steel rings are used for bond anchorage H, see Annex 1, Annex 13, Annex 15, and Annex 16, fixed coupler with coupler head K, see Annex 12 and Annex 26, movable coupler with coupler head V, see Annex 12, and as well as for floating block anchorage Z, see Annex 30.

1.9.8 Wedge and compression fitting

Only 3-piece wedge and compression fitting according to Annex 3 are used.

Three wedges that are similar in geometry and are made of different material are used.

- Two wedges with 30 ° tooth geometry according to Annex 3 are made of two different materials
- One wedges with 45 ° tooth geometry according to Annex 3 is made of one material

Within one anchorage and one coupler, only one of these three wedges is installed.

1.9.9 Retainer plate

Retainer plate and retainer ring plate are used for fixed anchor with anchor head EP, see Annex 9, Annex 21, and Annex 22, for movable coupler with coupler head V, see Annex 12 and Annex 26, as well as for floating block anchorage Z, see Annex 30.

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 body MA or anchor plate E 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 23, and Annex 24.

1.11 Duct

1.11.1 Steel strip sheath

Usually, a corrugated duct made of steel strip 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 6-12 is 1.50 m and for larger tendons 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 two prestressing steel strands are consecutively pushed or pulled into the respective duct or the entire tendon all at once.

The ducts have circular cross section – so called "round" duct – and for tendons 6-3 to 6-5, ducts with oval cross sections – so called "flat" duct – are available. The ends of the ducts are connected with sockets. 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.

1.11.2 GDP plastic duct

The corrugated GDP plastic duct conforms to Annex 27, Annex 28, and Annex 32. The plastic duct is made of polypropylene according to Annex 32 with circular or oval cross section and toroidal corrugations. The main dimensions of the plastic duct are given in Annex 27 and Annex 28.

Couplers to joint sections of plastic ducts and connections to trumpets of anchorages, see Annex 27, Annex 28, and Annex 29, are made with heat shrinking sleeves. For supporting the plastic ducts during installation, in general no specific stiffeners are required.

Inner diameter of circular duct and corresponding minimum radius of curvature, R_{min}, are given in Annex 29 for ambient and high temperature. The minimum radius of curvature at high temperatures is applied if the temperature of concrete next to the plastic duct is expected to be at or exceeds 37 °C at the time of stressing operations.

The GDP plastic ducts have been tested according to *fib* bulletin 7 within a temperature range of − 20 °C to + 50 °C.

Alternatively other corrugated plastic ducts may be used as well, if permitted at the place of use.

1.12 Permanent corrosion protection

1.12.1 General

In the course of preparing the European Technical Assessment no characteristic has been assessed for components and materials of the corrosion protection system, except for plastic ducts according to Clause 1.11.2. In execution, all components and materials are selected according to the standards and regulations in force at the place of use. In the absence of such standards or regulations, components and materials in accordance with ETAG 013 are deemed as acceptable. Österreichisches Institut für Bautechnik has been notified about such materials.

Corrosion protection of tendon, anchorage, and coupler is provided by grout according to EN 447, special grout according to ETAG 013, or ready-mixed grout with an adequate composition according to standards and regulations in force at the place of use.

1.12.2 Electrically isolated tendon

As an additional measure for corrosion protection, electrically isolated tendons with plastic trumpets and plastic ducts are used. Between anchor head E and anchor plate E, and coupler anchor head K – EI and anchor plate K – EI, an isolation plate with a load distributing steel plate is installed, see Annex 21, Annex 25, and Annex 26. Therefore, the tendon, including anchorages and fixed and movable coupler is completely encased by isolation material. Its integrity can be verified by measuring the electrical resistance between tendon and surrounding structure.

1.13 Material specifications of the components

Material specifications of the components are given in Annex 31.

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

2.1 Intended uses

The PT system SUSPA Strand DW is intended to be used for the prestressing of structures. The specific intended uses are listed in Table 5.

Table 5 Intended uses

Line №	Use category
Use category according to tendon configuration and material of structure	
1	Internal bonded tendon for concrete and composite structures
Optional use categories	
2	Internal bonded tendon with plastic duct
3	Electrically isolated tendon
4	Tendon for use in structural masonry construction as internal tendon

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 6-12 $D \geq 1.50$ m

For larger tendons $D \geq 1.80$ 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.

Design of the structure permits correct installation and stressing 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 1.2.6, Clause 1.2.7, Clause 1.2.8, Annex 10, Annex 11, Annex 13, Annex 14, Annex 15, Annex 16, Annex 19, Annex 21, Annex 23, Annex 24, and Annex 30 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 10, Annex 11, Annex 13, Annex 14, Annex 15, Annex 16, Annex 19, Annex 23, and Annex 24 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 protection caps and venting 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, 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 need not to be taken into consideration.

2.2.3.4 Fixed and movable coupler

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

The length of the protective tube and its position relative to the coupler ensures unimpeded movement of the coupler in the protective tube along a length of minimum $1.15 \cdot \Delta l + 30$ mm, with Δl in mm as the expected displacement of the coupler during stressing.

2.2.3.5 Tendons in masonry structures

Load transfer of prestressing force to masonry structures is via concrete or steel members designed according to the European Technical Assessment, especially according to the Clauses 1.2.6, 1.2.7, and 1.2.8, 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 ETAG 013, Annex D.1 and 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 SUSPA Strand DW.

2.2.4.2 Anchorages

2.2.4.2.1 General

Anchorages with anchor heads E, EP, and coupler head K can be installed with either an anchor body MA or a anchor plate E. In all that cases, the same installation procedure applies, see Annex 22. The anchorages with anchor bodies MA or anchor plates E and anchor heads or coupler heads 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 the anchor plate E or to anchor body MA or by means of spacers braced against the tendon. The additional reinforcement is fastened centrically to the trumpet by tying or by means of spacers.

When installing an electrically isolated tendon, a load distributing steel plate and an isolation plate are placed between anchor head E and anchor plate E or coupler head K – EI and anchor plate K – EI, see Annex 25 and Annex 26.

2.2.4.2.2 Stressing anchor

Site assembly comprises the following working steps, see Annex 17 and Annex 22.

- Fastening anchor body MA or anchor plate E or anchor SK6 to the formwork.
- Installation of the trumpet between anchor body MA or anchor plate E and duct or installation of the PE-sleeve between anchor SK6 and duct.
- If the helix is not already welded onto anchor body MA or anchor plate E in the manufacturing plant, the helix is placed, centred to the tendon axis, and fastened to the reinforcement.
- Pushing the duct into trumpet or PE-sleeve to approximately a length of d, with d as the duct diameter, or, in the case of appropriately shaped polyethylene trumpets, screwing the duct onto the trumpet.
- Sealing the joint between trumpet or PE-sleeve and duct.
- Pushing the anchor head E over the prestressing steel strands just before stressing.
- Tightening the prestressing steel strands with 3-piece wedges.

The anchor head E can be provided with an external thread, on which a protection cap can be screwed on for grouting, see Annex 22.

2.2.4.2.3 Fixed anchor

The anchor head E can also be used in a fixed anchor. In that case, the anchorage remains accessible during stressing of the tendon. The installation is the same as for the stressing anchor according to Clause 2.2.4.2.2 using an anchor body MA or an anchor plate E.

The anchor head EP can be either pre-fabricated or assembled at the construction site. Due to the geometrically equivalence this anchor can be installed similarly to the stressing anchor. Instead of wedges, compression fittings are used for anchoring the prestressing steel strands. The compression fittings are secured by a retaining plate.

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 plant or on site by cold forming and all bond heads are arranged by means of spacers according to their designated position.

2.2.4.2.5 Floating block anchorage Z

Floating block anchorage Z is in general used for ring tendons, e.g. in storage facilities or tanks. Both ends, end 1 and end 2, of the ring tendon overlap in the floating block anchor head Z.

Site assembly comprises the following steps.

- Pushing the anchor head Z over the prestressing steel strands just before stressing, whereas end 1 of the tendon is inserted into the inner bores and end 2 of the tendon into the outer bores of anchor head Z.
- Alignment of anchor head Z by anticipating its displacement during stressing
- Anchoring the prestressing steel strands of end 2 with 3-piece wedges and securing the wedges with retainer plates.
- Stressing is carried out at end 1 of the tendon by means of a special deviation chair.

Floating block anchorage Z may also be applied as intermediate stressing anchor between two fixed anchors. In this case the two tendon ends overlap in the anchor head Z. Installation steps are the same as for ring tendons.

2.2.4.3 Couplers

2.2.4.3.1 Fixed coupler with coupler head K

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

Site assembly of the 2nd tendon comprises the following steps.

- Jointing the 2nd tendon with the 1st tendon by inserting the prestressing steel strands, provided with compression fittings, into the slots of the outer ring collar of coupler head K. The compression fittings are held in place by a tensioning belt.
- Installing the trumpet.
- Arranging a vent pipe for grouting.

2.2.4.3.2 Movable coupler with coupler head V and movable coupler K6-K6

The movable coupler joints two tendons prior to stressing.

With the movable coupler with coupler head V, the prestressing steel strands of both tendons are anchored by means of compression fittings. The anchorage of the prestressing steel strands of the 1st tendon in coupler head V is equivalent to the fixed anchor with anchor head EP.

Site assembly of movable coupler with coupler head V comprises the following steps.

- Connecting tendon 2 by inserting the prestressing steel strands, provided with compression fittings, into the slots of the outer ring collar of coupler head V. The compression fittings of tendon 1 are held in place by a retainer plate and those of tendon 2 by a retainer ring plate and a tensioning belt.
- Placing the coupler head V into the protective tube.
- The correct position of coupler head V in the protective tube with regard to direction and amount of displacement during stressing is checked prior to final assembly of the protective tube.
- Arranging a vent pipe behind coupler head V facing the grouting direction. If the coupler, in grouting direction, is placed in a downwards position, a vent pipe is also arranged in front of coupler head V.

Movable coupler K6-K6 is installed analogously.

2.2.4.4 Ducts and tendon placement

Tendons are installed with high accuracy on supports, see Clause 1.6. During installation careful handling of tendons is ensured.

Prior to concreting, the PT site manager carries out a final examination of the installed tendons. Damages to duct or tendons are either repaired immediately or reported to the responsible person.

2.2.4.5 Electrically isolated tendon

Installation of electrically isolated tendons requires special care with regard to completely encase the tendon with electrically isolation material. Checks are made by the responsible person, in particular at the following working steps.

- After installation of tendon with regard to geometry of tendon, integrity of the duct especially at joints, and deformation of the duct especially at supports to avoid unintended kinks and too small radii with a risk of penetration of the prestressing steel strands during stressing
- Before concreting with special attention to integrity of duct especially at contact points to reinforcing steel and the joint trumpet to anchor plate E or anchor plate K – EI
- Before stressing with regard to the joint trumpet to anchor plate E or anchor plate K – EI and to a complete and correct installation of the isolation plate at the anchor
- After stressing with regard to correct position of anchor head E or coupler head K – EI on the isolation plate
- Before grouting with regard to clean and undamaged sealing surfaces, and correct and tight position of protection caps
- After grouting with regard to correct and tight position of protection caps and penetration of grout out of the encased tendon

All shortcomings shall be rectified immediately. Major damages are immediately reported to the person responsible for the construction site for further actions. For each tendon the checks performed, with all relevant findings and corrective measures, and with all measured electrical resistances are systematically recorded.

2.2.4.6 Stressing and stressing records

2.2.4.6.1 Stressing

With a mean concrete compressive strength in the anchorage zone according to Annex 10, Annex 11, Annex 13, Annex 15, Annex 16, Annex 19, Annex 23, Annex 24, and Annex 30 full prestressing may be performed.

The prestressing forces are applied in accordance with a prescribed stressing schedule. Said schedule includes

- Mean cube or cylinder compressive strength of the concrete at time of stressing
- Time and sequence of the various prestressing levels
- Prestressing forces and elongations calculated for the tendons
- Time and kind of shuttering lowering and removal
- Any possible spring back forces of the falsework are taken into account.

2.2.4.6.2 Restressing

Except for the floating block anchorage Z, restressing of tendons in combination with release and reuse of wedges is permitted. After restressing the wedges bite into a least 15 mm of virgin strand surface, and no wedge marks remain on the tendon between the anchorages.

2.2.4.6.3 Stressing records

For each tendon any important observation made during the stressing operation, in particular prestressing forces applied and elongation measured, are recorded in stressing records.

2.2.4.6.4 Stressing equipment, clearance requirements, and safety-at-work

For stressing, hydraulic jacks are used. Information about the stressing equipment has been submitted to Österreichisches Institut für Bautechnik. Special jack with power-seating mechanism for reduced slip at the stressing anchor requires co-ordinated with the ETA holder for timely availability.

To stress the tendons, clearance of approximately 1 m directly behind the anchorages is ensured. The ETA holder keeps available more detailed information on prestressing jacks used and the required space for handling and stressing.

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

2.2.4.7 Grouting of tendons

2.2.4.7.1 Grout

Grout according to EN 447, special grout according to ETAG 013, or ready-mixed grout with an adequate composition according to standards and regulations in force at the place of use is used.

2.2.4.7.2 Grouting procedure

All anchorages have inlets and vents for grouting or ventilation. The ducts have vent pipes at their top points and at additional points, if required.

For the grouting procedure, EN 446 applies. Standards and regulations in force at the place of use are observed. After completion of the prestressing operation and acceptance of the stressing records, the tendons are grouted as soon as possible. If tendons remain ungrouted for a longer time, appropriate corrosion protection measures are implemented after acceptance of the ETA holder.

Where plastic ducts are used, the relevant notes in the technical documentation of the plastic ducts system are observed.

The anchor recesses of anchorages with anchor recess 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 the SUSPA Strand DW of 100 years, provided that the SUSPA Strand DW 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[4].

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 the PT system for the essential characteristics are given in Table 6 and Table 7. In Annex 37 the combinations of essential characteristics and corresponding intended uses are listed.

Table 6 Essential characteristics and performances of the product

№	Essential characteristic	Product performance
Product	SUSPA Strand DW	
Intended use	The PT system is intended to be used for the prestressing of structures, Clause 2.1, Table 5, line № 1.	
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)	See Clause 3.2.1.5.
6	Practicability, reliability of installation	See Clause 3.2.1.6.
Basic requirement for construction works 2: Safety in case of fire		
—	Not relevant. No characteristic assessed.	—
Basic requirement for construction works 3: Hygiene, health, and the environment		
7	Content, emission, and/or release of dangerous substances	See Clause 3.2.2.
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.	—
Related aspects of serviceability		
8	Related aspects of serviceability	See Clause 3.2.3.

[4] 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.

Table 7 Essential characteristics and performances of the product in addition to Table 6 for optional use categories

№	Additional essential characteristic	Product performance
Product	SUSPA Strand DW	
Optional use category	Clause 2.1, Table 5, line № 2, internal bonded tendon with plastic duct	
Basic requirement for construction works 1: Mechanical resistance and stability		
9	Practicability, reliability of installation	See Clause 3.2.4.1.
Optional use category	Clause 2.1, Table 5, line № 3, electrically isolated tendon	
Basic requirement for construction works 1: Mechanical resistance and stability		
10	Practicability, reliability of installation	See Clause 3.2.4.2.
Optional use category	Clause 2.1, Table 5, line № 4, tendon for use in structural masonry construction as internal tendon	
Basic requirement for construction works 1: Mechanical resistance and stability		
11	Load transfer to the structure	See Clause 3.2.4.3.

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 ETAG 013, Clause 6.1.1-I. The characteristic values of maximum force, F_{pk}, of tendons with prestressing steel strands according to Annex 33 are listed in Annex 5 and Annex 6.

3.2.1.2 Resistance to fatigue

The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.2-I. The characteristic values of maximum force, F_{pk}, of tendons with prestressing steel strands according to Annex 33 are listed in Annex 5 and Annex 6.

Fatigue resistance of anchors and couplers was tested and verified with an upper force of $0.65 \cdot F_{pk}$, a fatigue stress range of 80 MPa, 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 ETAG 013, Clause 6.1.3-I. The characteristic values of maximum force, F_{pk}, of tendons with prestressing steel strands according to Annex 33 are listed in Annex 5 and Annex 6.

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

The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.4-I. For friction losses including friction coefficient see Clause 1.5.

3.2.1.5 Deviation, deflection (limits)

The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.5-I. For minimum radii of curvature see Clause 1.7.

3.2.1.6 Practicability, reliability of installation

The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.6-I.

3.2.2 Hygiene, health, and the environment

Content, emission, and/or release of dangerous substances is determined according to ETAG 013, Clause 5.3.1. No dangerous substances is the performance of the PT system in this respect. A manufacturer’s declaration to this effect has been submitted.

NOTE In addition to specific clauses relating to dangerous substances in the European Technical Assessment, there may be other requirements applicable to the product falling within their scope, e.g. transposed European legislation and national laws, regulations, and administrative provisions. These requirements also need to be complied with, when and where they apply.

3.2.3 Related aspects of serviceability

The PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.7.

3.2.4 Mechanical resistance and stability

3.2.4.1 Internal bonded tendon with plastic duct – Practicability, reliability of installation

For internal bonded tendons with plastic duct, the PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.6-II(d).

3.2.4.2 Electrically isolated tendon – Practicability, reliability of installation

For electrically isolated tendons the PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.6-II(f).

3.2.4.3 Tendon in masonry structures – Load transfer to the structure

For tendons for use in structural masonry construction as internal tendon, the PT system as described in the ETA meets the acceptance criteria of ETAG 013, Clause 6.1.3-II(h). See in particular Clause 2.2.3.5 for tendons in masonry structures. The characteristic values of maximum force, F_{pk}, of tendons with prestressing steel strands according to Annex 33 are listed in Annex 5 and Annex 6.

