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Italian Technical Assessment Body

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Designated according to Article 29 of Regulation (EU) N° 305/2011.

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European Technical Assessment ETA 15/0329 of 30/12/2025

GENERAL PART

Trade name of the construction product	**TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands**
Product family to which the construction product belongs	**PAC 16: Reinforcing and prestressing steel for concrete (and ancillaries). Post tensioning kits.**
Manufacturer	**TTM tension technology S.r.l. Via Oger Martin, 21 03024 Ceprano (FR) - Italy**
Manufacturing plant	**TTM tension technology S.r.l. Via Alberto da Giussano, 9 20011 Corbetta (MI) - Italy**
This European Technical Assessment contains:	**53 pages, including 42 annexes which form an integral part of this assessment**
This European Technical Assessment is issued in accordance with Regulation (EU) n° 305/2011, on the basis of	**EAD 160004-00-0301 – Post-tensioning kits for prestressing of structures**
This version replaces	**ETA 15/0329 (version 02) of 05/05/2016**

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SPECIFIC PARTS

1. TECHNICAL DESCRIPTION OF THE PRODUCT

1.1 Definition of the product

The **TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands** consists of:

- tendon:
  - bonded and unbonded tendons with 4 to 27 tensile elements;
- tensile elements:
  - 7-wire prestressing steel strand having the characteristics indicated in Table 1; the wire can be equipped with a protective sheathing against corrosion:

Table 1: Tensile elements

Strands type	Nominal diameter [mm]	Nominal cross section [mm^2]	Characteristic tensile strength [MPa]
Normal – T15	15.2	139	1860
Super – T15S	15.7	150	1860
Compact T15C	15.2	165	1860

- anchorage:

M	Active anchorage	Internal post tension
ME	Active anchorage	External post tension replaceable
MER	Active anchorage	External post tension replaceable and restressable
MEM	Active anchorage	External post tension not replaceable
MX	Active anchorage	Internal post tension completely encapsulated
MEX	Active anchorage	External post tension replaceable completely encapsulated
D	Passive anchorage	Internal post tension
DEM	Passive anchorage	External post tension not replaceable

	Number of strands							
	4	7	9	12	15	19	22	27
M – ME – MER – MEM – MX - MEX	X	X	X	X	X	X	X	X
D - DEM	X	X	X	X	X	X	X	X

- bursting reinforcement (helixes and stirrups);
- sheathing (ducts);
- corrosion protection for all tensile elements and anchorages.

The product description, with reference to its components, is given in Annexes A1-A34.

1.2 Components

The components correspond to the drawings and provisions given in this European Technical Assessment including the Annexes.
The characteristic material values, dimensions and tolerances of the components not indicated in the Annexes or in the following paragraphs correspond to the respective values laid down in the technical documentation of this European Technical Assessment.

1.2.1 Strands

As long as prEN 10138 remains a pre-standard, 7-wire strands in accordance with national provisions are used. The corresponding characteristics are given in Table 2.

Table 2: Dimensions and properties of 7-wire strands

Designation	Symbol	Unit	Value		
Characteristic tensile strength	f_{ptk}	MPa	1860	1860	1860
Nominal diameter	D	mm	15.2	15.7	15.2
Nominal cross section	A_p	mm^2	139	150	165
Nominal mass	M	g/m	1093	1172	1289

To avoid any possible confusions, only strands with one nominal diameter shall be used on one site. Only strands stranded in the same direction shall be used in a tendon. Further characteristic values of the strands are reported in Annex A31.

1.2.2 Wedges

Wedges type T15 are made of case hardening steel 16NiCrS4Pb according to EN 10277-4. Only one type of wedge is used. The 3 segments of the wedges, held together by a spring ring, are 43 mm long and have a 60°- tooth. In case of passive anchorages wedges are kept in place by springs and a retaining plate.
For further characteristic values of the wedges see Annex A1.

1.2.3 Anchor heads

Anchor heads, realized by closed die forging, are made by steel C40-45 according to EN 10083-2 and have a conical hole drilled in circular arrangement to accommodate strands and wedges. Additionally, passive anchorages have threaded holes to fix the retaining plate and cylindrical seating for retaining springs. For further characteristic values of the anchor heads see Annex A1.

1.2.4 Cast iron block

Cast iron blocks are made of a EN-GJS-500-7 cast iron according to UNI-ISO 4544. They are designed with a shape able to transmit prestressing forces from the anchor head to the concrete. For 4 to 27 strands, circular bearing plates shall be used (see Annex A2). An air vent is provided and in order to guarantee a suitable ventilation a tube must be fitted to these air-vent.

1.2.5 Helix and stirrups

The steel grades and dimensions of the helix and of the stirrups shall comply with the values given in the Annexes. The helix shall be placed exactly in the tendon axis. The helix dimensions shall comply with the values specified in Annexes A4 to A6.
If required for a specific project design, the reinforcement given in the Annex A4 to A6 may be modified in accordance with the respective regulations in force at the place of use as well as with the eventual relevant approval of the local authority and of the Manufacturer to provide equivalent performance.

1.2.6 Tubes and trumpets

Tubes and trumpets (see Annex A2) are positioned between the sheath and the anchorage and guarantee proper protection to the strand where the sheath is removed. They are made of H.D.P.E. and they are able to keep stability when high temperatures are reached during the injection process. For external post tension application and replaceable tendon, should be used the tubes indicated in the Annex A25.

1.2.7 Grout

Grout shall be used in accordance with EN 447 or EAD 160027-00-0301. In case of use of a special grout, this must comply with EAD 160027-00-0301. In case of use of grease, this must comply with EAD 160027-00-0301. Standards and regulations for grouts and grouting valid in place of use shall be considered. In re-stressable tendons grout may not be considered in case of use of plastic-coated strands.

1.2.8 Ducts

TTM's prestressing kit for post-tensioning may be used with different types of ducts depending on the project and the categories of tendons based on their use. There are cases where the internal diameter of the ducts may be increased in sections with a large curvature to ease threading, for example in the case of prefabricated cables threaded in one transaction. The relevant diameters to be used with each type of tendon are given in Annex A2. Recommended dimensions are also given in the Annexes A12 to A15. The steel strip sheaths are circular and corrugated to guarantee a mechanical bond with the concrete. The steel strip sheaths are made of cold-formed (if corrugated) steel strip wound helically and welded along the edges or locked together by crimping (see Annex A30). The metallic sheath is purchased in accordance to EN 523. System can also be used with plastic ducts for internal bonded tendons and these must comply with EAD 160004-00-0301. For external post tension application should be used steel or HDPE sheaths in accordance with EN 12201.

1.2.9 Protection cap

The protection cap is made of HDPE or steel and it guarantees the protection of the head anchor from aggressive elements. For re-stressable tendons see Annex A29.

1.2.10 Permanent corrosion protection

All components or materials have to be selected according to the standards and regulations in force at the place of use. In absence of such standards or regulations, components and materials in accordance with EAD 160004-00-0301 are deemed as acceptable.
The strand for unbounded applications is provided in the factory with corrosion protection consisting of corrosion protective grease and extruded PE sheathing.
Bonded tendons are completely filled with injection products to protect the tendon from corrosion and to provide bond between tendon and structure (see Annex B1).
Application of corrosion protection in the anchorage zone shall comply with the assembly instructions specified in Annex B1. The void in the anchorage zone shall be completely filled with a corrosion protective grease.