3.3 Assessment methods

The assessment of the essential characteristics in Clause 3.1 of the PT system, for the intended uses, and in relation to the requirements for mechanical resistance and stability, and for hygiene, health and the environment, in the sense of the basic requirements for construction works № 1 and 3 of Regulation (EU) № 305/2011, has been made in accordance with ETAG 013, Post-Tensioning Kits for Prestressing of Structures, Edition June 2002, used according to Regulation (EU) № 305/2011 Article 66 (3) as European Assessment Document, and was based on the assessment for internal bonded PT systems.

3.4 Identification

The European Technical Assessment for the SUSPA Strand DW is issued on the basis of agreed data[5] that identify the assessed product. 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.

[5] 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 the SUSPA Strand DW 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[6].

(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

In the manufacturing plant, the manufacturer establishes and continuously maintains a factory production control. All procedures and specifications adopted by the manufacturer are documented in a systematic manner. Purpose of factory production control is to ensure the constancy of performances of the SUSPA Strand DW with regard to the essential characteristics.

The manufacturer only uses raw materials supplied with the relevant inspection documents as laid down in the control plan. The incoming raw materials are subjected to controls by the manufacturer before acceptance. Check of incoming materials includes control of inspection documents presented by the manufacturer of the raw materials.

Testing within factory production control is in accordance with the prescribed test plan. The results of factory production control are recorded and evaluated. The records are presented to the notified product certification body involved in continuous surveillance and are kept at least for

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[6] 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.

ten years after the product has been placed on the market. On request, the records are presented to Österreichisches Institut für Bautechnik.

If test results are unsatisfactory, the manufacturer immediately implements measures to eliminate the defects. Products or components that are not in conformity with the requirements are removed. After elimination of the defects, the respective test – if verification is required for technical reasons – is repeated immediately.

At least once a year the manufacturer audits the manufacturers of the components given in Annex 36.

The basic elements of the prescribed test plan are given in Annex 34 and Annex 35, conform to ETAG 013, Annex E.1, and are specified in the quality management plan of the SUSPA Strand DW.

5.1.2 Declaration of performance

The manufacturer is responsible for preparing the declaration of performance. When all the criteria of the assessment and verification of constancy of performance are met, including the certificate of constancy of performance issued by the notified product certification body, the manufacturer draws up the declaration of performance. Essential characteristics to be included in the declaration of performance for the corresponding intended use are given in Table 6 and Table 7. In Annex 37 the combinations of essential characteristics and corresponding intended uses are listed.

5.2 Tasks for the notified product certification body

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

The notified product certification body verifies the ability of the manufacturer for a continuous and orderly manufacturing of the SUSPA Strand DW according to the European Technical Assessment. In particular, the following items are appropriately considered.

- Personnel and equipment
- Suitability of the factory production control established by the manufacturer
- Full implementation of the prescribed test plan

5.2.2 Continuing surveillance, assessment, and evaluation of factory production control

The notified product certification body visits the factory at least once a year for routine inspection. In particular the following items are appropriately considered.

- Manufacturing process including personnel and equipment
- Factory production control
- Implementation of the prescribed test plan

Each manufacturer of the components given in Annex 36 is audited at least once in five years. It is verified that the system of factory production control and the specified manufacturing process are maintained, taking account of the prescribed test plan.

The results of continuous surveillance are made available on demand by the notified product certification body to Österreichisches Institut für Bautechnik. When the provisions of the European Technical Assessment and the prescribed test plan are no longer fulfilled, the certificate of constancy of performance is withdrawn by the notified product certification body.

5.2.3 Audit-testing of samples taken by the notified product certification body at the manufacturing plant or at the manufacturer's storage facilities

During surveillance inspections, the notified product certification body takes samples of components of the SUSPA Strand DW for independent testing. For the most important components, Annex 36 summarises the minimum procedures performed by the notified product certification body.

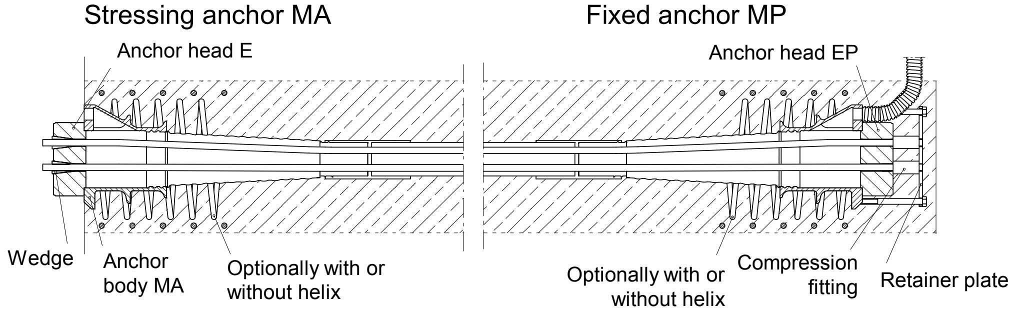
Issued in Vienna on 11 December 2017
by Österreichisches Institut für Bautechnik

The original document is signed by

Rainer Mikulits
Managing Director

Anchorages

Multi-plane anchorage MA



Bond anchorage H, HL, and HR

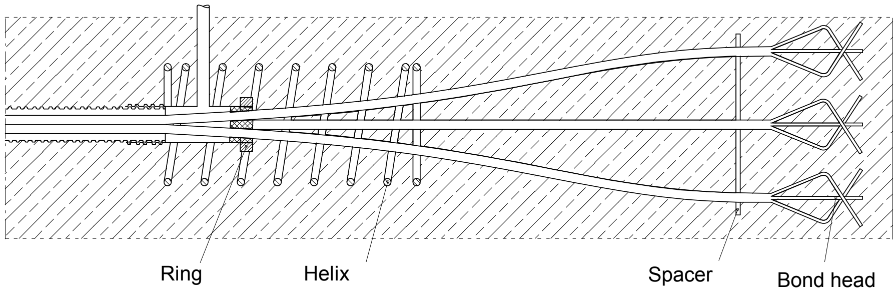
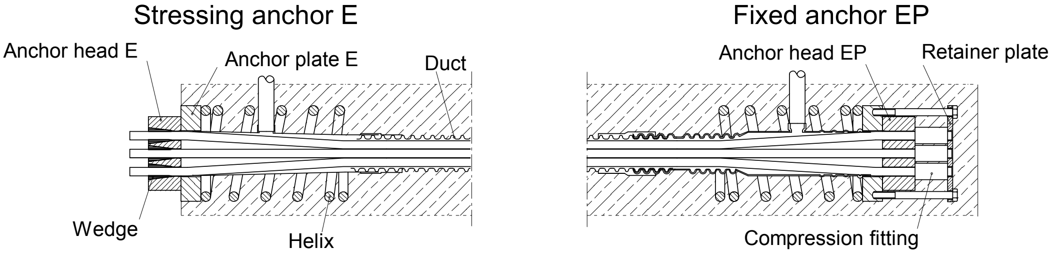
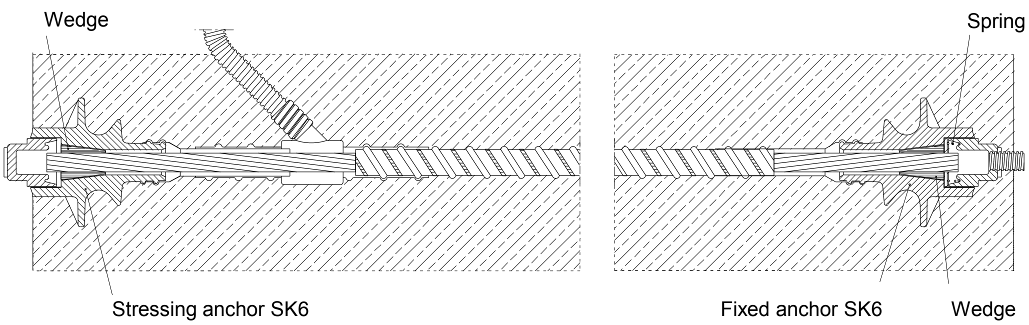


Plate anchorage E

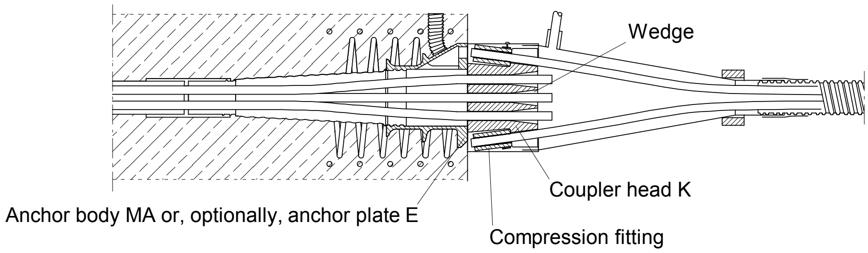


Single strand anchorage SK6

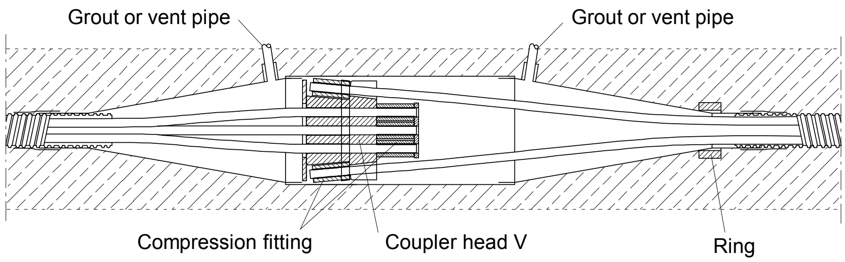


Couplers

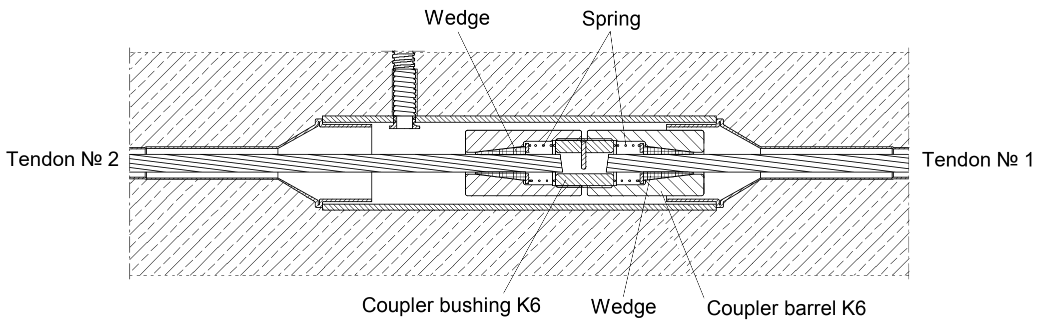
Fixed coupler K



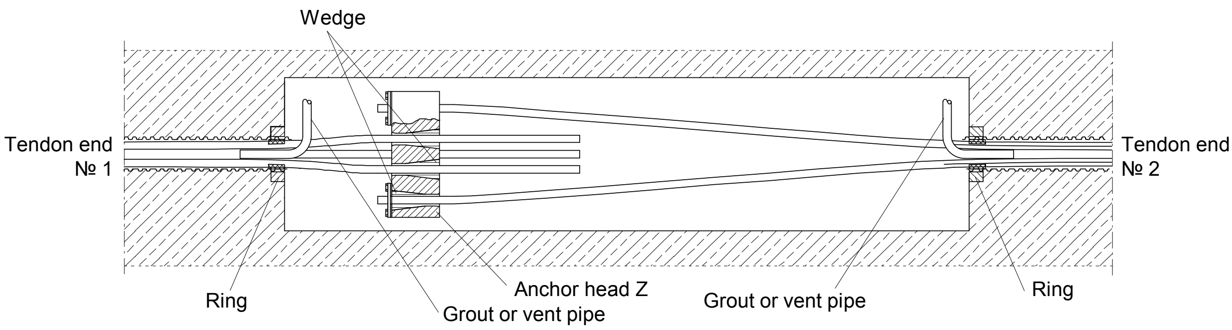
Movable coupler V



Movable coupler K6-K6

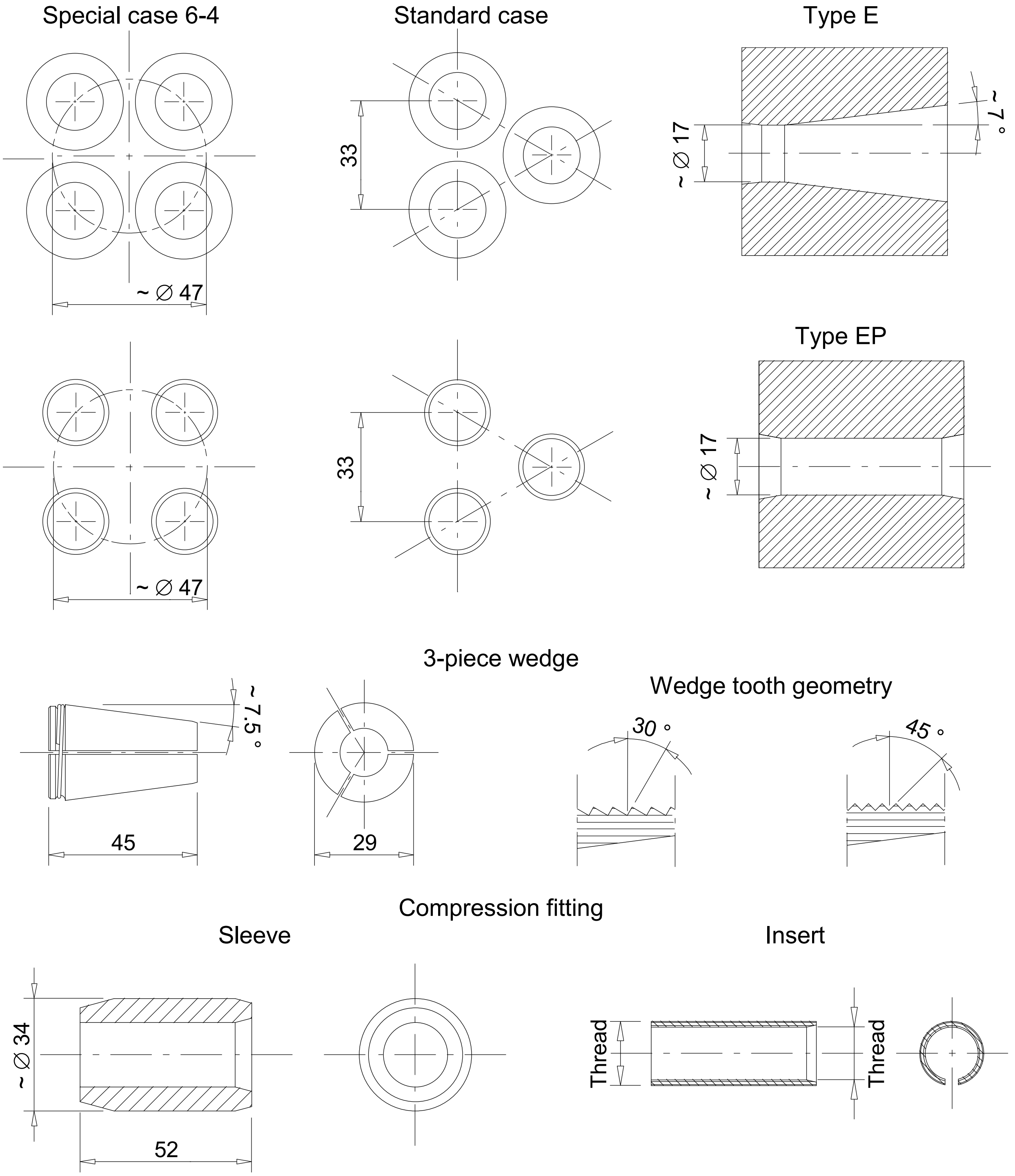


Floating block anchorage Z



DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Overview on couplers Floating block anchorage Z	**Annex 2** of European Technical Assessment **ETA-13/0839** of 11.12.2017

Geometry of anchor heads for strands Y1770S7 15.7 and Y1860S7 15.7



Dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Basic components for anchoring the prestressing steel strand	**Annex 3** of European Technical Assessment **ETA-13/0839** of 11.12.2017

OiB Member of EOTA

Technical data for tendons 6-1 to 6-22 with circular steel strip duct
strand Y1770S7 15.7 and strand Y1860S7 15.7

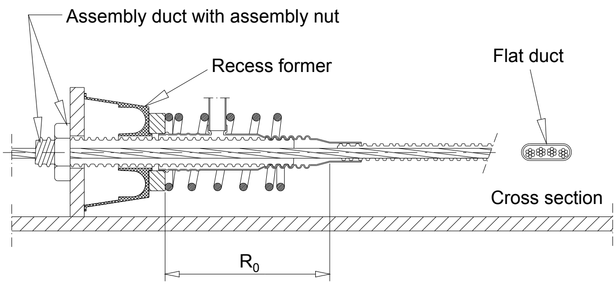
Tendon		**6-1**	**6-3**	**6-4**	**6-5**	**6-7**	**6-9**	**6-12**	**6-15**	**6-19**	**6-22**
Number of strands ∅ 15.7 mm		1	3	4	5	7	9	12	15	19	22
Nominal cross sectional area of prestressing steel	mm^2	150	450	600	750	1 050	1 350	1 800	2 250	2 850	3 300
Nominal mass of prestressing steel	kg/m	1.17	3.52	4.69	5.86	8.20	10.55	14.06	17.58	22.27	25.78
Modulus of elasticity	N/mm^2	195 000 (standard value)									
Circular steel strip duct											
Wobble coefficient k		0.005 rad/m ≙ 0.30 °/m									
Duct type I ∅ d_i / d_a	mm	20/27	40/47	45/52	50/57	55/62	65/72	75/82	80/87	90/97	95/102
Eccentricity	mm	3	6	7	7	6	9	10	10	10	10
Friction coefficient μ	rad^{-1}	0.20									
Distance of tendon support	m	0.60–1.80									
Duct type II ∅ d_i / d_a	mm	25/32	45/52	50/57	55/62	60/67	70/77	80/87	85/92	95/102	105/112
Eccentricity	mm	5	9	10	11	9	12	14	13	14	18
Friction coefficient μ	rad^{-1}	0.19									
Distance of tendon support	m	0.50–1.80 m with stiffening, e.g. with PE tube 0.60–1.00 m with strengthened duct In a tendon section with minimum radius of curvature a distance of 0.60–0.75 m applies.									
Friction loss in stressing anchorage E	%	—[1]	1.0	1.3	1.2	1.0	0.7	0.8	0.8	0.7	0.6
Friction loss in movable couplers K6-K6 and V	%	—[1]	1.8	2.0	—	1.8	1.7	1.7	1.7	1.7	1.6

[1] Friction losses are low and do not have to be considered in design and execution.

Technical data for tendons 6-3 to 6-5 with flat steel strip duct
strand Y1770S7 15.7 and strand Y1860S7 15.7

Tendon			**6-3**	**6-4**	**6-5**
Number of strands ∅ 15.7 mm			3	4	5
Trumpet length	R_o	m	370	325	535
Flat steel strip duct					
Dimensions	d_i	mm	55 × 21	70 × 21	85 × 21
	d_a	mm	60 × 25	75 × 25	90 × 25
Distance of tendon support		M	0.50–1.00		
Wobble coefficient	k		0.014 rad/m ≙ 0.80 °/m		
Bending around weak axis, Minimum radius of curvature	R	M	2.5		
Friction coefficient	μ	rad^{-1}	0.15		
Bending around strong axis Minimum radius of curvature	R	m	5.0		
Friction coefficient	μ	rad^{-1}	0.23	0.26	0.32

Stressing anchor E
Assembly condition



NOTE Flat ducts can be installed with anchor body MA and with anchor plate E.

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Tendon range – Strand Y1770S7 15.7 – f_{pk} = 1 770 N/mm²

Number of strands	Mass of strands	Nominal cross-sectional area	Maximum prestressing force [1), 3)]	Maximum overstressing force [1), 2), 3)]	Characteristic value of maximum force
		A_p	$0.90 \cdot F_{p0.1}$	$0.95 \cdot F_{p0.1}$	F_{pk}
—	kg/m	mm²	kN	kN	kN
1	1.17	150	211	222	266
2	2.34	300	421	445	532
3	3.52	450	632	667	798
4	4.69	600	842	889	1 064
5	5.86	750	1 053	1 112	1 330
6	7.03	900	1 264	1 334	1 596
7	8.20	1 050	1 474	1 556	1 862
8	9.38	1 200	1 685	1 778	2 128
9	10.55	1 350	1 895	2 001	2 394
10	11.72	1 500	2 106	2 223	2 660
11	12.89	1 650	2 317	2 445	2 926
12	14.06	1 800	2 527	2 668	3 192
13	15.24	1 950	2 738	2 890	3 458
14	16.41	2 100	2 948	3 112	3 724
15	17.58	2 250	3 159	3 335	3 990
16	18.75	2 400	3 370	3 557	4 256
17	19.92	2 550	3 580	3 779	4 522
18	21.10	2 700	3 791	4 001	4 788
19	22.27	2 850	4 001	4 224	5 054
20	23.44	3 000	4 212	4 446	5 320
21	24.61	3 150	4 423	4 668	5 586
22	25.78	3 300	4 633	4 891	5 852

1) 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.

2) Overstressing is permitted if the force in the prestressing jack can be measured to an accuracy of ± 5 % of the final value of the overstressing force.

3) For strands according to prEN 10138-3, 09.2000, the values are multiplied by 0.98.

Where

f_{pk} ....Characteristic tensile strength of prestressing steel strand

F_{pk} ....Characteristic value of maximum force of tendon

$F_{p0.1}$ ....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 strand see Annex 33.

A_p ....Nominal cross-sectional area of tendon

Tendon range – Strand Y1860S7 15.7 – f_{pk} = 1 860 N/mm²

Number of strands	Mass of strands	Nominal cross-sectional area	Maximum prestressing force [1), 3)]	Maximum overstressing force [1), 2), 3)]	Characteristic value of maximum force
		A_p	$0.90 \cdot F_{p0.1}$	$0.95 \cdot F_{p0.1}$	F_{pk}
—	kg/m	mm²	kN	kN	kN
1	1.17	150	221	234	279
2	2.34	300	443	467	558
3	3.52	450	664	701	837
4	4.69	600	886	935	1 116
5	5.86	750	1 107	1 169	1 395
6	7.03	900	1 328	1 402	1 674
7	8.20	1 050	1 550	1 636	1 953
8	9.38	1 200	1 771	1 870	2 232
9	10.55	1 350	1 993	2 103	2 511
10	11.72	1 500	2 214	2 337	2 790
11	12.89	1 650	2 435	2 571	3 069
12	14.06	1 800	2 657	2 804	3 348
13	15.24	1 950	2 878	3 038	3 627
14	16.41	2 100	3 100	3 272	3 906
15	17.58	2 250	3 321	3 506	4 185
16	18.75	2 400	3 542	3 739	4 464
17	19.92	2 550	3 764	3 973	4 743
18	21.10	2 700	3 985	4 207	5 022
19	22.27	2 850	4 207	4 440	5 301
20	23.44	3 000	4 428	4 674	5 580
21	24.61	3 150	4 649	4 908	5 859
22	25.78	3 300	4 871	5 141	6 138

1) 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.
2) Overstressing is permitted if the force in the prestressing jack can be measured to an accuracy of ± 5 % of the final value of the overstressing force.
3) For strands according to prEN 10138-3, 09.2000, the values are multiplied by 0.98.

Where
f_{pk} ....Characteristic tensile strength of prestressing steel strand
F_{pk} ....Characteristic value of maximum force of tendon
$F_{p0.1}$ ....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 strand see Annex 33.
A_p ....Nominal cross-sectional area of tendon

Minimum radii of curvature for steel strip duct – $\mathbf{p_{R,\,max}}$ **= 140 kN/m**

Strand Y1770S7, f_{pk} = 1 770 N/mm^2					Strand Y1860S7, f_{pk} = 1 860 N/mm^2				
Number of strands	Duct I	Min. radius of curvature	Duct II	Min. radius of curvature	Number of strands	Duct I	Min. radius of curvature	Duct II	Min. radius of curvature
n	∅ d_i	R_{min}	∅ d_i	R_{min}	n	∅ d_i	R_{min}	∅ 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
2	40	2.0	45	2.0	2	40	2.0	45	2.0
3	40	3.8	45	3.2	3	40	4.0	45	3.2
4	45	3.9	50	3.8	4	45	4.1	50	3.8
5	50	4.5	55	4.1	5	50	4.7	55	4.3
6	55	4.9	60	4.5	6	55	5.1	60	4.7
7	55	5.7	60	5.2	7	55	6.0	60	5.5
8	65	5.5	70	5.1	8	65	5.8	70	5.4
9	65	6.2	70	5.7	9	65	6.5	70	6.0
10	75	5.9	80	5.6	10	75	6.3	80	5.9
11	75	6.5	80	6.1	11	75	6.9	80	6.4
12	75	7.1	80	6.7	12	75	7.5	80	7.0
13	80	7.2	85	6.8	13	80	7.6	85	7.2
14	80	7.8	85	7.3	14	80	8.2	85	7.7
15	80	8.4	85	7.9	15	80	8.8	85	8.3
16	90	7.9	95	7.5	16	90	8.3	95	7.9
17	90	8.4	95	8.0	17	90	8.9	95	8.4
18	90	8.9	95	8.5	18	90	9.4	95	8.9
19	90	9.4	95	8.9	19	90	9.9	95	9.4
20	95	9.4	105	8.5	20	95	9.9	105	8.9
21	95	9.9	105	8.9	21	95	10.4	105	9.4
22	95	10.3	105	9.3	22	95	10.9	105	9.8

Minimum radii of curvature for steel strip duct – $\mathbf{p_{R,\,max}}$ **= 200 kN/m**

Strand Y1770S7, f_{pk} = 1 770 N/mm²					Strand Y1860S7, f_{pk} = 1 860 N/mm²				
Number of strands	Duct I	Min. radius of curvature	Duct II	Min. radius of curvature	Number of strands	Duct I	Min. radius of curvature	Duct II	Min. radius of curvature
n	∅ d_i	R_{min}	∅ d_i	R_{min}	n	∅ d_i	R_{min}	∅ 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
2	40	2.0	45	2.0	2	40	2.0	45	2.0
3	40	2.7	45	2.3	3	40	2.8	45	2.3
4	45	2.7	50	2.5	4	45	2.8	50	2.7
5	50	3.1	55	2.8	5	50	3.3	55	3.0
6	55	3.4	60	3.1	6	55	3.6	60	3.3
7	55	4.0	60	3.6	7	55	4.2	60	3.8
8	65	3.8	70	3.6	8	65	4.0	70	3.8
9	65	4.3	70	4.0	9	65	4.5	70	4.2
10	75	4.2	80	3.9	10	75	4.4	80	4.1
11	75	4.6	80	4.3	11	75	4.8	80	4.5
12	75	5.0	80	4.7	12	75	5.3	80	4.9
13	80	5.1	85	4.8	13	80	5.3	85	5.0
14	80	5.5	85	5.1	14	80	5.7	85	5.4
15	80	5.9	85	5.5	15	80	6.2	85	5.8
16	90	5.6	95	5.3	16	90	5.8	95	5.5
17	90	5.9	95	5.6	17	90	6.2	95	5.9
18	90	6.2	95	5.9	18	90	6.6	95	6.2
19	90	6.6	95	6.2	19	90	6.9	95	6.6
20	95	6.6	105	5.9	20	95	6.9	105	6.3
21	95	6.9	105	6.2	21	95	7.3	105	6.6
22	95	7.2	105	6.5	22	95	7.6	105	6.9

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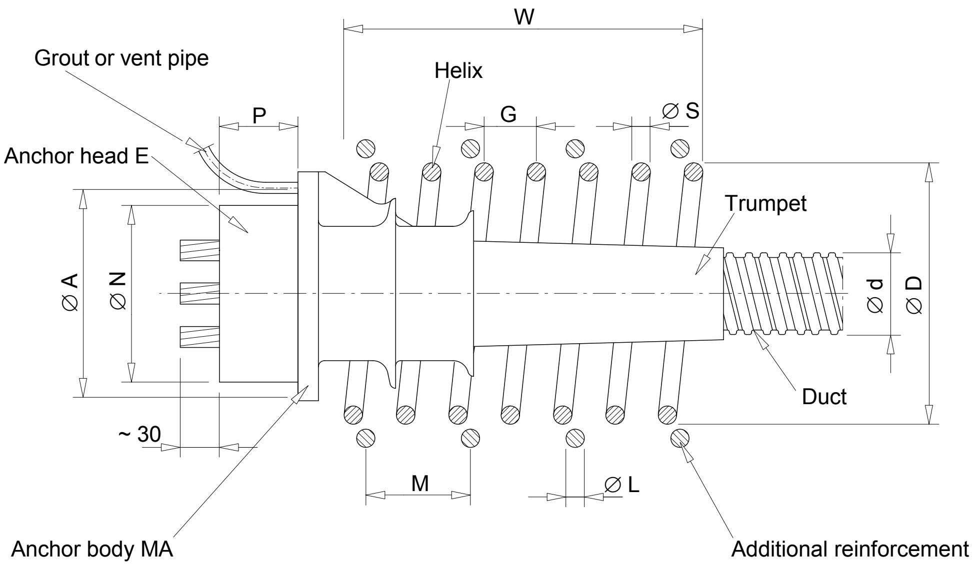
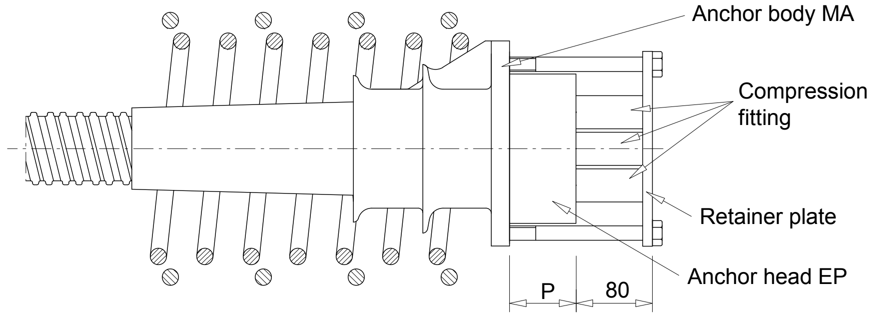
Stressing anchor MA



Fixed anchor MP

Other dimensions as per stressing anchor MA

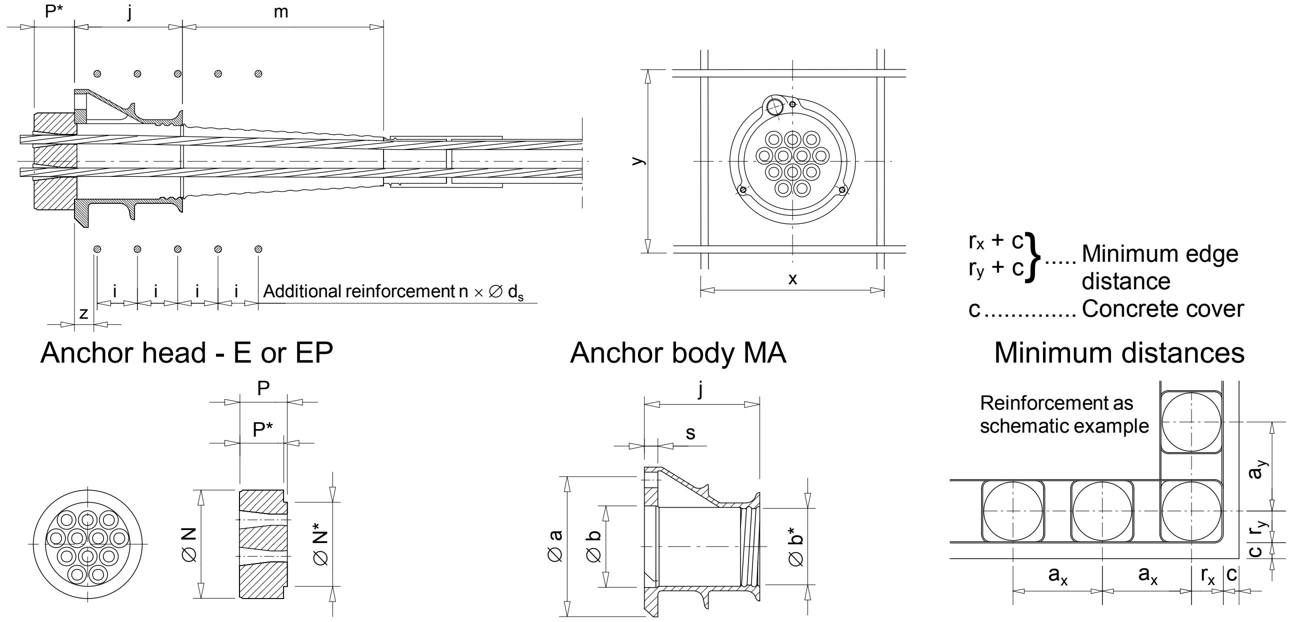


Dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Stressing anchor MA and fixed anchor MP	**Annex 9** of European Technical Assessment **ETA-13/0839** of 11.12.2017

OIB Member of EOTA

Multi-plane anchorage MA with additional reinforcement and without helix
6-5 to 6-22, strand Y1770S7 15.7 and strand Y1860S7 15.7



Tendon		6-5	6-7	6-9	6-12	6-15	6-19	6-22
Number of strands		5	7	9	12	15	19	22
Strand arrangement								
Anchor head	∅ N	135	135	155	170	190	200	220
	∅ N*	88	96	112	128	148	159	176
thickness	P	60	60	65	75	85	95	100
depth	P*	56.5	56.5	61.5	71.5	81.5	91.5	96.5
Anchor body MA	∅ a	150	170	190	220	250	280	305
	∅ b	90	98	114	130	150	162	179
	∅ 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

Tendon		6-5			6-7			6-9			6-12			6-15			6-19			6-22		
Minimum concrete compressive strength at time of stressing																						
$f_{cm, 0, cube}$	N/mm²	**34**	**44**	**54**	**34**	**44**	**54**	**34**	**44**	**54**	**34**	**44**	**54**	**34**	**44**	**54**	**34**	**44**	**54**	**34**	**44**	**54**
$f_{cm, 0, cyl}$	N/mm²	**28**	**35**	**43**	**28**	**35**	**43**	**28**	**35**	**43**	**28**	**35**	**43**	**28**	**35**	**43**	**28**	**35**	**43**	**28**	**35**	**43**
Centre distance	a_x, a_y	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) [1]	r_x, r_y	120	105	95	140	125	110	160	140	130	180	160	145	205	180	165	230	200	185	245	215	195
Additional reinforcement, ribbed reinforcing steel $R_e \geq 500$ N/mm²																						
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	∅ d_s	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	I	50	50	50	50	50	50	50	50	50	45	50	50	55	45	45	55	55	50	50	50	50
External dimensions [2]	x, y	240	205	175	280	235	195	305	260	225	320	295	260	380	335	300	410	370	350	430	390	360

[1] c … concrete cover
[2] The external dimensions x, y have to be met exactly.