1.3 Design of the PT kit

1.3.1 Maximum prestressing forces

Prestressing and over-tensioning forces have to be specified in accordance with national provisions. For more details, see Annex A35.
The number of strands in a tendon may be reduced by leaving out strands lying radial- symmetrically in the anchor head. The provisions for tendons with completely filled anchors also apply to tendons with only partly filled anchor heads. Into the free drills in the anchor head the short pieces of strands with wedges have to be pressed to prevent slipping out.
For further characteristic values of the tendons (mass per meter, ultimate stressing force F_{pk}) see Annexes A31.

1.3.2 Losses of the prestressing force due to friction and wobble effects

The losses of the prestressing force due to friction and wobbling effects may normally be determined in the calculation by using the friction coefficients μ and the unintentional angular displacement k (wobble coefficient) given in Table 3. The values μ and k depend on the given duct dimensions and on the maximum distances between the tendon supports.
The given value of k only applies if the strands are in the ducts at the time of concreting.
If the strands are arranged after concreting, the given values μ shall only be used in the calculation if the ducts are adequately stiffened during concreting, e.g., by means of PE pipes, or if reinforced ducts are used in connection with smaller distances between tendon supports.
For the determination of strains and forces of prestressing steel friction losses ΔPμ (x) it should refer to the details in EN 1992-1-1:

$$\Delta P_{\mu}(x) = P_{max} \left(1 - e^{-\mu (\theta + kx)}\right)$$

where:

- θ is the sum of the angular displacements over a distance x (irrespective of direction or
- sign);
- μ is the coefficient of friction between the tendon and its duct;
- k is an unintentional angular displacement for internal tendons (per unit length);
- x is the distance along the tendon from the point where the prestressing force is equal to P_{max} (the force at the active end during tensioning).

Values of μ and k values are specified for strands in Table 4 and are the values provided by the European standard EN 1992-1-1 (Table 7.2).

Table 3: Friction and wobble coefficients for strands according to EN 1992-1-1 (Table 7.2).

Friction coefficient μ [rad^{-1}]				**Wobble coefficient k [rad/m]**
Internal tendons		Greased and sheated strand	External tendons	0.05-0.01
Metal duct	Polymer duct	PE duct	PE duct	
0.19	0.14	0.05	0.12	

1.3.3 Radii of curvature of internal tendons

The smallest admissible radius of curvature of the tendons with circular duct depending on the diameter of the duct is given in Table 4.

Table 4. Inner diameter of the duct d_i and minimum radius of curvature R_{min}.

Number of strand	**Corrugated steel sheaths**		**Corrugated plastic duct**		**Corrugated plastic duct External post tension***	
	d_i [mm]	**R_{min} [m]**	**d_i [mm]**	**R_{min} [m]**	**d_e [mm]**	**R_{min} [m]**
4	45	5,00	59	5,40	63	2,0
7	62	5,00	69	6,30	75	2,2
9	72	6,40	76	9,93	90	2,5
12	80	7,10	86	7,83	110	3,0
15	85	7,80	87	7,74	110	3,0
19	95	9,50	99	9,09	125	3,2
22	100	9,90	105	9,63	125	3,2
27	110	10,90	114	9,90	140	3,5

* If the ambient temperature is close to zero the expressed values should be doubled.

1.3.4 Concrete strength

Concrete according to EN 206-1 has to be used. At the time of transmission of the full prestressing force to the concrete member the mean concrete strength in the anchor zone shall be at least $f_{cmj,cube}$ or $f_{cmj,cyl}$ according to Annex A36. The mean concrete strength shall be verified by means of at least three specimens, which shall be stored under the same conditions as the concrete member, with the individual values of specimens not to differ more than 5%.

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

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

Spacing and distances shall not be less than values given in the Annex B2.

A reduction of up to 15% of the centre spacing of tendon anchorages in one direction is permitted but should not be less than the outside diameter of the helix and the placing of an additional reinforcement shall still be possible. In this case the spacing in the perpendicular direction shall be increased by the same percentage.

1.4 Installation

The information about installation is provided with the technical documentation from the manufacturer and it is assumed that the product will be installed according to it or (in absence of such instructions) according to the usual practice of the building professionals.

Installation instructions are reported in Annexes B1, B2 and B3.

2. SPECIFICATION OF THE INTENDED USE IN ACCORDANCE WITH EUROPEAN ASSESSMENT DOCUMENT N° 160004-00-0301 (hereinafter EAD)

2.1 Intended use

The **TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands** is intended to be used for the prestressing of structures of normal weight concrete, also subjected to dynamic loads, as:

- Internal bonded tendon for concrete and composite structure (with anchors placed in concrete);
- Internal unbonded tendon for concrete and composite structures (with anchors placed in concrete).
- External tendon for concrete and composite (steel-concrete) structures with a tendon path situated outside the cross section of the structure or member but inside its envelope (with anchors placed in concrete). Included are ring tendons, e.g., tanks, placed circumferentially onto the outer surface of the structure.

Structural members shall be designed in accordance with national laws.
For special application in aggressive environment, the active and passive anchorage M and D may be equipped coated with an epoxy-polyester coating, as a corrosion protection. They are identified with Mep and Dep series, also the epoxy-polyester coating is not covered by this ETA.

2.2 Packaging, transport and storage

Concerning product packaging, transport and storage it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport and storage, as he considers necessary in order to reach the declared performances.

The components and the tendons shall be protected against moisture and staining, taking all necessary measures to avoid conditions for rust and chemical, mechanical and electrochemical damages to components.
Tensile elements shall be kept separate from areas where welding operations are carried out.

2.3 Use, maintenance, repair

Manufacturer's installation instructions have to comply with EN 17678-1:2022 — "Installation of post-tensioning kits for prestressing of structures — Part 1: Competence of personnel for the installation. In any case respective standards and regulations in force at the place of use should be observed.

2.4 Assumed working life

The performances assessed in this European Technical Assessment, according to the applicable EAD, are based on an assumed intended working life of 100 years, provided that the conditions for packaging, transport, storage, installation as well as appropriate use, maintenance and repair are met. The indications given on the working life cannot be interpreted as a guarantee given by the manufacturer but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3. PERFORMANCE OF THE PRODUCT AND REFERENCES TO THE METHODS USED FOR ITS ASSESSMENT

The tests for performance assessment of **TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands** were carried out in compliance with EAD 160004-00-0301 according to the test methods reported herein, as well for what concerns sampling, conditioning and testing provisions.
The numbering (#) in the following tables corresponds to the numbering of Table 1 of EAD 160004-00-0301.