Dimensions in mm

DSI
DYWIDAG-Systems International GmbH
www.dywidag-systems.com

Bonded prestressing system
SUSPA Strand DW

Multi-plane anchorage MA
with additional reinforcement and without helix
Data sheet for tendons 6-5 to 6-22

Annex 10
of European Technical Assessment
ETA-13/0839 of 11.12.2017

OIB
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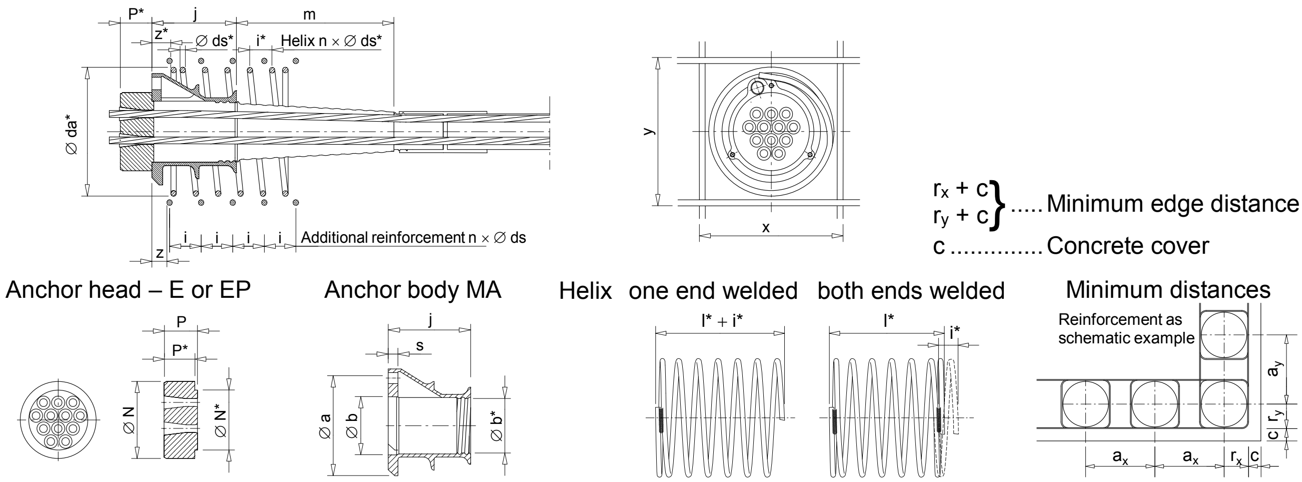
Multi-plane anchorage MA with additional reinforcement and with helix and with minimum centre distances, 6-5 to 6-22, strand Y1770S7 15.7 and strand Y1860S7 15.7



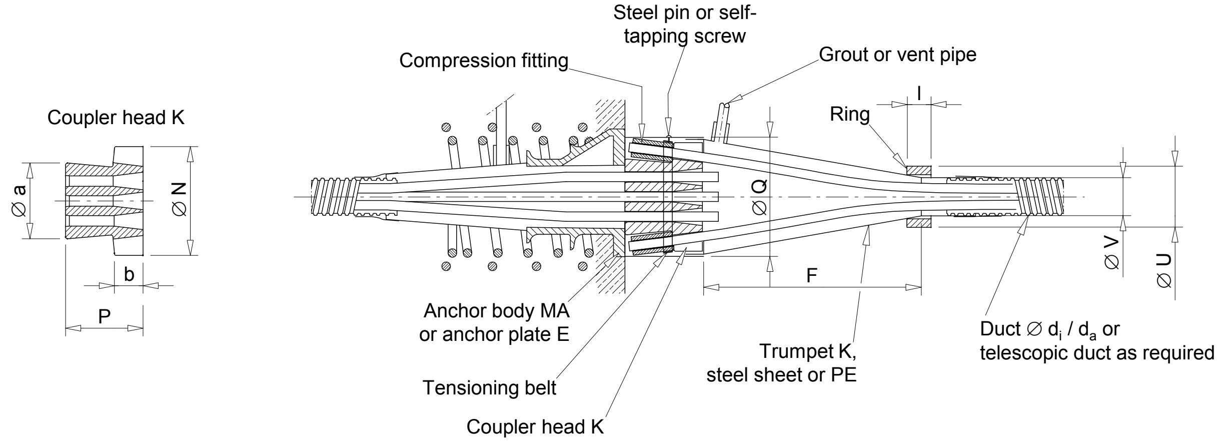
Tendon		6-5	6-7	6-9	6-12	6-15	6-19	6-22
Number of strands		5	7	9	12	15	19	22
Strand arrangement								
Anchor head	∅ N	135	135	155	170	190	200	220
	∅ N*	88	96	112	128	148	159	176
thickness	P	60	60	65	75	85	95	100
depth	P*	56.5	56.5	61.5	71.5	81.5	91.5	96.5
Anchor body MA	∅ a	150	170	190	220	250	280	305
	∅ b	90	98	114	130	150	162	179
	∅ 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								
$f_{cm, 0, cube}$	N/mm²	**25 34 45**	**25 34 45**	**25 34 45**	**25 34 45**	**25 34 45**	**25 34 45**	**25 34 45**
$f_{cm, 0, cyl}$	N/mm²	**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) [1]	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	∅ d_s*	12 12 12	14 14 14	14 14 14	14 14 14	16 14 14	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	∅ 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/mm²								
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	∅ 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	35 35 35	35 35 35	35 35 35	40 40 40	40 40 40	40 40 40	45 45 45
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

[1] c … concrete cover

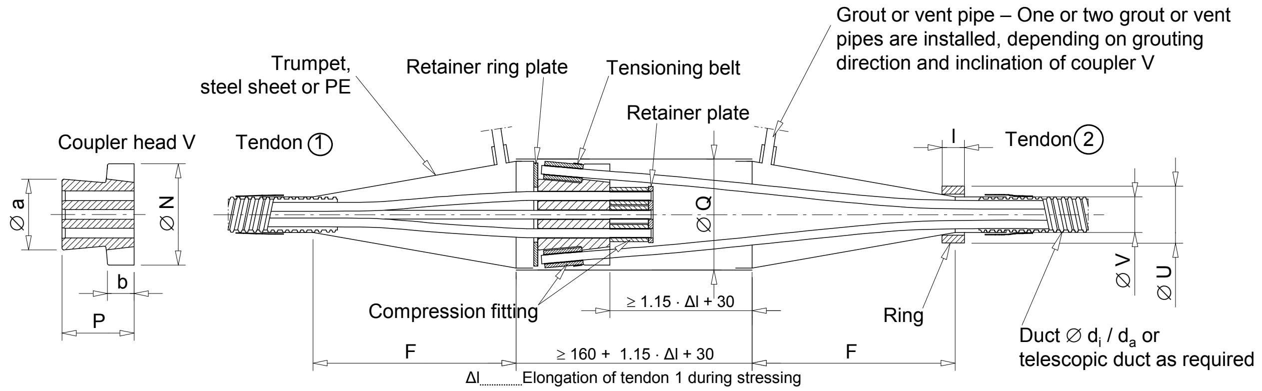
Dimensions in mm

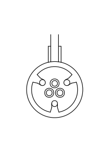
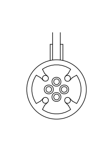
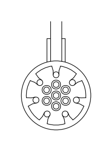
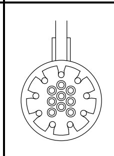
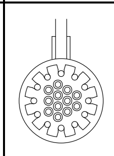
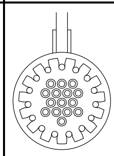
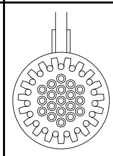
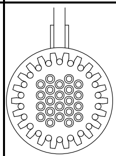
Coupler K and V 6-3 to 6-22 – Strand Y1770S7 15.7 and strand Y1860S7 15.7

Fixed coupler K – Tendons 6-7 to 2-22 with anchor body MA and 6-3 to 6-22 with anchor plate



Movable coupler V – Tendons 6-3 to 6-22 – Position of coupler head V prior to stressing



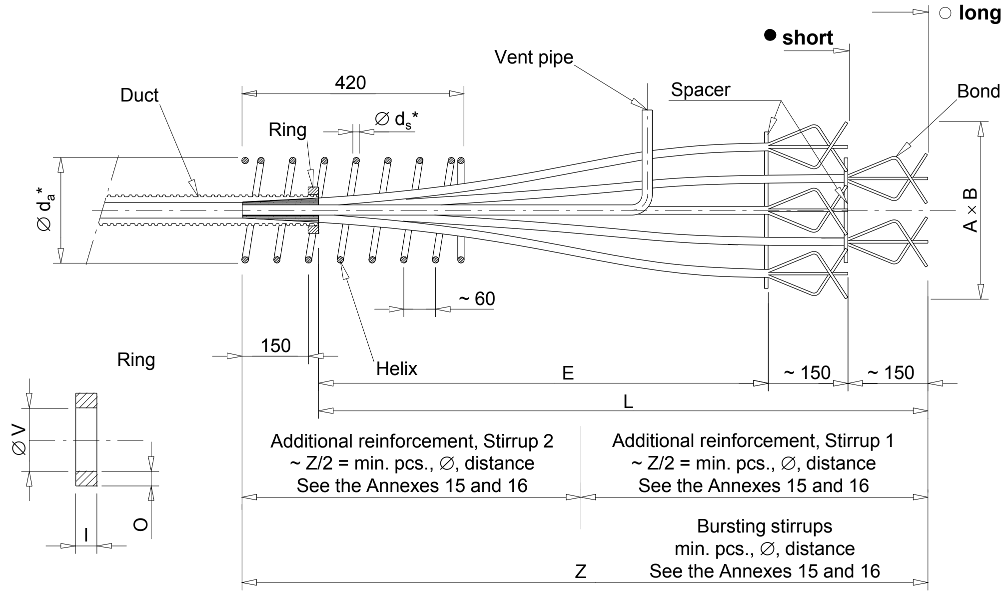
Tendon		**6-3**	**6-4**	**6-7**	**6-9**	**6-12**	**6-15**	**6-19**	**6-22**
Number of strands		3	4	7	9	12	15	19	22
Strand arrangement									
Coupler head	∅ N	140	150	180	210	220	260	260	290
	∅ a	86	96	126	156	166	206	206	236
	P	128	128	128	128	128	128	128	128
	b	50	50	50	50	50	50	50	50
Friction loss in movable coupler V		1.8 %	2.0 %	1.8 %	1.7 %	1.7 %	1.7 %	1.7 %	1.6 %
Trumpet	F	250	280	370	410	460	570	570	640
	∅ Q	150	160	190	230	240	280	280	310
Ring	∅ V	55	60	73	82	92	97	109	122
	l	30	30	40	40	40	50	50	50
	∅ U	70	80	101	110	127	140	159	171
Duct	Duct I ∅ d_i / d_a	40/47	45/52	55/62	65/72	75/82	80/87	90/97	95/102
	Duct II ∅ d_i / d_a	45/52	50/57	60/67	70/77	80/87	85/92	95/102	105/112

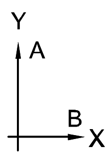
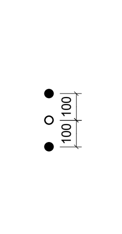
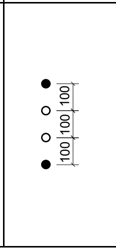
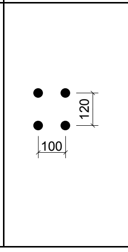
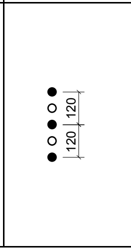
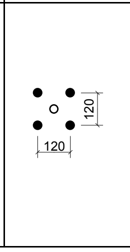
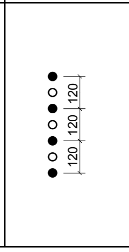
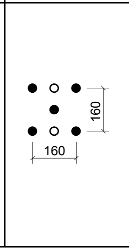
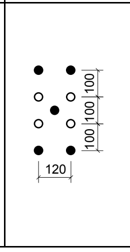
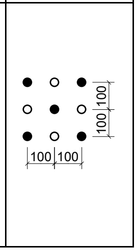
Dimensions in mm

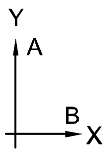
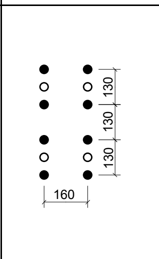
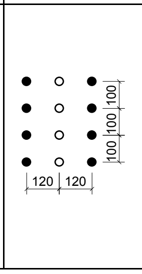
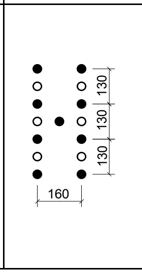
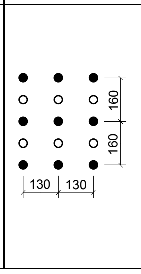
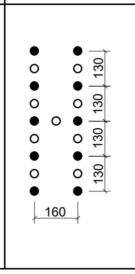
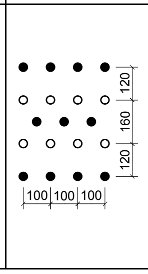
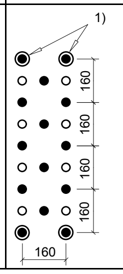
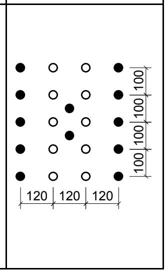
Member of EOTA

Bond anchorage H 6-3 to 6-22

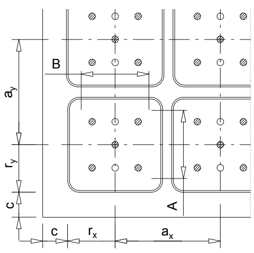
for $f_{cm,\,0,\,cube} \geq 34$ N/mm² or $f_{cm,\,0,\,cyl} \geq 28$ N/mm²



Tendon	6-3	6-4		6-5		6-7		6-9	
Format	HL	HL	HR	HL	HR	HL	HR	HL	HR
Elevation anchorage 									

Tendon	6-12		6-15		6-19		6-22	
Format	HL	HL	HL	HR	HL	HR	HL	HR
Elevation anchorage 								

Key
○.................Position long
●.................Position short
◉ ....3rd position 1)
r_x + c }
r_y + c } ....Minimum edge distance
c.................Concrete cover



1) 3rd position see Annex 14

Reinforcement as schematic example

Dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system SUSPA Strand DW** Bond anchorage H Strand arrangement – Helix	**Annex 13** of European Technical Assessment **ETA-13/0839** of 11.12.2017

OiB
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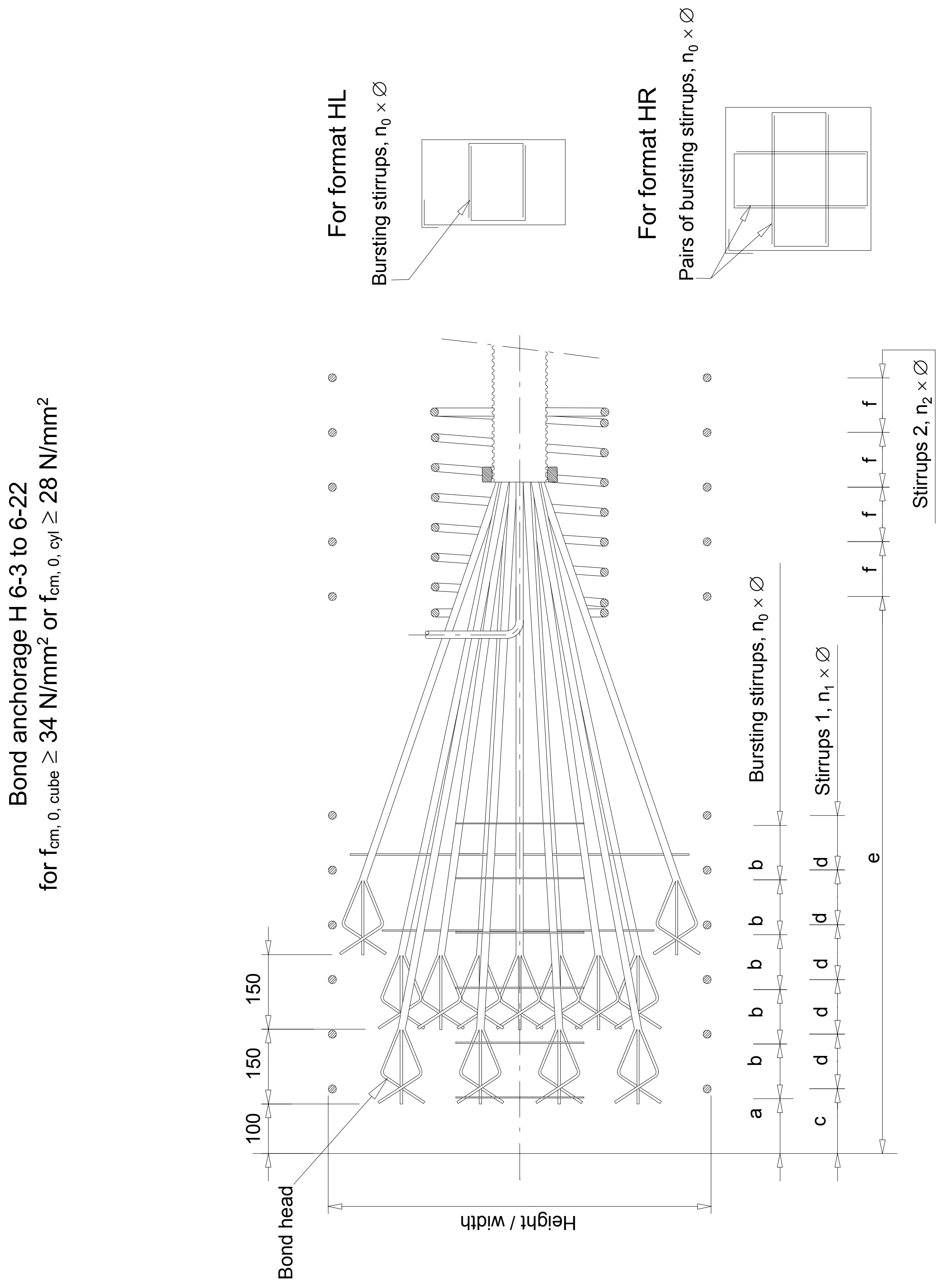

Dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Bond anchorage H Stirrup reinforcement	**Annex 14** of European Technical Assessment **ETA-13/0839** of 11.12.2017

Bond anchorage H 6-3 to 6-9 for $f_{cm,\,0,\,cube} \geq 34$ N/mm^2 or $f_{cm,\,0,\,cyl} \geq 28$ N/mm^2
strand Y1770S7 15.7 and strand Y1860S7 15.7

For layout see the Annexes 13 and 14.