3.1 MECHANICAL RESISTANCE AND STABILITY (BWR 1)

#	Essential characteristic	Performance
1	Resistance to static load – Clause 2.2.1	See Annex C1
2	Resistance to fatigue – Clause 2.2.2	See Annex C2
3	Load transfer to the structure – Clause 2.2.3	See Annex C3
4	Friction coefficient – Clause 2.2.4	According to EN 1992-1-1 Table 7.2 See Clause 1.3.2
5	Deviation/deflection (limits) for internal bonded and internal unbonded tendon - Clause 2.2.5	The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.5. See Clause 1.3.2
6	Deviation/deflection (limits) for external tendon - – Clause 2.2.6	The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.6. See Clause 1.3.2.
7	Assessment of assembly - Clause 2.2.7	The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.7. See Annex B1.
8	Resistance to static load under cryogenic conditions for applications with anchorage/coupling outside the possible cryogenic zone - Clause 2.2.8	Not applicable
9	Resistance to static load under cryogenic conditions for applications with anchorage/coupling inside the possible cryogenic zone – Clause 2.2.9	Not applicable
10	Material properties, component performance, system performance of plastic duct – Clause 2.2.10	No performance assessed
11	Material properties, component performance, system performance of plastic duct to provide an encapsulated tendon – Clause 2.2.11	No performance assessed
12	Material properties, component performance, system performance of plastic duct to provide an electrically isolated tendon – Clause 2.2.12	No performance assessed
13	Corrosion protection – Clause 2.2.13	The PT system as described in the ETA meets the acceptance criteria of EAD 160004-00-0301, Clause 2.2.13. See Clause 1.2.10

#	Essential characteristic	Performance
Monostrand, sheathing base material		
14	Melt index – Clause 2.2.14	Not applicable
15	Density – Clause 2.2.15	Not applicable
16	Carbon black – Clause 2.2.16	Not applicable
17	Tensile strength – Clause 2.2.17	Not applicable
18	Elongation – Clause 2.2.18	Not applicable
19	Thermal stability – Clause 2.2.19	Not applicable
Monostrand, manufactured sheathing		
20	Tensile strength – Clause 2.2.20	Not applicable
21	Elongation – Clause 2.2.21	Not applicable
22	Surface of sheathing - Clause 2.2.22	Not applicable
23	Environmental stress cracking - Clause 2.2.23	Not applicable
24	Temperature resistance - Clause 2.2.24	Not applicable
25	Resistance to externally applied agents - Clause 2.2.25	Not applicable
26	Sheathing minimum thickness - Clause 2.2.26	Not applicable
Monostrand, manufactured monostrand		
27	External diameter of sheathing - Clause 2.2.27	Not applicable
28	Mass of sheathing per metre - Clause 2.2.28	Not applicable
29	Mass of filling material per metre - Clause 2.2.29	Not applicable
30	Alteration of dropping point caused by monostrand manufacturing - Clause 2.2.30	Not applicable
31	Alteration of oil separation caused by monostrand manufacturing - Clause 2.2.31	Not applicable
32	Impact resistance - Clause 2.2.32	Not applicable
33	Friction between sheathing and strand - Clause 2.2.33	Not applicable
34	Leak tightness - Clause 2.2.34	Not applicable

3.2 SAFETY IN CASE OF FIRE (BWR 2)

#	Essential characteristic	Performance
35	Reaction to fire	No performance assessed

3.3 HYGIENE, HEALTH AND THE ENVIRONMENT (BWR 3)

#	Essential characteristic	Performance
36	Content, emission and/or release of dangerous substances – Clause 2.2.36	PT system does not contain and release any dangerous substances; it does not cause harmful emission of toxic gases, dangerous particles or radiation to the indoor environment nor contamination of the outdoor environment (air, soil, water).

4. ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE (AVCP) SYSTEM APPLIED, WITH REFERENCE TO ITS LEGAL BASE

In accordance with the European Assessment Document EAD No. 160004-00-0301 the applicable European legal act is: **Commission Decision 98/456/EC.**
The system of assessment and verification of constancy of performance (AVCP) is **1+**.

5. TECHNICAL DETAILS NECESSARY FOR THE IMPLEMENTATION OF THE AVCP SYSTEM, AS PROVIDED FOR IN EAD 160004-00-0301

Technical details necessary for the implementation of the AVCP system are laid down in the Control Plan deposited at ITAB/ITC-CNR.

Issued in San Giuliano Milanese, Italy on 30/12/2025
by ITAB / ITC–CNR

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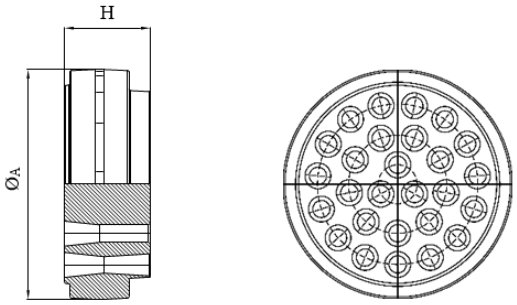
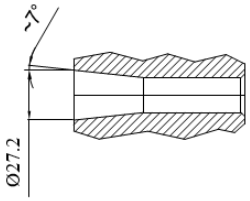
Anchor head "M"



Cone "M"



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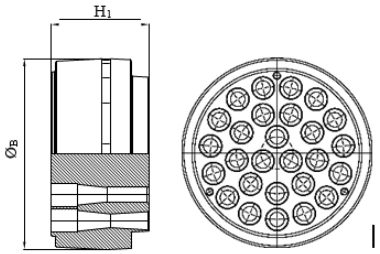
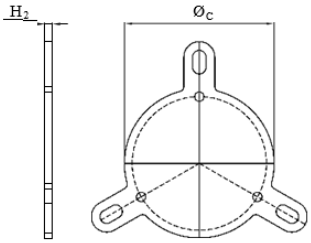


Cover anchor head



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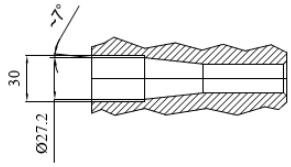
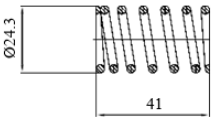
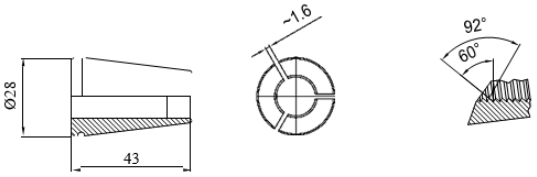


Spring



Wedge "T15"



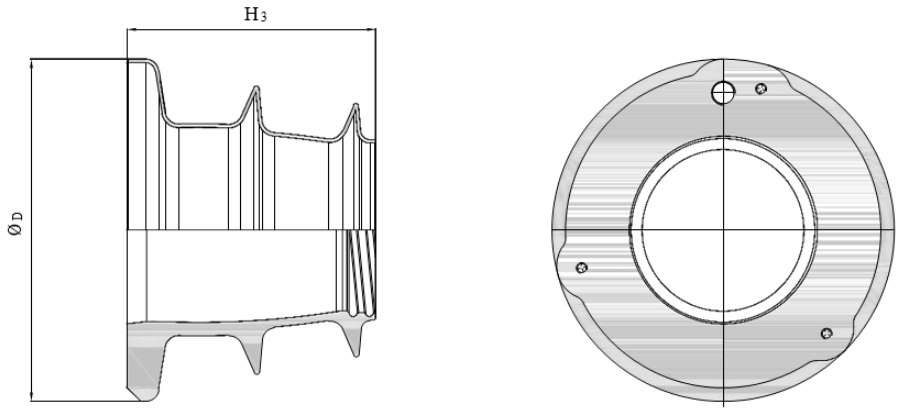
Number of strands	4	7	9	12	15	19	22	27
Anchor head M								
Diameter "Ø A" [mm]	105	125	146	160	176	200	230	250
Height "H" [mm]	53	55	58	53	63	80	86	93
Anchor head D								
Diameter "Ø B" [mm]	105	125	146	160	176	200	230	250
Height "H1" [mm]	88	90	93	88	98	115	121	128
Cover anchor head D								
Diameter "Ø C" [mm]	95	115	130	145	160	180	200	220
Height "H2" [mm]	10	10	10	10	10	15	15	15