Tendon		**6-3**	**6-4**		**6-5**		**6-7**		**6-9**	
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	∅ d_a*	—	—	—	160	160	180	180	230	230
	∅ d_s*	—	—	—	12	12	12	12	14	14
Ring	∅ V	Duct outer diameter + ~ 3 mm								
	O	11	14	14	14	14	14	14	14	14
	I	20	20	20	20	20	30	30	30	30
Minimum centre and edge distance	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
	r_y	180	205	135	210	145	240	160	240	180
Bursting stirrups [1]	a	100	100	—	100	—	100	—	100	100
	b	80	80	—	80	—	83	—	90	100
	n_0	6	6	—	6	—	6	—	6	5
	∅	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
	∅	12	12	12	12	12	12	12	14	14
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
	∅	12	12	12	12	12	12	12	14	14
Width		160	170	265	190	285	210	320	260	355
Height		360	410	265	420	285	480	320	480	355

[1] Crosswise installation of bursting reinforcement for fixed anchorage HR according to Annex 14

Dimensions in mm

Member of EOTA

Bond anchorage H 6-12 to 6-22 for $f_{cm,\,0,\,cube} \geq 34$ N/mm² or $f_{cm,\,0,\,cyl} \geq 28$ N/mm²
strand Y1770S7 15.7 and strand Y1860S7 15.7

For layout see the Annexes 13 and 14.

Tendon		**6-12**		**6-15**		**6-19**		**6-22**	
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	∅ d_a*	250	250	295	295	330	330	360	360
	∅ d_s*	14	14	16	16	16	16	16	16
Ring	∅ 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
	∅	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
	∅	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
	∅	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 anchorage HR according to Annex 14
2) Bond head in 3rd position

Dimensions in mm

DSI
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www.dywidag-systems.com

Bonded prestressing system
SUSPA Strand DW

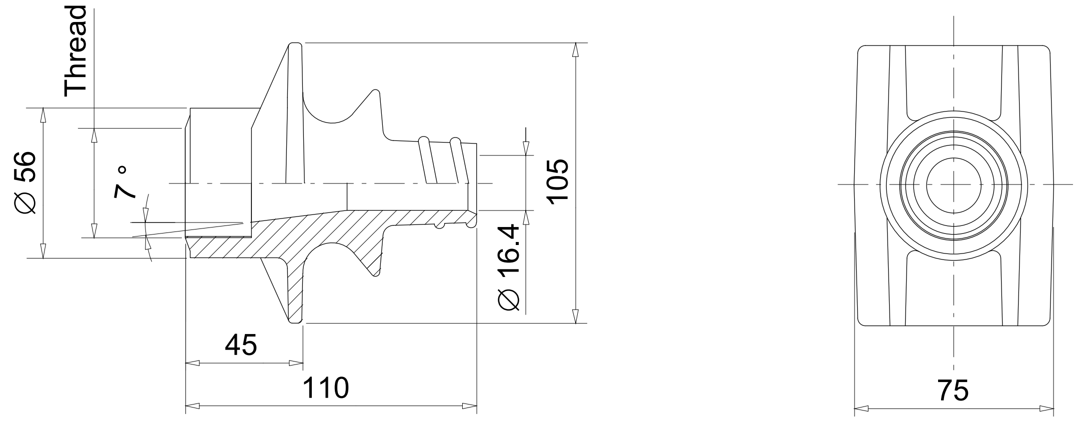
Bond anchorage H
Data sheet for tendons 6-12 to 6-22

Annex 16
of European Technical Assessment
ETA-13/0839 of 11.12.2017

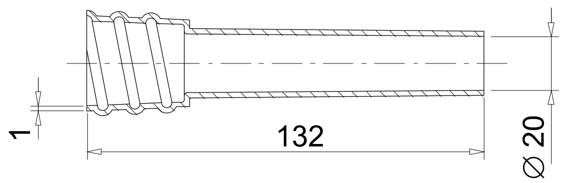
OiB
Member of EOTA

Single strand anchorage SK6

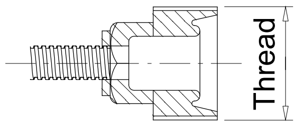
Anchor SK6



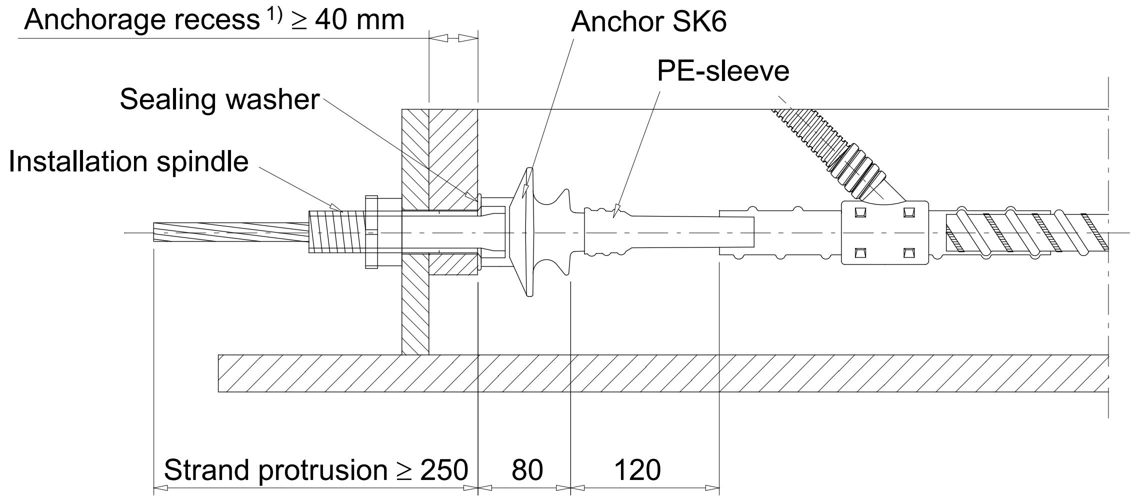
PE-sleeve



Venting cap



Stressing anchor SK6 – Assembly state



1) Concrete cover on venting cap ≥ 25 mm

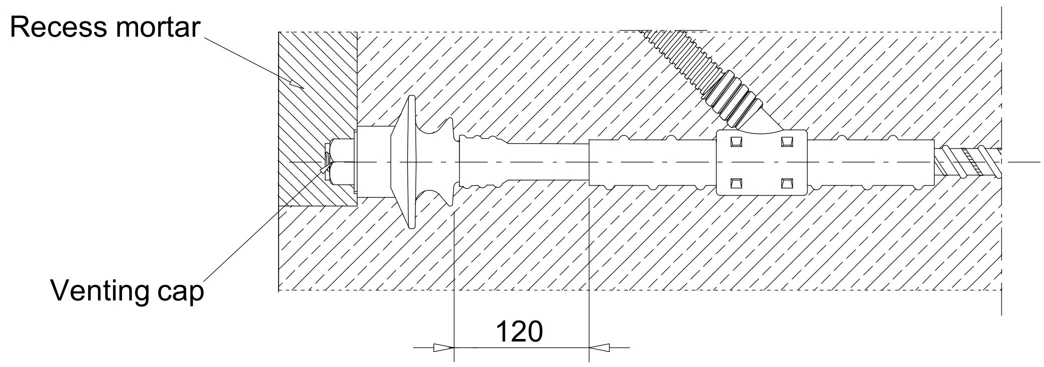
Dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Single strand anchorage SK6 Basic components and assembly	**Annex 17** of European Technical Assessment **ETA-13/0839** of 11.12.2017

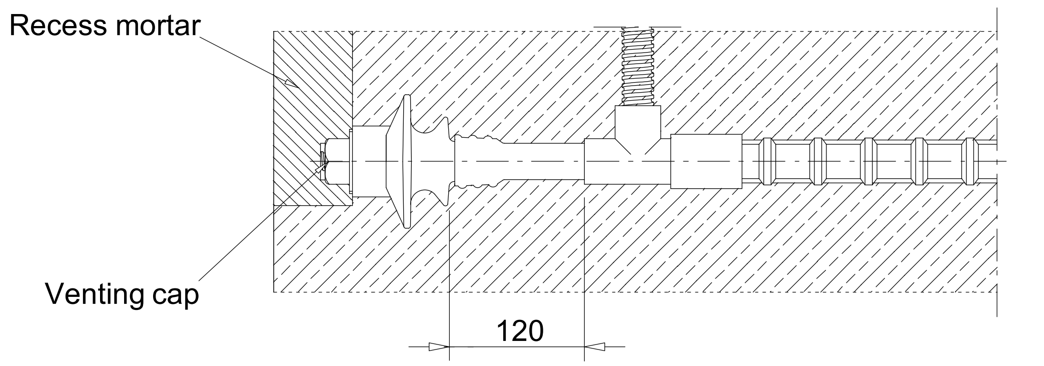
Member of EOTA

Single strand anchorage SK6

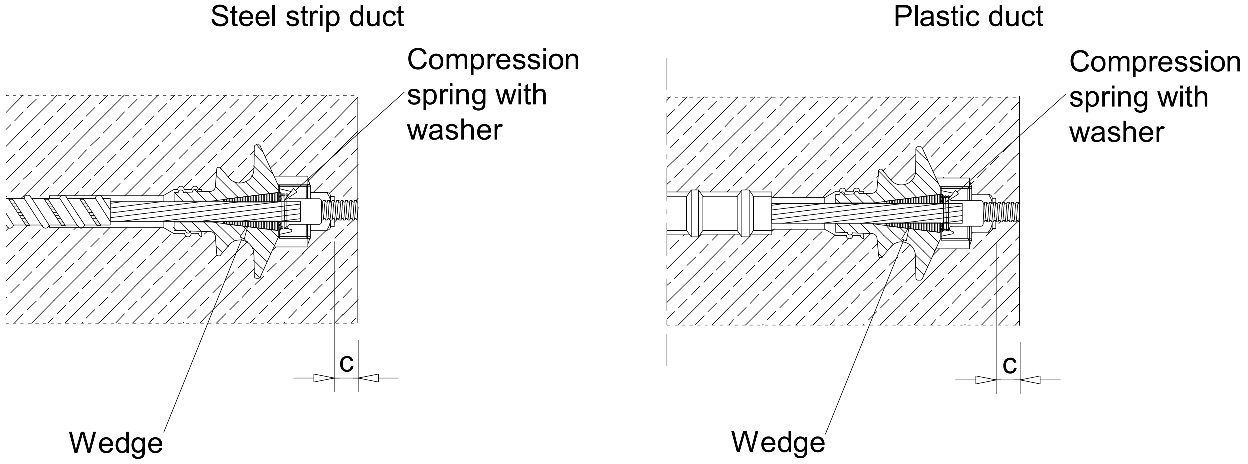
Stressing anchor SK6 after prestressing – Steel strip duct



Stressing anchor SK6 after prestressing – Plastic duct
Sealing of joints to duct with heat shrinking sleeves



Fixed anchor SK6 grouted



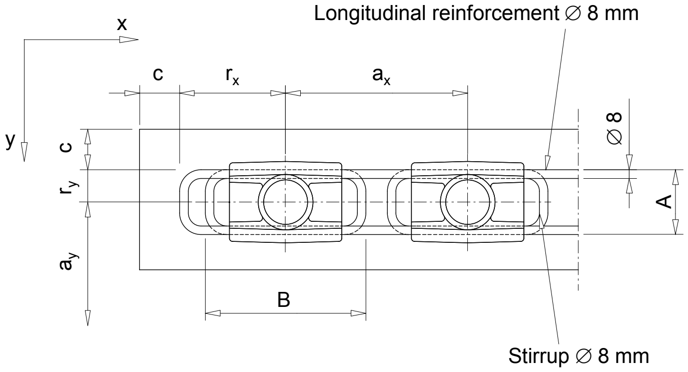
c..... Concrete cover on venting cap ≥ 25 mm

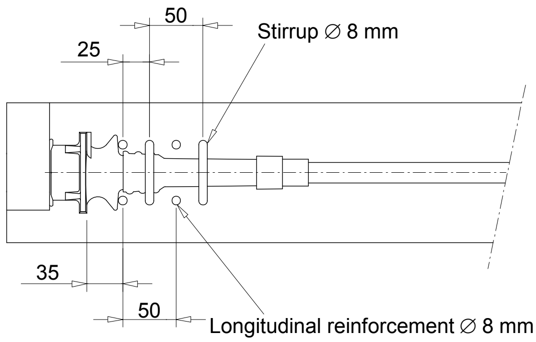
Dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Single strand anchorage SK6 Stressing and fixed anchor	**Annex 18** of European Technical Assessment **ETA-13/0839** of 11.12.2017

OiB Member of EOTA

Single strand anchorage SK6
strand Y1770S7 15.7 and strand Y1860S7 15.7
minimum centre and edge distances



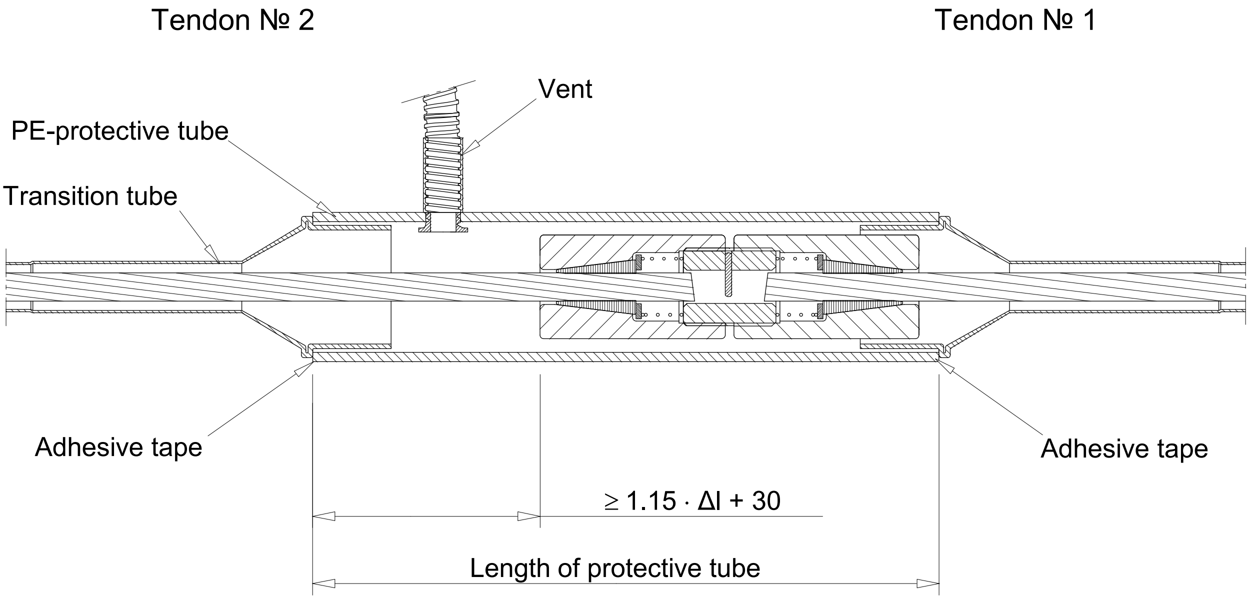


a_x, a_y .... Minimum centre distance
$r_x + c$, $r_y + c$ .... Minimum edge distance
c .... Concrete cover

Minimum concrete strength at time of stressing	$f_{cm,\,0,\,cube}$	N/mm²	20	28	36
	$f_{cm,\,0,\,cyl}$	N/mm²	16	23	29
Minimum centre distance		a_x	210	190	170
		a_y	120	105	90
Minimum edge distance		r_x	120	110	100
		r_y	50	45	35
Additional reinforcement, ribbed reinforcing steel, $R_e \geq 500$ N/mm²					
Minimum number of longitudinal reinforcement, ∅ 8 mm, per side			2	2	2
Minimum number of stirrups ∅ 8 mm			2	2	2
Minimum height		A	100	85	70
Minimum width		B	190	170	150
Friction loss in stressing anchorage are low and do not have to be considered in design and execution.					