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

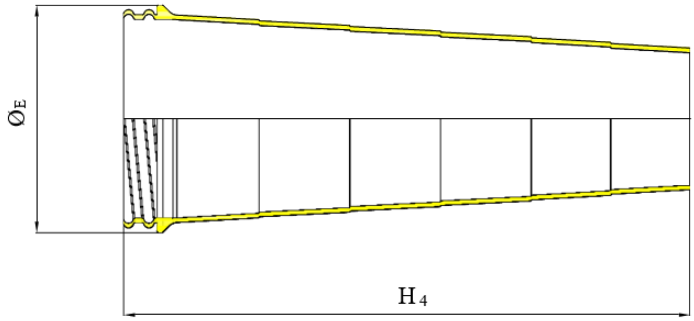
Product Description – Components

Annex A1
of ETA N° 15/0329

Bearing Plate



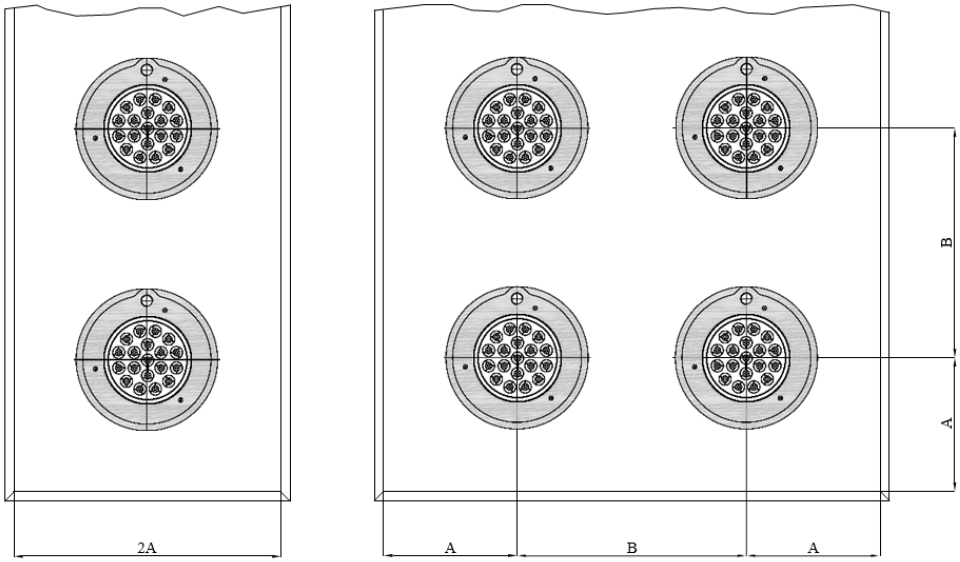
Trumpet



Number of strands	4	7	9	12	15	19	22	27
Bearing plate								
Diameter "$Ø_D$" [mm]	160	200	235	265	290	320	355	380
Height "H_3" [mm]	103	133	163	179,5	197	215	260	277
Trumpet								
Diameter "$Ø_E$" [mm]	80	96	118	134	144	156	189	201
Height "H_4" [mm]	312	355	400	405	425	453	451	500

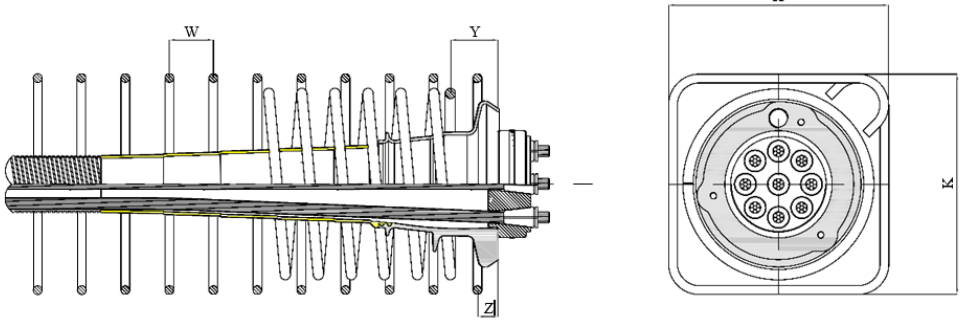
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A2** **of ETA N° 15/0329**
Product Description – Components	

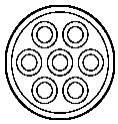
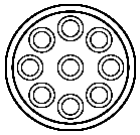
ANCHORAGES M – ME – MER – MX – MEX - DISTANCE FROM EDGES



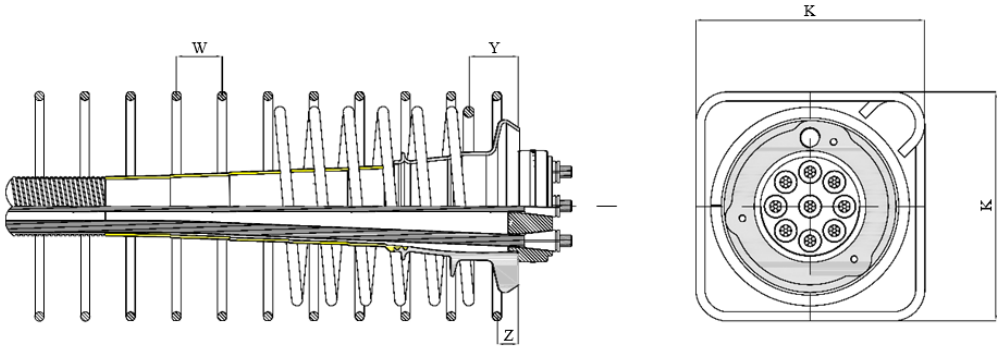
Number of strands	4	7	9	12	15	19	22	27
$f_{cmj,\ cube}$	**Minimum centre spacing B** [mm]							
35 MPa	250	335	370	430	480	545	585	650
45 MPa	230	295	320	380	430	485	520	580
	Minimum centre distances A [mm]							
35 MPa	130	175	190	220	245	280	300	330
45 MPa	120	155	165	195	220	250	265	295

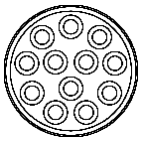
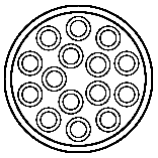
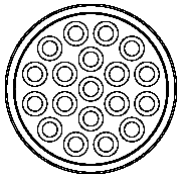
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A3** **of ETA N° 15/0329**
Product Description – Distances (Anchorage M – ME – MER – MEM – MX – MEX)	



Number of strands	4		7		9	
Strand pattern						
Strand [mm^2] Cross section area [mm^2]	165 660		165 1155		165 1485	
f_{ptk} [MPa]	1860		1860		1860	
Helix and additional reinforcement						
$f_{cmj,\ cube}$ [MPa]	35	45	35	45	35	45
Helix						
Outer diameter [mm]	180	170	240	220	300	246
Bar diameter [mm]	12	12	12	12	14	14
Length [mm]	202,5	180	270	247,5	270	247,5
Pitch [mm]	45	45	45	45	45	45
Number of pitches	5	4	7	6	7	6
Distance [mm] “Y”	40	40	50	50	65	65
Additional reinforcement						
Number of stirrups	8	8	11	10	12	11
Bar diameter [mm]	10	10	12	12	12	12
Spacing [mm] “W”	60	60	60	60	60	60
Distance from anchor head	15	15	20	20	27,5	27,5
Outer dimensions [mm] “K”	230	210	315	275	350	300

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A4** **of ETA N° 15/0329**
Product Description – Dimensions of anchorages, helix and additional reinforcement (4, 7 and 9 strands)	

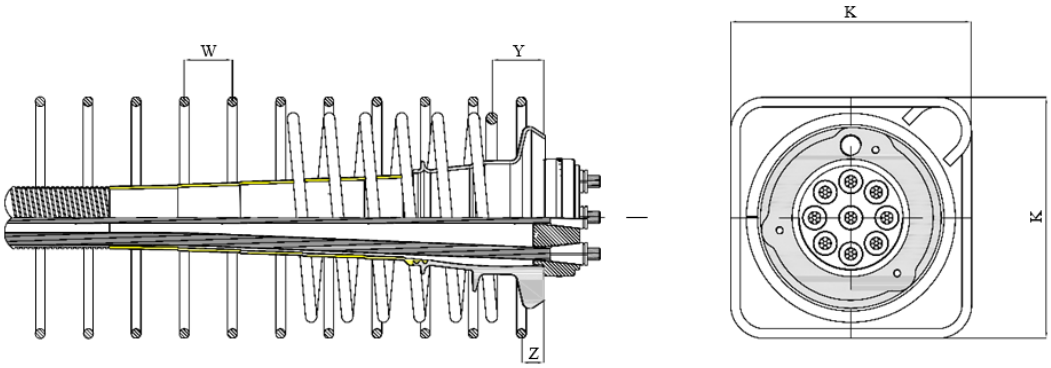


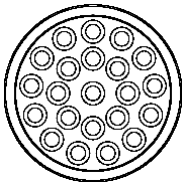
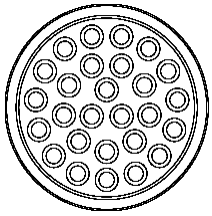
Number of strands	12		15		19	
Strand pattern						
Strand [mm^2] Cross section area [mm^2]	165 198		165 2475		165 3135	
f_{ptk} [MPa]	186		1860		1860	
Helix and additional reinforcement						
$f_{cmj,\ cube}$ [MPa]	35	45	35	45	35	45
Helix						
Outer diameter [mm]	350	300	410	354	440	400
Bar diameter [mm]	16	16	16	16	16	16
Length [mm]	350	300	400	350	450	425
Pitch [mm]	50	50	50	50	50	50
Number of pitches	7	6	9	8	9	8
Distance [mm] “Y”	65	65	70	70	75	75
Additional reinforcement						
Number of stirrups	14	12	15	14	18	16
Bar diameter [mm]	12	12	12	12	12	12
Spacing [mm] “W”	60	60	60	60	60	60
Distance from anchor head [mm] “Z”	27,5	27,5	27,5	27,5	27,5	27,5
Outer dimensions [mm] “K”	410	360	460	410	525	465

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

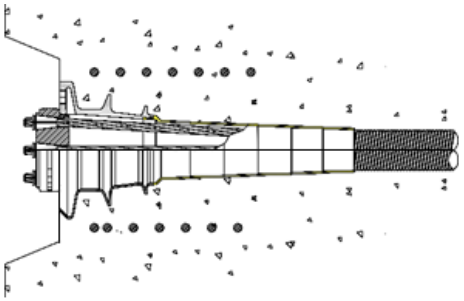
Product Description – Dimensions of anchorages, helix and additional reinforcement (12, 15 and 19 strands)

Annex A5
of ETA N° 15/0329

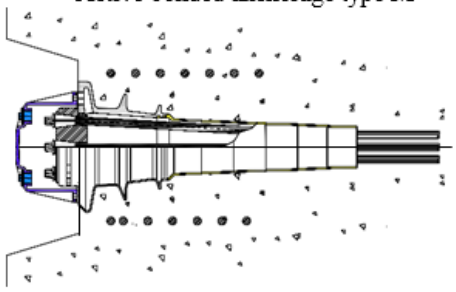


Number of strands	22		27	
Strand pattern				
Strand [mm²] Cross section area [mm²]	165 3630		165 4455	
f_{ptk} [MPa]	1860		1860	
Helix and additional reinforcement				
$f_{cmj,\ cube}$ [MPa]	35	45	35	45
Helix				
Outer diameter [mm]	480	420	530	460
Bar diameter [mm]	18	18	18	18
Length [mm]	450	425	480	400
Pitch [mm]	50	50	60	50
Number of pitches	9	8	9	8
Distance [mm] "Y"	80	80	80	80
Additional reinforcement				
Number of stirrups	19	17	18	19
Bar diameter [mm]	12	12	14	12
Spacing [mm] "W"	60	60	70	60
Distance from anchor head [mm] "Z"	27,5	27,5	27,5	27,5
Outer dimensions [mm] "K"	565	500	630	560

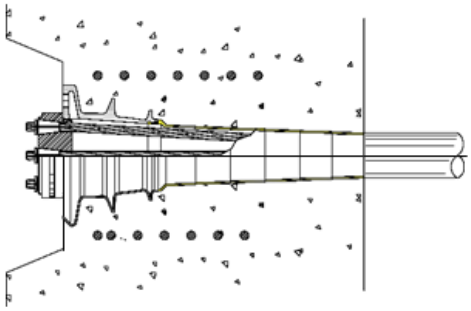
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A6** **of ETA N° 15/0329**
Product Description – Dimensions of Anchorages, Helixes and additional reinforcing (22 and 27 strands)	



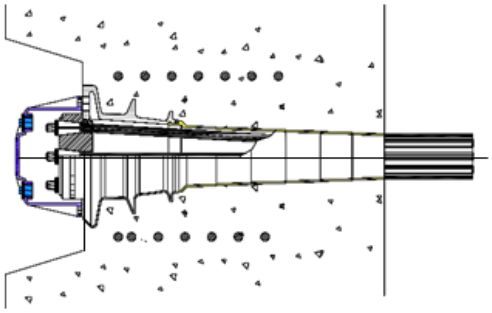
Active bonded anchorage type M



Active unbonded anchorage type M with cap and strands greased and coated

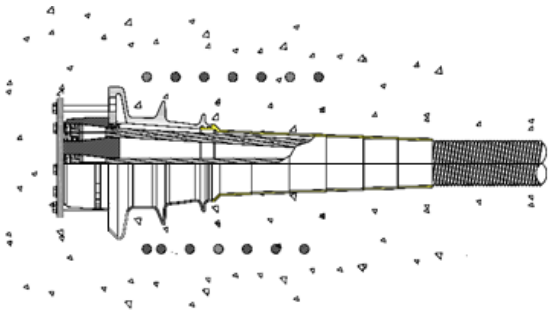


Active bonded anchorage type **MEM** for external post tension applications

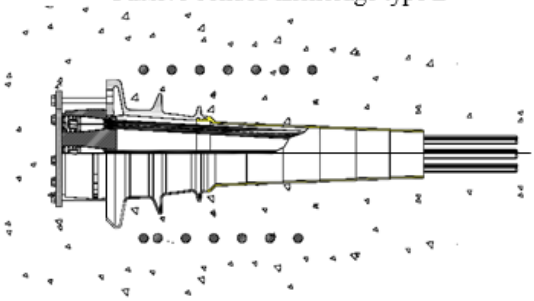


Active unbonded anchorage type **MEM** with protection cap and strands greased and coated for external post tension applications