Dimensions in mm

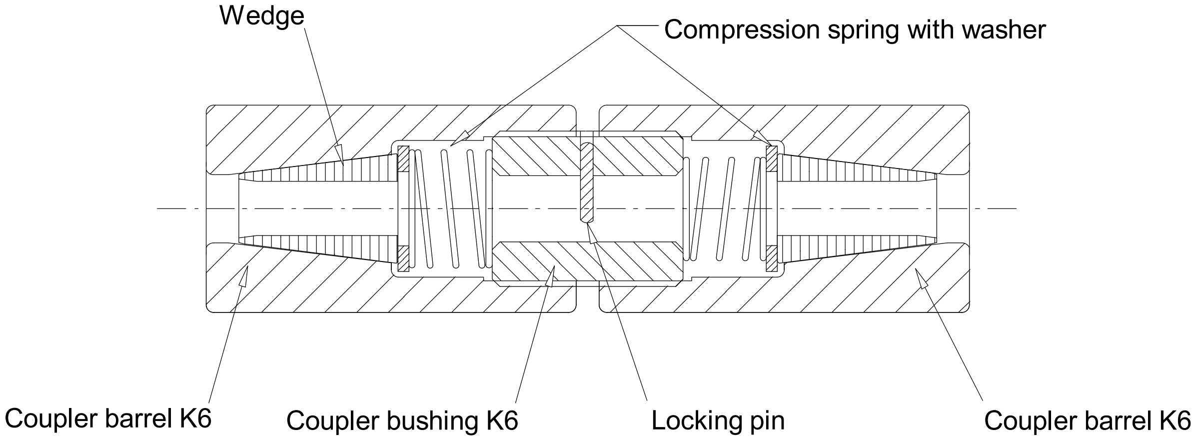
Movable coupler K6-K6
strand Y1770S7 15.7 and strand Y1860S7 15.7



Δl........Elongation of tendon 1 during stressing

Minimum engagement length of coupler cushing: 20 mm on both sides

Coupler K6-K6 – Condition as delivered



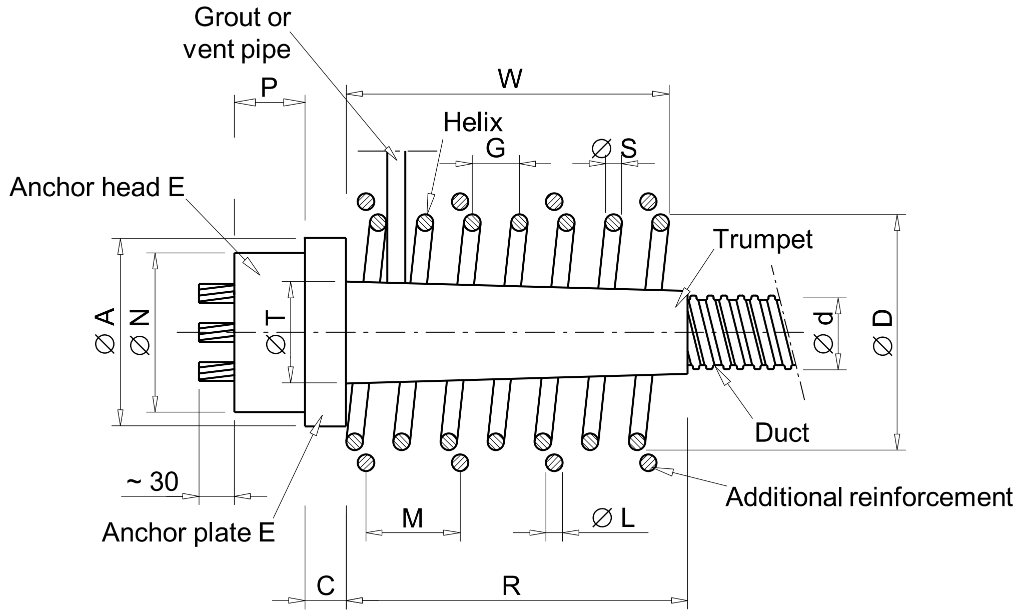
Friction losses in movable coupler K6-K6 during stressing are low and do not have to be considered in design and execution.

Dimensions in mm

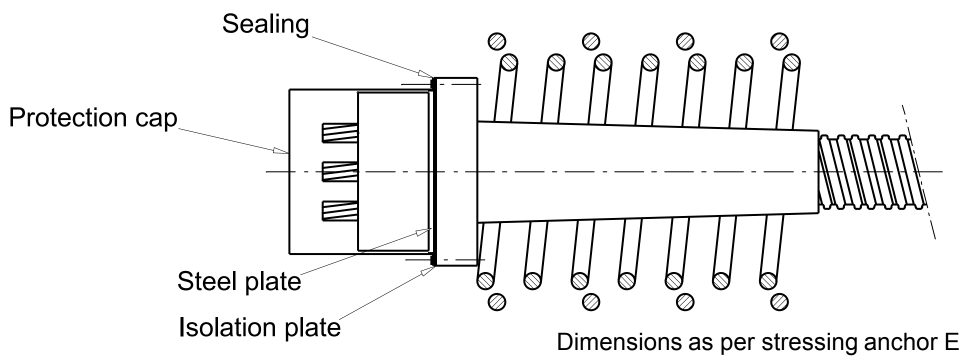
DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Single strand coupler K6-K6	**Annex 20** of European Technical Assessment **ETA-13/0839** of 11.12.2017

Member of EOTA

Stressing anchor E

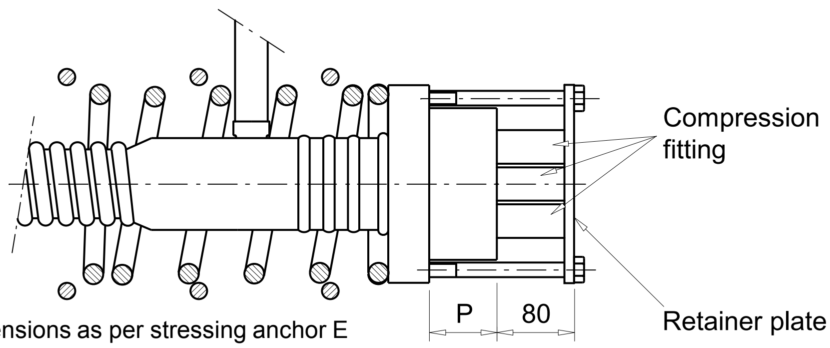


Electrically isolated stressing anchor E



Dimensions as per stressing anchor E

Fixed anchor EP



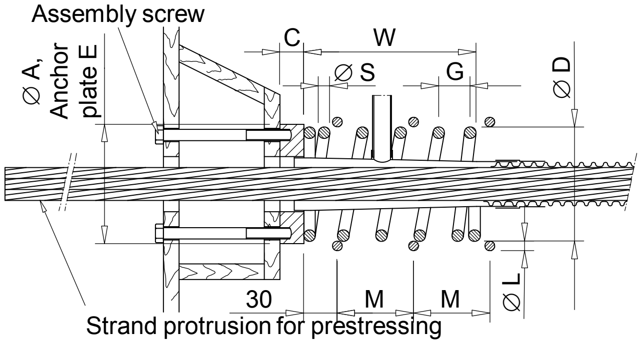
Other dimensions as per stressing anchor E

Dimensions in mm

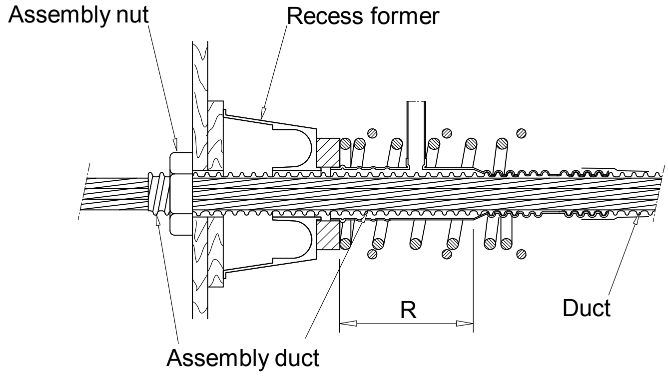
DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Anchor E and EP Electrically isolated stressing anchor E	**Annex 21** of European Technical Assessment **ETA-13/0839** of 11.12.2017

Assembly overview
Stressing anchor E

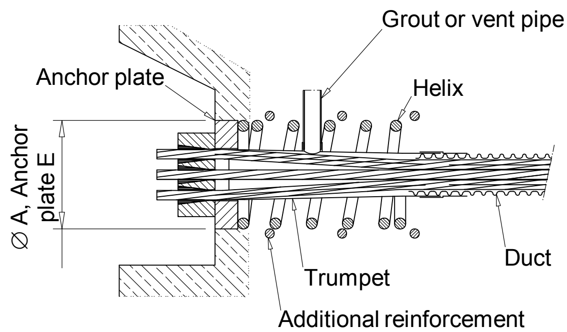
(a) Fastening the bearing plate with assembly screws
Assembly condition

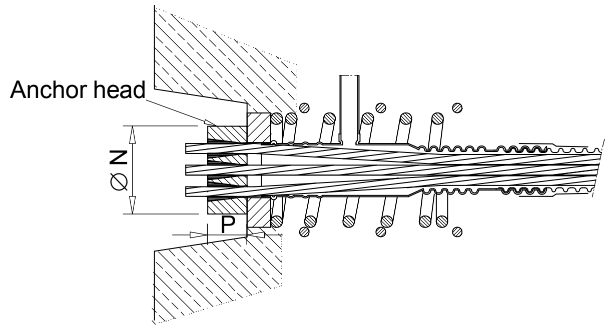


(b) Fastening the bearing plate with assembly duct and recess formerr
Assembly condition 6-3 to 6-5



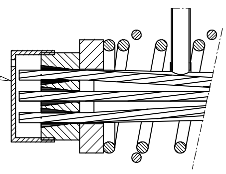
(a) and (b) after stressing





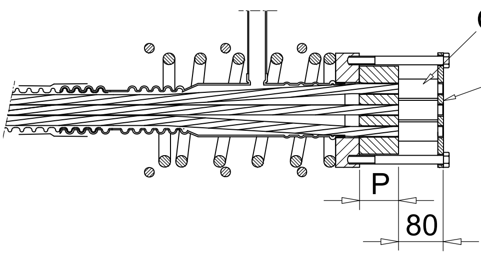
(a) and (b) with screwed on protection cap

Screwed protection cap for grouting



Fixed anchor EP

With compression fittings
Assembly and after stressing



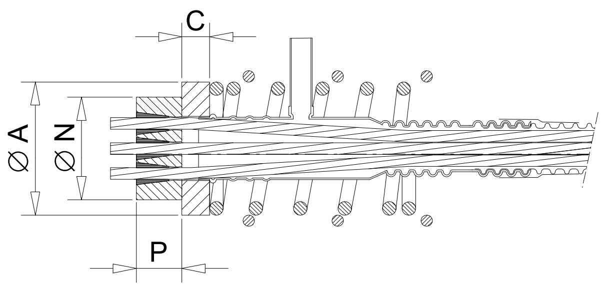
Other dimensions as per stressing anchor E

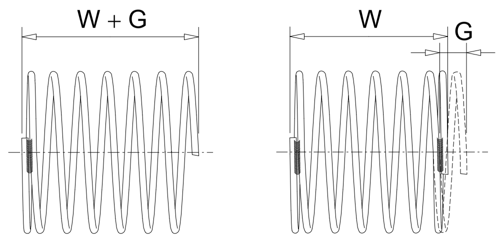
Dimensions in mm

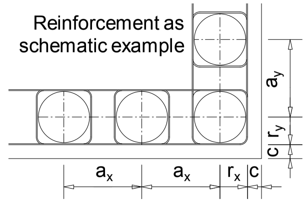
DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	**Bonded prestressing system** **SUSPA Strand DW** Assembly – Overview	**Annex 22** of European Technical Assessment **ETA-13/0839** of 11.12.2017

Member of EOTA

Stressing anchor E-6 to E-22 and fixed anchor EP 6-3 to 6-22
Strand Y1770S7 15.7







r_x + c, r_y + c ..... Minimum edge distance
c .... Concrete cover

Tendon		6-3	6-4	6-5	6-7	6-9	6-12	6-15	6-19	6-22
Number of strands		3	4	5	7	9	12	15	19	22
Strand arrangement										
Anchor head diameter	Ø N	95	110	135	135	155	170	190	200	220
Thickness	P	50	55	60	60	65	75	85	95	100
Trumpet length	R	160	170	290	290	460	460	650	650	750
Duct — Duct I	Ø d_i / d_a	40/47	45/52	50/57	55/62	65/72	75/82	80/87	90/97	95/102
Duct — Duct II	Ø d_i / d_a	45/52	50/57	55/62	60/67	70/77	80/87	85/92	95/102	105/112

For strand Y1770S7, nominal diameter 15.7 mm

Tendon		6-3			6-4			6-5			6-7			6-9			6-12			6-15			6-19			6-22		
Minimum concrete compressive strength at time of stressing																												
$f_{cm,0,cube}$	**N/mm²**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**
$f_{cm,0,cyl}$	**N/mm²**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**
Minimum centre distance	a_x, a_y	215	195	—	245	220	205	270	245	225	315	280	260	360	325	300	410	370	345	455	410	380	515	460	425	560	500	465
Min. edge distance (+c)	r_x, r_y	100	90	—	115	100	95	125	115	105	150	130	120	170	155	140	195	175	165	220	195	180	250	220	205	270	240	225
Anchor plate																												
Diameter	Ø A	150	130	—	170	150	150	190	170	170	230	200	200	260	230	230	290	280	280	330	290	290	380	330	330	420	360	360
Thickness	C	25	20	—	30	25	25	30	25	25	35	30	30	45	40	35	50	45	40	60	55	50	65	60	55	70	65	60
Hole diameter	Ø T	58	58	—	72	72	72	86	86	86	86	86	86	112	112	112	120	120	120	150	150	150	152	152	152	174	174	174
Helix																												
Minimum external diameter	Ø D	150	150	—	180	160	160	185	160	160	240	200	180	270	240	240	315	285	270	350	315	300	390	340	330	470	390	360
Minimum wire diameter	Ø S	12	12	—	12	12	14	14	12	14	14	14	14	14	14	14	16	16	14	16	16	14	16	16	16	16	16	16
Maximum pitch	G	50	50	—	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	55	50	50	50	50	50	50
Minimum length	W	235	235	—	285	235	240	290	285	240	340	290	290	390	340	340	395	345	340	445	395	370	445	445	395	495	495	345
Minimum number of turns	H	5	5	—	6	5	5	6	6	5	7	6	6	8	7	7	8	7	7	9	8	7	9	9	8	10	10	7
Additional reinforcement, ribbed reinforcement steel, $R_e \geq 500$ N/mm²																												
Minimum number of layers	K	4	4	—	5	4	4	5	5	4	4	4	4	5	5	5	6	5	5	6	6	6	7	7	6	8	7	7
Minimum bar diameter	Ø L	10	10	—	10	12	12	10	12	12	12	14	14	12	14	14	14	14	14	14	14	16	14	14	16	14	16	16
Maximum spacing	M	70	60	—	60	60	60	60	60	60	80	70	70	80	80	70	80	80	70	80	70	70	80	70	75	75	75	75

Dimensions in mm

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Bonded prestressing system
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Stressing anchor E and fixed anchor EP
Prestressing steel strand Y1770S7, 15.7 mm
Data sheet for tendons 6-3 to 6-22

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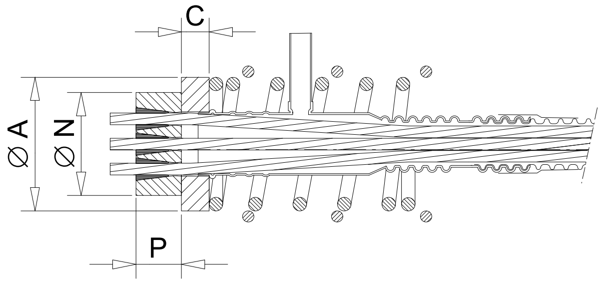
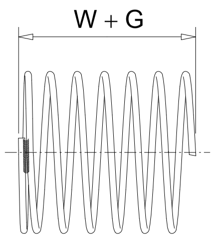
of European Technical Assessment
ETA-13/0839 of 11.12.2017

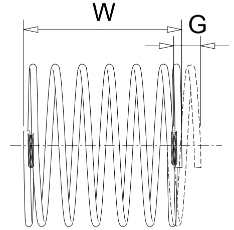
Stressing anchor E-6 to E-22 and fixed anchor EP 6-3 to 6-22
Strand Y1860S7 15.7

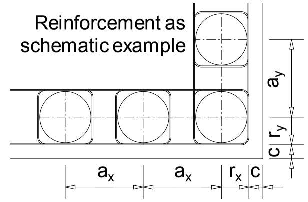


Helix
One end welded



Helix
Both ends welded





$r_x + c$, $r_y + c$ .... Minimum edge distance
c.............. Concrete cover

Tendon		6-3	6-4	6-5	6-7	6-9	6-12	6-15	6-19	6-22
Number of strands		3	4	5	7	9	12	15	19	22
Strand arrangement										
Anchor head diameter	Ø N	95	110	135	135	155	170	190	200	220
Thickness	P	50	55	60	60	65	75	85	95	100
Trumpet length	R	160	170	290	290	460	460	650	650	750
Duct I	Ø d_i / d_a	40/47	45/52	50/57	55/62	65/72	75/82	80/87	90/97	95/102
Duct II	Ø d_i / d_a	45/52	50/57	55/62	60/67	70/77	80/87	85/92	95/102	105/112

For strand Y1860S7, nominal diameter 15.7 mm

		6-3			6-4			6-5			6-7			6-9			6-12			6-15			6-19			6-22		
Minimum concrete compressive strength at time of stressing																												
$f_{cm, 0, cube}$	**N/mm²**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**
$f_{cm, 0, cyl}$	**N/mm²**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**
Minimum centre distance	a_x, a_y	225	205	185	250	230	210	275	255	235	320	295	270	365	335	305	415	385	350	465	425	390	520	480	440	555	515	475
Min. edge distance (+c)	r_x, r_y	105	95	85	115	105	95	130	120	110	150	140	125	175	160	145	200	185	165	225	205	185	250	230	210	270	250	230
Anchor plate																												
Diameter	Ø A	155	155	155	175	165	165	200	185	185	235	205	205	260	230	230	295	265	265	330	300	300	380	330	330	420	360	360
Thickness	C	25	25	25	30	30	30	30	30	30	40	40	40	45	40	40	50	50	50	60	55	50	65	60	55	70	65	60
Hole diameter	Ø T	58	58	58	72	72	72	86	86	86	86	86	86	112	112	112	120	120	120	150	150	150	152	152	152	174	174	174
Helix																												
Minimum external diameter	Ø D	160	150	140	180	170	160	200	190	180	245	230	220	280	255	240	330	305	270	375	345	300	430	400	330	470	435	360
Minimum wire diameter	Ø S	12	12	12	12	12	14	12	12	14	14	14	14	14	14	14	16	16	14	16	16	16	16	16	16	16	16	16
Maximum pitch	G	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Minimum length	W	235	235	235	285	235	240	285	285	240	390	290	340	390	340	340	395	345	340	445	395	345	445	445	395	495	495	345
Minimum number of turns	H	5	5	5	6	5	5	6	6	5	8	6	7	8	7	7	8	7	7	9	8	7	9	9	8	10	10	7
Additional reinforcement, ribbed reinforcement steel, $R_e \geq 500$ N/mm²																												
Minimum number of layers	K	4	4	4	5	4	4	5	4	4	4	4	4	5	5	5	6	5	5	6	6	6	7	7	6	8	7	7
Minimum bar diameter	Ø L	10	10	12	10	12	12	10	12	12	12	14	14	12	14	14	14	16	16	14	16	16	14	16	16	14	16	16
Maximum spacing	M	70	60	60	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70

Dimensions in mm

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Bonded prestressing system
SUSPA Strand DW

Stressing anchor E and fixed anchor EP
Prestressing steel strand Y1860S7, 15.7 mm
Data sheet for tendons 6-3 to 6-22

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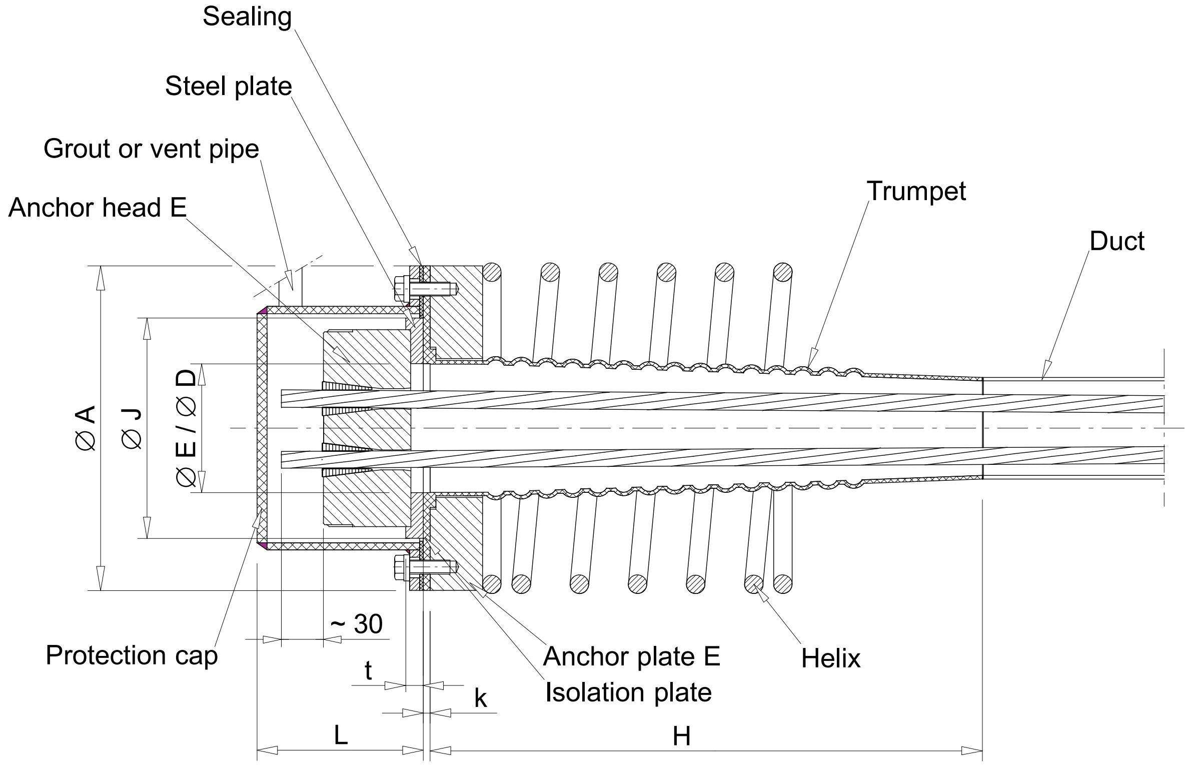
Electrically isolated anchorage, 6-3 to 6-22
Strand Y1770S7 15.7 and strand Y1860S7 15.7



Helix and additional reinforcement according to Annex 23 and Annex 24

Tendon		**6-3**	**6-4**	**6-5**	**6-7**	**6-9**	**6-12**	**6-15**	**6-19**	**6-22**
Number of strands		3	4	5	7	9	12	15	19	22
Strand arrangement										
Steel plate										
Diameter	∅ J	100	110	145	145	160	185	210	225	250
Thickness	t	15	15	15	15	15	15	15	20	25
Hole diameter	∅ E	59	66	83	83	112	115	144	150	170
Trumpet length	H	170	185	298	300	470	470	660	660	760
For strand Y1770S7 15.7 and strand Y1860S7 15.7										
Isolation plate										
Diameter	∅ A	130	150	170	200	230	265	290	330	360
Thickness	k	6	6	6	6	6	6	6	6	6
Hole diameter	∅ D	59	66	83	83	112	115	144	150	170

Dimensions in mm

OiB
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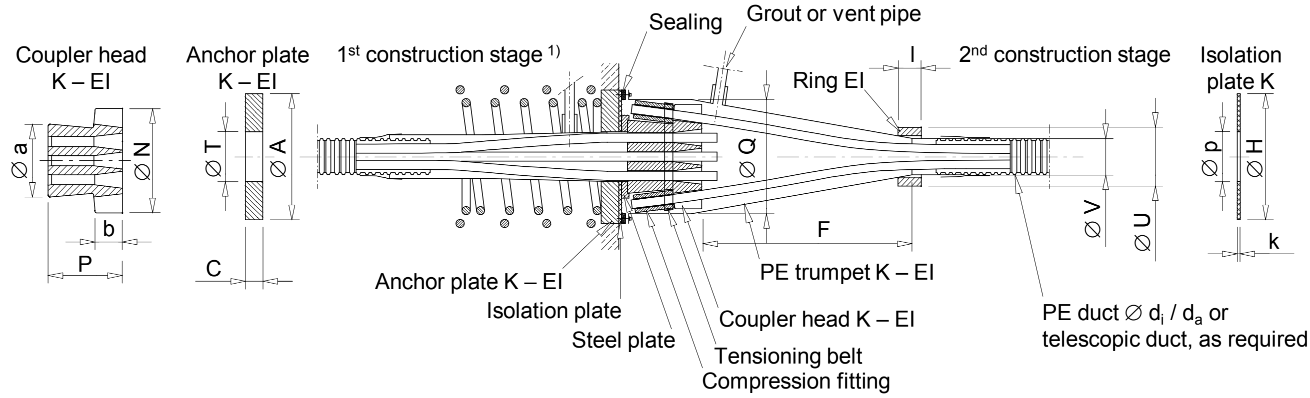
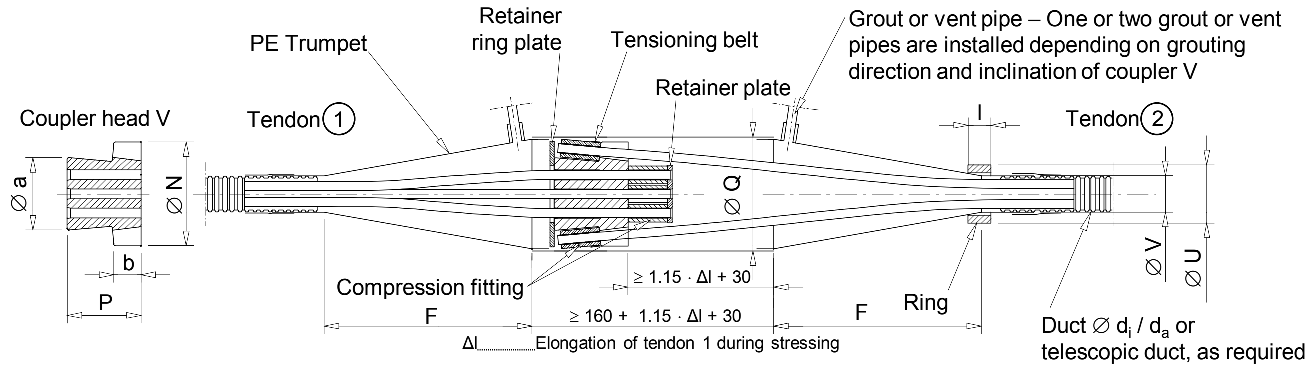
Coupler K – EI and V – EI – Strand Y1770S7 15.7 and strand Y1860S7 15.7

Fixed coupler K – EI – Tendons 6-7 to 6-22



Movable coupler V – EI – Coupler position prior to stressing – Tendons 6-3 to 6-22, see Annex 12



Tendon			**6-7**			**6-9**			**6-12**			**6-15**			**6-19**			**6-22**		
Number of strands 2)			7			9			12			15			19			22		
Coupler head K - EI		Ø N	180			210			220			260			260			290		
		Ø a	126			156			166			190			200			220		
	Height	P	128			128			128			128			128			128		
	Thickness	b	50			50			50			50			50			50		
Trumpet		F	410			470			520			670			670			780		
		Ø Q	205			245			245			285			285			315		
Minimum concrete compressive strength at time of stressing																				
	$f_{cm,0,cube}$	N/mm²	**25**	**34**	**45**	**25**	**34**	**45**	**25**	**34**	**45**	**25**	**34**	**45**	**25**	**34**	**45**	**25**	**34**	**45**
	$f_{cm,0,cyl}$	N/mm²	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**	**20**	**28**	**36**
Anchor plate K - EI	Diameter	Ø A	260	260	260	300	300	300	300	300	300	340	340	340	380	340	340	420	370	370
	Thickness	C	40	40	40	45	40	40	50	50	50	60	55	50	65	60	55	70	65	60
	Hole diameter	Ø T	86	86	86	112	112	112	120	120	120	152	152	152	152	152	152	174	174	174
Isolation plate K	Diameter	Ø H	260			300			300			340			340			370		
	Thickness	k	6			6			6			6			6			6		
	Hole diameter	Ø p	83			112			115			150			150			170		
Ring EI	Diameter	Ø V	94			114			114			129			129			129		
	Thickness	l	40			40			40			50			50			50		
	Hole diameter	Ø U	130			160			160			175			175			175		

1) Fixed coupler, 1st construction stage, corresponds to electrically isolated stressing anchor E, see Annex 25.
2) For strand arrangement see Annex 12

Dimensions in mm

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Bonded prestressing system
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Electrically isolated couplers K and V
Data sheet for tendons 6-7 to 6-22

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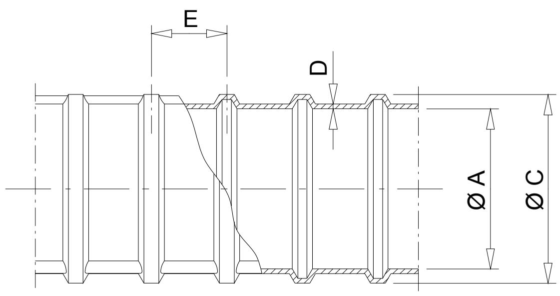
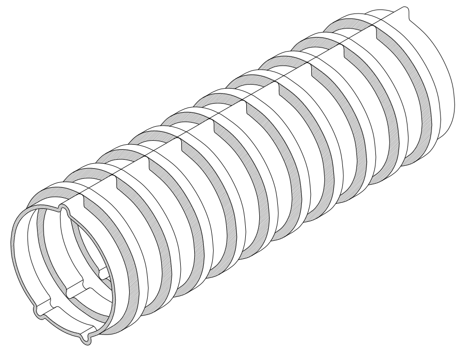
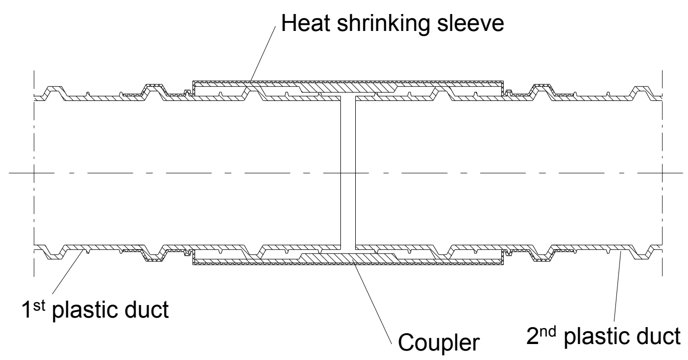




Circular GDP plastic duct			**23**	**48**	**59**	**76**	**85**	**100**
Number of strands ∅ 15.7 mm			1	3, 4, 5	7	9, 12	15	19, 22
Diameter								
inner	∅ A	mm	23.0	48.0	58.5	76.0	85.5	100.0
ribs	∅ C	mm	37.0	59.0	72.5	91.0	100.5	116.0
Wall thickness	D	mm	2.0	2.0	2.0	2.5	2.5	3.0
Rib distance	E	mm	39.5	28.0	42.0	52.5	39.5	39.5
Distance of supports		m	0.6–1.0					1.4
Wobble coefficient	k	rad/m	0.005					
Friction coefficient	μ	rad^{-1}	0.14					

NOTE Dimensions rounded to the closest 0.5 mm.

Coupling situation



Dimensions in mm

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Bonded prestressing system
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Circular GDP plastic duct
Data sheet

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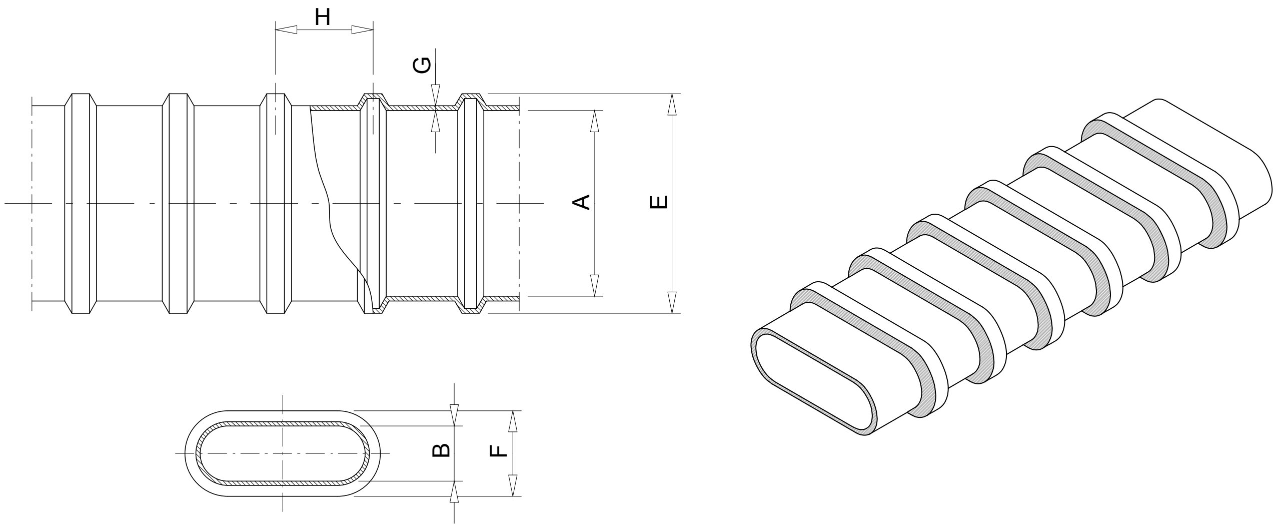
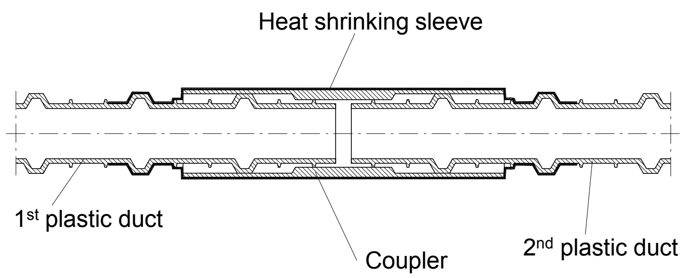


Flat plastic duct			38 × 22	72 × 21	76 × 25	91 × 22
Number of strands ∅ 15.7 mm			2	3	4	5
Dimensions of cross section						
inner	A	mm	37.5	71.0	75.5	91.0
	B	mm	21.5	21.0	25.0	22.0
ribbs	E	mm	52.5	85.5	90.0	105.0
	F	mm	36.5	36.0	40.0	40.0
Wall thickness	G	mm	2.0	2.0	2.0	2.0
Rib distance	H	mm	40.0	40.0	40.0	40.0
Distance of supports		m	0.5			
Wobble coefficient	k	rad/m	0.008			
Friction coefficient						
weak axis	μ	rad^{-1}	0.14			
strong axis	μ	rad^{-1}	0.14	0.15	0.20	0.25
Minimum radius of curvature						
weak axis		m	2.5			
strong axis		m	3.5	5.5	7.0	9.0

NOTE Dimensions rounded to the closest 0.5 mm.