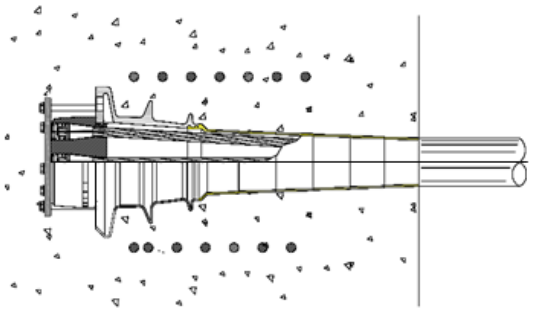
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A7** **of ETA N° 15/0329**
Product Description – Active bonded and unbonded anchorages	



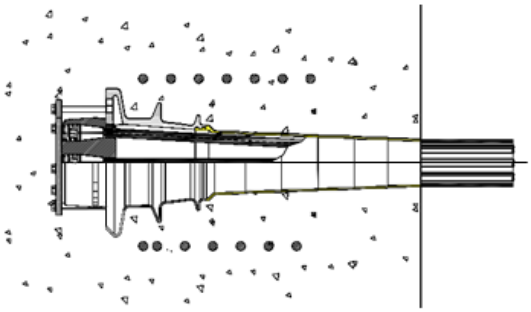
Passive bonded anchorage type D



Passive unbonded anchorage type D with cap and strands greased and coated

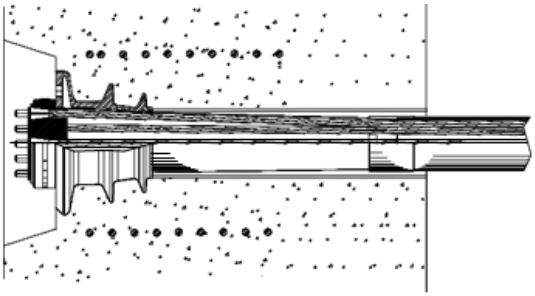


Passive bonded anchorage type **DEM** for external post tension applications

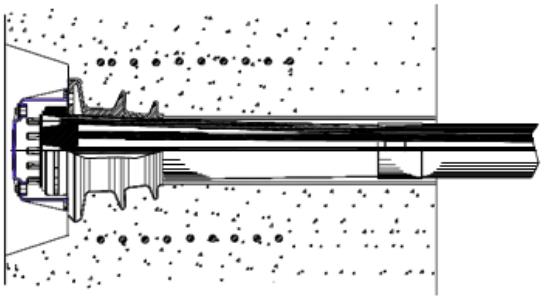


Passive unbonded anchorage type **DEM** with protection cap and strands greased and coated for external post tension applications

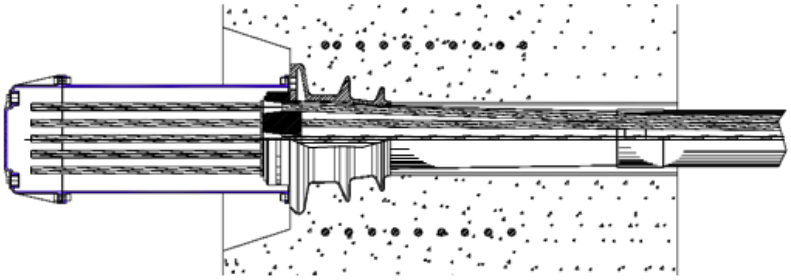
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A8** **of ETA N° 15/0329**
Product Description – Passive bonded and unbonded anchorages	



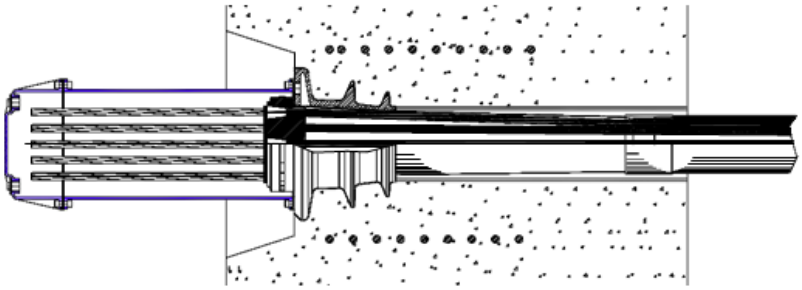
Active bonded anchorage type **ME** for external post tension applications



Active unbonded anchorage type **ME** with protection cap and strands greased and coated for external post tension applications



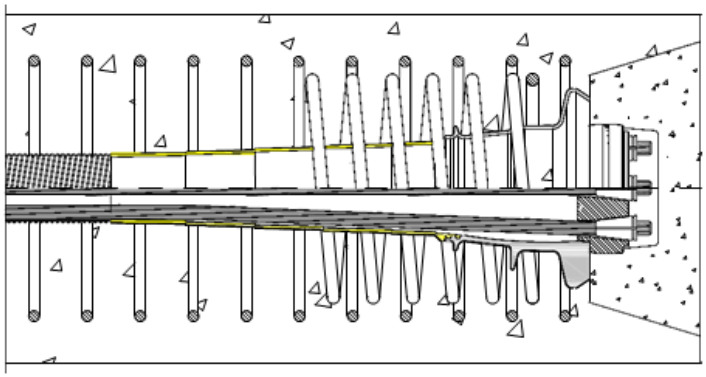
Active bonded anchorage type **MER** replaceable and restressable for external post tension applications



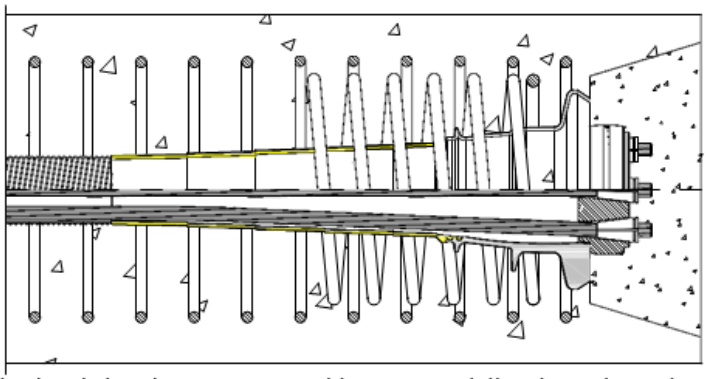
Active unbonded anchorage type **MER** with protection cap and strands greased and coated, replaceable and restressable for external post tension applications

.

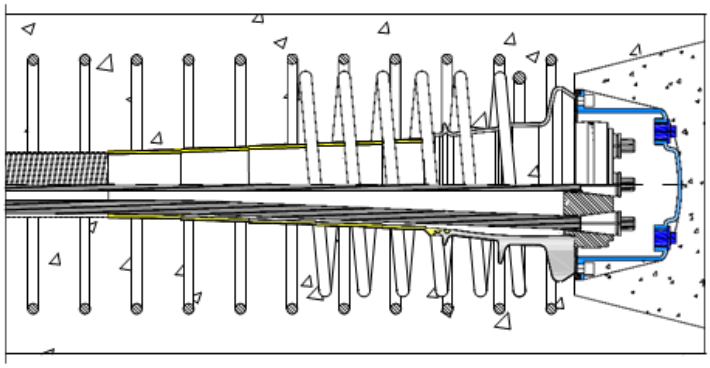
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A9** **of ETA N° 15/0329**
Product Description – External post tension anchorages	



Active bonded anchorage type M with cement pad on the anchor block

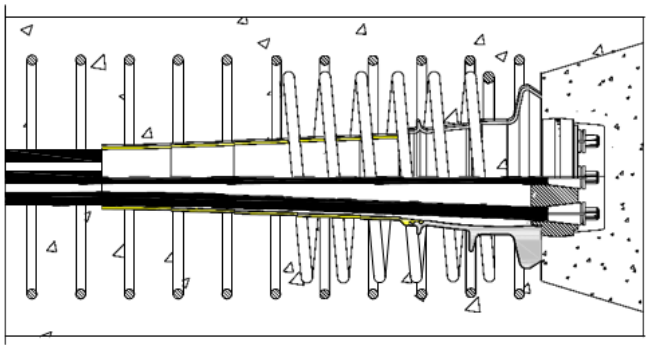


Active bonded anchorage type M with cement pad directly on the anchorage

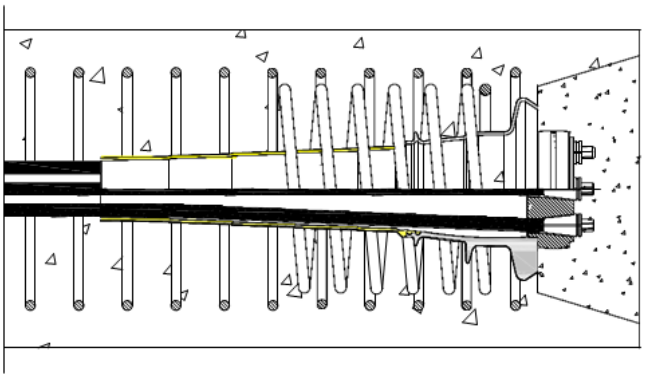


Active unbonded anchorage type M with grouted permanent cap

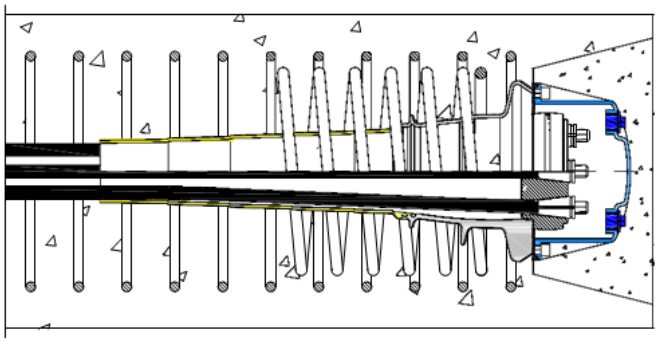
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A10** **of ETA N° 15/0329**
Product Description – Active bonded and unbonded anchorage type M	



Active unbonded anchorage type M with cement pad on the anchor block, and strands greased and coated

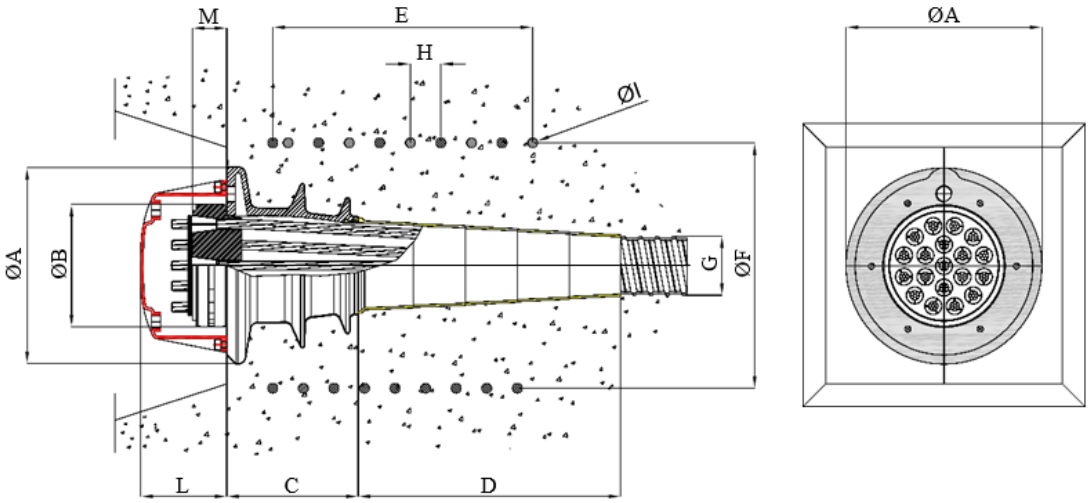


Active unbonded anchorage type M with cement pad directly on the anchorage, and strands greased and coated



Active unbonded anchorage type M with grouted permanent cap and strands greased and coated

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A11** **of ETA N° 15/0329**
Product Description – Active bonded and unbonded anchorage type M	

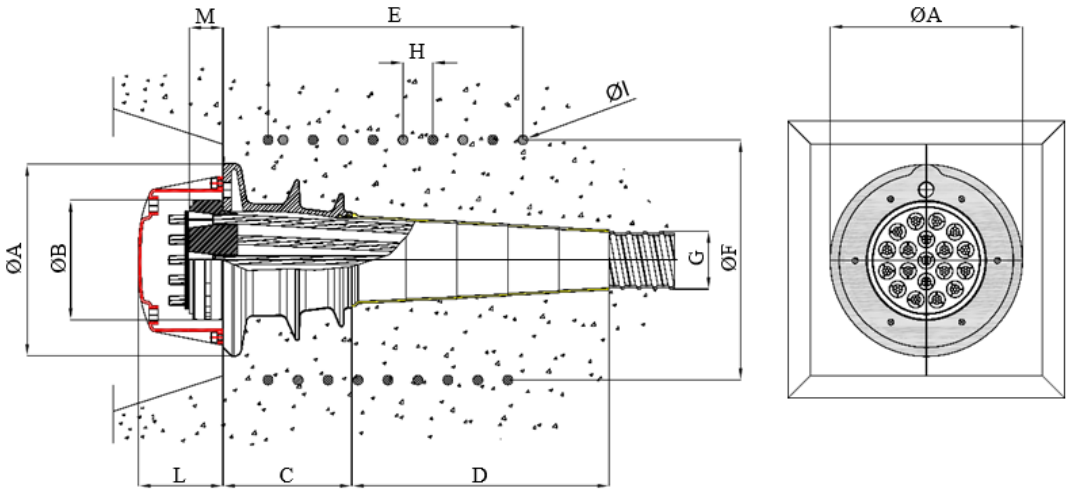


Type	A	B	C	D	E	F	G	H	I	L	M
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
4M15	160	105	103	300	180	170	45/50	45	12	145	45
7M15	200	125	133	340	250	220	62/67	45	12	145	45
9M15	235	146	163	380	250	250	72/77	45	14	145	45
12M15	265	160	180	385	300	300	80/85	50	16	145	45
15M15	290	176	197	405	350	355	85/90	50	16	145	45
19M15	320	200	215	430	425	400	95/100	50	16	120	56
22M15	355	230	260	430	425	420	100/105	50	18	145	61
27M15	380	250	277	470	400	460	110/115	50	18	145	70