Coupling situation



Dimensions in mm

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Bonded prestressing system
SUSPA Strand DW

Flat GDP plastic duct
Data sheet

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of European Technical Assessment
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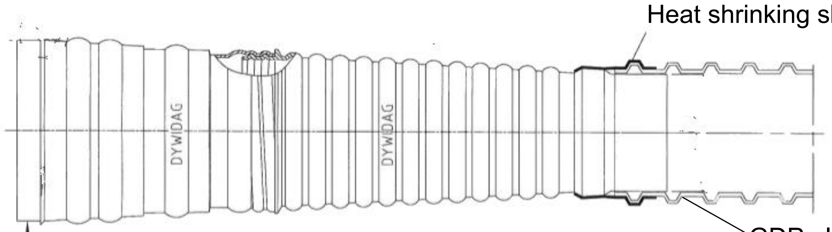
GDP plastic duct, transition to anchorage



GDP plastic duct
Inner diameter, d_i, and
minimum radii of curvature, R_{min}, at ambient and high temperature

Number of strands —	Circular GDP plastic duct —	R_{min} 1) ambient temperature m	R_{min} 1) high temperature m
3	48	3.2	5.5
4	48	4.5	7.8
5	48	5.7	9.8
7	59	6.5	11.1
9	76	6.5	11.1
12	76	7.4	11.1
15	85	8.3	11.6
19	100	8.3	11.6
22	100	8.5	11.6

1) Based on wear resistance tests according to *fib* bulletin 7

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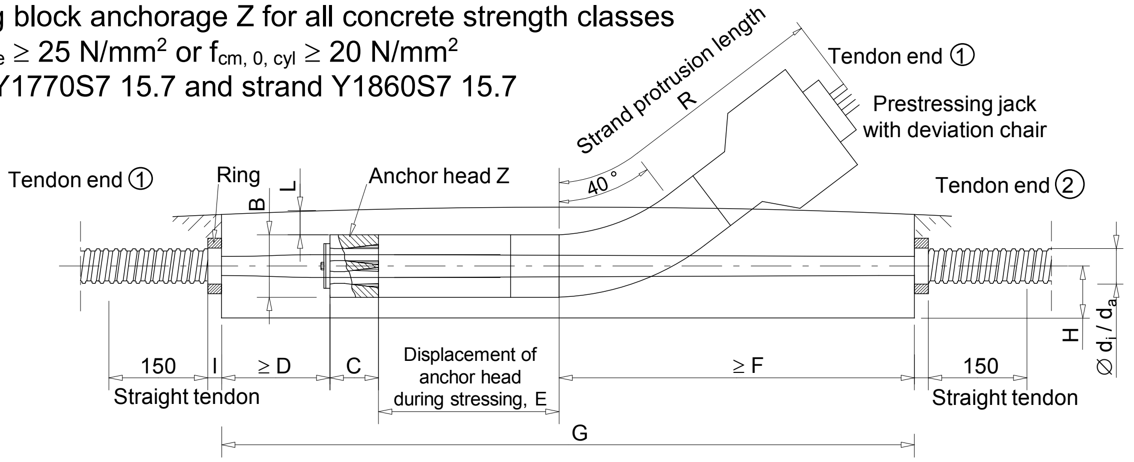
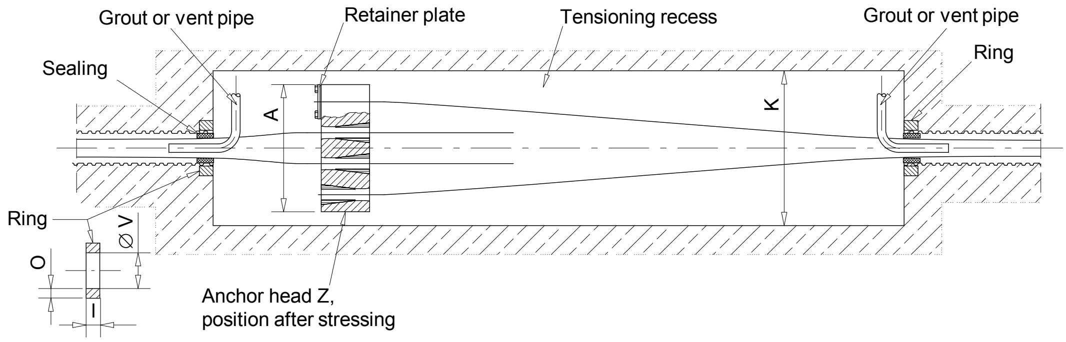
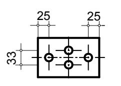
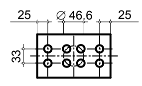
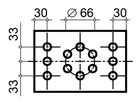
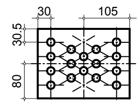
Floating block anchorage Z for all concrete strength classes
$f_{cm,\,0,\,cube} \geq 25$ N/mm² or $f_{cm,\,0,\,cyl} \geq 20$ N/mm²
strand Y1770S7 15.7 and strand Y1860S7 15.7





Over tensioning with subsequent detensioning is impossible.

Tendon			**Z 6-2**	**Z 6-4**	**Z 6-6**	**Z 6-8**
Number of strands			2	4	6	8
Strand arrangement						
Anchor head	Length	A	140	170	210	210
	Width	B	90	100	140	160
	Thickness	C	70	80	100	100
Strand protrusion	Length	R	850	1 000	1 000	1 200
Duct	Duct I	Ø d_i / d_a	40/47	45/52	55/62	65/72
	Duct II	Ø d_i / d_a	45/52	50/57	60/67	70/77
Ring		Ø V	Duct outer diameter + ~ 3 mm			
		min. O	11	14	14	14
		l	20	20	30	30
Tensioning recess		D	100	200	300	400
		E	Elongation of tendon end 2			
		F	550	800	1 000	1 100
		G	720 + E	1 080 + E	1 400 + E	1 600 + E
		H	65	70	90	100
		K	180	210	250	250
		L	Concrete cover required			
Friction loss in anchorage Z, including loss in deviation chair			13 %	13 %	13 %	16 %

Dimensions in mm

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Floating block anchorage Z
Data sheet for tendons Z 6-2 to Z 6-8

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Designation	Specification	Material [1)]
Anchor head E, Anchor head EP	EN 10083-1	Steel
Single strand anchor SK6	EN 1562	Ductile cast iron
	EN 1563	
Anchor head Z	EN 10083-1	Steel
	EN 10083-2	
Coupler head K, Coupler head V, Coupler barrel K6, Coupler bushing K6	EN 10083-1	Steel
Anchor plate	EN 10025-2	Steel
Anchor body MA 2311	EN 1563	Ductile cast iron
Wedge	EN 10277-2	Steel
Compression fitting	EN 10277-2	Steel
Duct, Telescopic duct	EN 523	Steel
	GDP plastic duct	Polypropylene (PP), Annex 32
Protective tube	EN 10130	Steel
	EN ISO 17855-1	PE-HD
PE sleeve	EN ISO 17855-1	PE-HD
Helix	—	Ribbed reinforcing steel, $R_e \geq 500$ N/mm^2
	EN 10025-2	Plain round steel
Additional reinforcement	—	Ribbed reinforcing steel, $R_e \geq 500$ N/mm^2
Ring	EN 10025-2	Steel
Retainer plate, Venting cap	EN 10025-2	Steel
Load distributing steel plate	EN 10025-2	Steel
Electrical isolation plate	—	Reinforced plastics
Trumpet	EN 10130 EN ISO 17855-1	Steel PE-HD
Protection cap	EN ISO 17855-1	PE-HD
Sealing	—	Synthetic caoutchouc

[1)] Detailed material specifications are deposited at Österreichisches Institut für Bautechnik

Characteristics of granulate	Method	Specification
Melt Mass-Flow Rate MFR 230/5	ISO 1133	1.4 ± 0.3 g/10 min
Hardness: Ball indentation method H 132/30	ISO 2039-1	42 ± 5 N/mm²
Charpy impact strength of notched specimens at + 23 °C	ISO 179-1 eA	≥ 35 kJ/m²
Charpy impact strength of notched specimens – 30 °C	ISO 179-1 eA	≥ 3 kJ/m²
Tensile impact strength of notched specimens	ISO 8256	≥ 80 kJ/m²
Tensile strength at yield	DIN 53455	≥ 24 N/mm²
Elongation at yield	DIN 53455	≥ 8 %
Environmental stress cracking (ESC)	ASTM D 1693-70	≥ 192 h
Vicat VST A50	ISO 306	≥ 70 °C
Linear expansion-coefficient – average value	DIN 53752	140 to 180 · 10^{-6} K^{-1}
Elastic modulus	DIN 53457	1 580 ± 40 N/mm²
Characteristics of duct	Method	Specification
Density	DIN 53479	0.90 ± 0.01 g/cm³
Melt Mass-Flow Rate MFR 230/5, increase compared to the granulate	ISO 1133	≤ 0.4 g/10 min
Indentation test dependent on time and temperature – 1 hour	ISO 2039-1	≥ 27 N/mm² at 23 °C ≥ 23 N/mm² at 60 °C

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Strand			Y1770S7	Y1860S7
Characteristic tensile strength	R_m	N/mm²	1 770	1 860
Nominal diameter of strand	D	mm	15.7	
Nominal diameter of outer wire	d_o	mm	5.2	
Diameter of core wire d	d'	mm	$\geq 1.03 \cdot d_o$	
Nominal mass per metre	M	g/m	1 172	
Nominal cross sectional area	A_p	mm²	150	
Characteristic value of maximum force	F_m	kN	266	279
Maximum value of maximum force	$F_{m,\,max}$	kN	306	321
Characteristic value of 0.1 % proof force [1]	$F_{p0.1}$	kN	234	246
Minimum elongation at maximum force, $L_0 \geq 500$ mm	A_{gt}	%	3.5	
Modulus of elasticity	E	N/mm²	195 000 [2]	
Relaxation after 1 000 h, for an initial force of – $0.70 \cdot F_{ma}$ – $0.80 \cdot F_{ma}$	— —	% %	≤ 2.5 ≤ 4.5	

[1] For strands according to prEN 10138-3, 09.2000, the value is multiplied by 0.98
[2] Standard value

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Bonded prestressing system
SUSPA Strand DW
Specification of the 7-wire prestressing steel strand

Annex 33
of European Technical Assessment
ETA-13/0839 of 11.12.2017

Component	Item	Test / Check	Traceability	Minimum frequency[1]	Documentation
Anchor head E, EP, Anchor head Z, Single strand anchor SK6, Coupler head K, Coupler head V, Coupler barrel K6, Coupler bushing K6, Anchor body MA	Material	Check	Full [2]	100 %	"3.1" [3]
	Detailed dimensions [4]	Test		5 %, ≥ 2 samples	Yes
	Visual inspection [5), 6]	Check		100 %	No
Anchor plate, Retainer plate, Load distributing steel plate, Electrical insulation plate	Material	Check	Bulk [7]	100 %	"2.2" [8]
	Detailed dimensions [4]	Test		3 %, ≥ 2 samples	Yes
	Visual inspection [5]	Check		100 %	No
Wedge, Compression fitting	Material	Check	Full [2]	100 %	"3.1" [3]
	Treatment, hardness [9), 10]	Test		0.5 %, ≥ 2 samples	Yes
	Detailed dimensions [4]	Test		5 %, ≥ 2 samples	Yes
	Visual inspection [5), 11]	Check		100 %	No
Strand [12]	Material	Check	"CE"	100 %	"CE"
	Diameter	Test		Each coil	No
	Visual inspection [5]	Check		Each coil	No
Helix in plain round steel, EN 10025	Material	Check	Full [2]	100 %	"2.2" [8]
	Visual inspection [5]	Check		100 %	No
Duct	Material	Check	"CE"	100 %	"CE" [13]
	Visual inspection [5]	Check		100 %	No
Protective tube	Material	Check	Full [2]	100 %	Yes [13]
	Visual inspection [5]	Check		100 %	No
Grouting cement	Material	Check	Full [2]	100 %	"CE"
Grouting admixtures, additives etc.	Material	Check	Bulk [7]	100 %	"CE"
GDP plastic duct	See Annex 35				

1) All samples shall be randomly selected and clearly identified.
2) Full: Full traceability of each component to its raw material.
3) "3.1": Inspection certificate "3.1" according to EN 10204
4) Detailed dimensions: Measurement of all external dimensions and angles according to the specification given in the prescribed test plan.
5) Visual inspection: E.g. main dimensions, gauge testing, correct marking or labelling, adequate performance, surfaces, ribs, kinks, smoothness, corrosion protection, notches, coating, as given in the specification of the component.
6) Visual inspection: All conical bores of the anchor and coupler heads in regard to angle, diameter and surface grade.
7) Bulk: Traceability of each component back to a certain point.
8) "2.2": Test report "2.2" according to EN 10204
9) Geometric properties
10) Hardness according to specification of the component
11) Teeth, cone surface
12) As long as the basis for the CE marking for prestressing steel is not yet available, an approval or certificate according to the respective standards and regulations in force at the place of use shall accompany each delivery.
13) Supplier's certificate

Component	Item	Test / Check	Trace-ability	Minimum frequency	Documen tation
GDP plastic duct	Raw material [6), 7)]	Check	full	100 %	"3.1" [1)]
	Melt mass flow rate [6), 7)]	Test		1 [2)]	yes
	Density [6), 7)]	Test			
	Detailed dimensions [6), 7)]	Test		1 [3)] ≥ 2 specimens per working shift [3)]	yes
	Mass per metre [6), 7)]	Test		4 specimens per working shift	yes
	Flexibility of duct [6), 7)]	Test		1 [3)] ≥ 2 specimens per working shift [3)]	yes
	Flexural behaviour of duct [6), 7)]	Test			
	Lateral load resistance of duct [7)]	Test		1 [4)]	yes
	Longitudinal load resistance of duct [7)]	Test			
	Leak tightness [7)]	Test			
	Wear resistance of duct [6), 7)]	Test			
	Visual inspection [5), 6), 7)]	Check		100 %	no

1) Inspection certificate "3.1" according to EN 10204. The inspection certificate shall in particular include test results on density, melt mass flow rate, tensile stress at yield, elongation at yield, modulus of elasticity, charpy impact strength of notched specimen at + 23 °C and – 30 °C. Further material characteristics shall be confirmed.

2) 1 at start of production, per shift of production and at each change of batch of raw material.

3) Numbers of tests per size of duct. 1 per 500 m duct length, at each change of machine settings and at each change of batch of raw material. At least 2 specimens per working shift and 2 at start of production.

4) Numbers of tests per size of duct. General 1 per delivery. Not more than 1 per week of production but at least 1 per batch of raw material.

5) Visual inspection includes: Correct size and shape, smoothness, fins, kinks, cavities, correct marking or labelling as detailed in the prescribed test plan

6) For applications with protection level PL1 according to *fib* bulletin 33

7) For applications with protection level PL2 according to *fib* bulletin 33

Component	Item	Test / Check	Sampling [1] – Number of components per visit
Anchor head E, Anchor head EP, Anchor head Z, Single strand anchorage SK6, Coupler head K, Coupler head V, Coupler barrel K6, Coupler bushing K6, Anchor body MA	Material according to specification	Test / Check	1
	Detailed dimensions	Test	
	Visual inspection [2]	Check	
Wedge, Compression fitting	Material according to specification	Test / Check	2
	Treatment	Test	2
	Detailed dimensions	Test	1
	Main dimensions, surface hardness and surface finish	Test	5
	Visual inspection [2]	Check	5
Single tensile element test	According to ETAG 013, Annex E.3	Test	1 series

1) All samples are randomly selected and clearly identified.

2) Visual inspection: E.g. main dimensions, gauge testing, correct marking or labelling, surfaces, ribs, kinks, smoothness, corrosion protection, corrosion, notches, coating, as given in the prescribed test plan.

№	**Essential Characteristic**	**Clause**	**Intended use Line № according to Clause 2.1, Table 5**			
			1	**2**	**3**	**4**
1	Resistance to static load	3.2.1.1	+	+	+	+
2	Resistance to fatigue	3.2.1.2	+	+	+	+
3	Load transfer to the structure	3.2.1.3	+	+	+	—
4	Friction coefficient	3.2.1.4	+	+	+	+
5	Deviation, deflection (limits)	3.2.1.5	+	+	+	+
6	Practicability, reliability of installation	3.2.1.6	+	+	+	+
7	Content, emission, and/or release of dangerous substances	3.2.2	+	+	+	+
8	Related aspects of serviceability	3.2.3	+	+	+	+
9	Practicability, reliability of installation	3.2.4.1	—	+	—	—
10	Practicability, reliability of installation	3.2.4.2	—	—	+	—
11	Load transfer to the structure	3.2.4.3	—	—	—	+

Key
+..................Essential characteristic relevant for the intended use
—................Essential characteristic not relevant for the intended use

For combinations of intended uses the essential characteristics of all intended uses composing the combination are relevant.

Reference documents

Guideline for European Technical Approval

ETAG 013, 06.2002	Guideline for European Technical Approval of Post-Tensioning Kits for Prestressing of Structures

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 1562, 03.2012	Founding – Malleable cast irons
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 10083-1, 08.2006	Steels for quenching and tempering – Part 1: General technical delivery conditions
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

ISO 179-1, 06.2015	Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test
ISO 306, 11.2013	Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)
ISO 1133, 12.2011	Plastics – Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics
ISO 2039-1, 12.2001	Plastics – Determination of hardness – Part 1: Ball indentation method
ISO 8256, 07.2004	Plastics – Determination of tensile-impact strength
ASTM D 1693-70	Standard test method for Environmental stress-cracking of Ethylene Plastics
DIN 53455	Testing of plastics; Tensile test
DIN 53457	Testing of plastics; determination of the elastic modulus by tensile, compression and bend testing
DIN 53479	Testing of Plastics and Elastomers; Determination of Density
DIN 53752	Testing of plastics; determination of the coefficient of linear thermal expansion
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

Other documents

fib bulletin 7, 01.2000	Corrugated plastic ducts for internal bonded post-tensioning
fib bulletin 33, 12.2005	Durability of post-tensioning tendons
98/456/EC	Commission decision 98/456/EC of 3 July 1998 on the procedure for attesting the conformity of construction products pursuant to Article 20 (2) of Council Directive 89/106/EEC as regards posttensioning kits for the prestressing of structures, Official Journal of the European Communities L 201 of 17 July 1998, p. 112
305/2011	Regulation (EU) № 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC, OJ L 88 of 4 April 2011, p. 5, amended by Commission Delegated Regulation (EU) № 568/2014 of 18 February 2014, OJ L 157 of 27.05.2014, p. 76 and Commission Delegated Regulation (EU) № 574/2014 of 21 February 2014, OJ L 159 of 28.05.2014, p. 41
568/2014	Commission Delegated Regulation (EU) № 568/2014 of 18 February 2014 amending Annex V to Regulation (EU) № 305/2011 of the European Parliament and of the Council as regards the assessment and verification of constancy of performance of construction products, OJ L 157 of 27.05.2014, p. 76

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