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

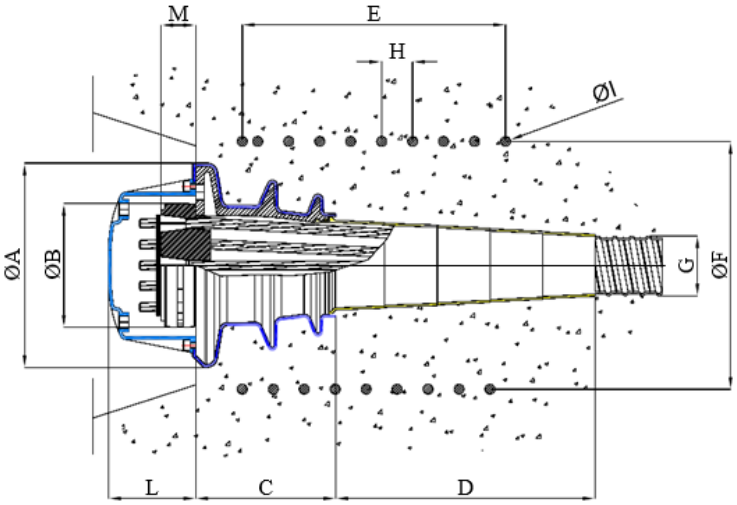
Product Description – Active anchorage type M – concrete 45 MPa

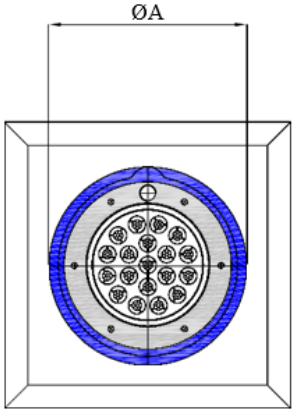
Annex A12
of ETA N° 15/0329



Type	A	B	C	D	E	F	G	H	I	L	M
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
4M15	160	105	103	300	205	180	45/50	45	12	145	45
7M15	200	125	133	340	270	240	62/67	45	12	145	45
9M15	235	146	163	380	270	300	72/77	45	14	145	45
12M15	265	160	180	385	350	350	80/85	50	16	145	45
15M15	290	176	197	405	450	410	85/90	50	16	145	45
19M15	320	200	215	430	450	440	95/100	50	16	120	56
22M15	355	230	260	430	425	480	100/105	50	18	145	61
27M15	380	250	277	470	480	530	110/115	60	18	145	70

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A13** **of ETA N° 15/0329**
Product Description – Active anchorage type M – concrete 35 MPa	



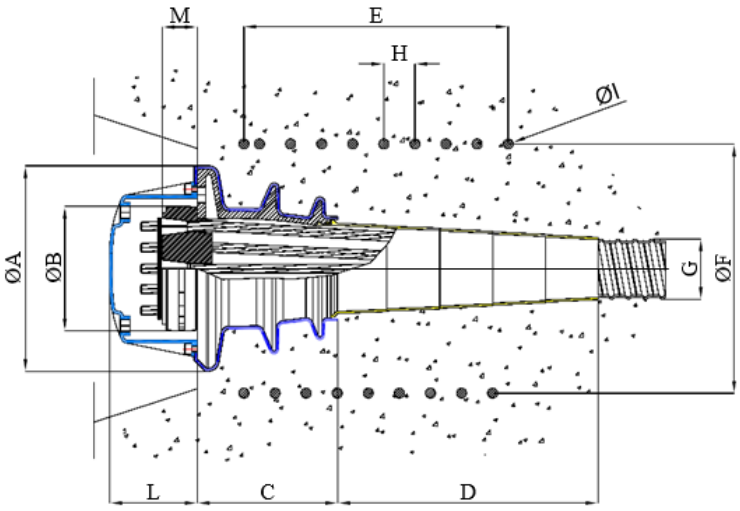


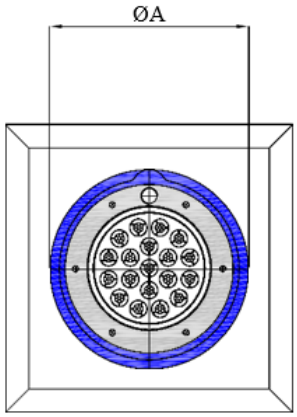
Type	A	B	C	D	E	F	G	H	I	L	M
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
4MX15	168	105	103	300	180	170	45/50	45	12	140	45
7MX15	208	125	133	340	250	220	62/67	45	12	140	45
9MX15	243	146	163	380	250	250	72/77	45	14	140	45
12MX15	273	160	180	385	300	300	80/85	50	16	140	45
15MX15	298	176	197	405	350	355	85/90	50	16	140	45
19MX15	328	200	215	430	425	400	95/100	50	16	115	56
22MX15	363	230	260	430	425	420	100/105	50	18	140	61
27MX15	388	250	277	470	400	460	110/115	50	18	140	70

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

Product Description – Active anchorage type MX – concrete 45 MPa

Annex A14
of ETA N° 15/0329



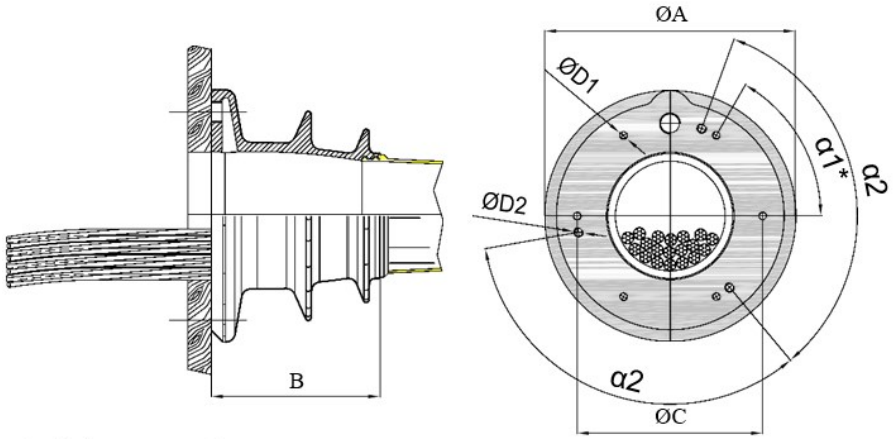


Type	A	B	C	D	E	F	G	H	I	L	M
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
4MX15	168	105	103	300	205	180	45/50	45	12	140	45
7MX15	208	125	133	340	270	240	62/67	45	12	140	45
9MX15	243	146	163	380	270	300	72/77	45	14	140	45
12MX15	273	160	180	385	350	350	80/85	50	16	140	45
15MX15	298	176	197	405	450	410	85/90	50	16	140	45
19MX15	328	200	215	430	450	440	95/100	50	16	115	56
22MX15	363	230	260	430	425	480	100/105	50	18	140	61
27MX15	388	250	277	470	480	530	110/115	60	18	140	70

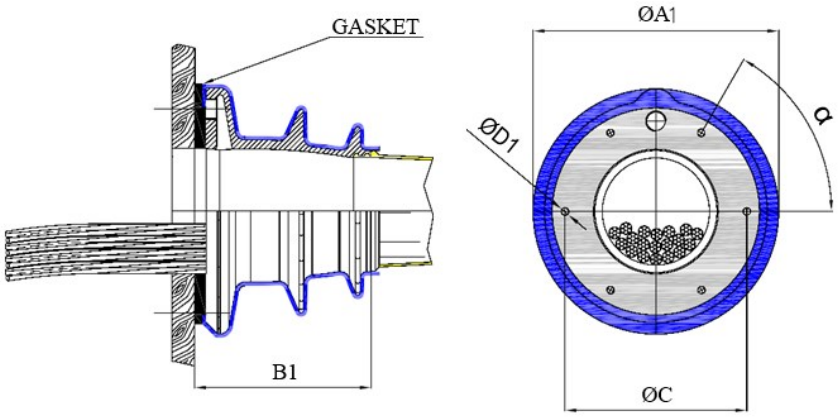
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

Product Description – Active anchorage type MX – concrete 35 MPa

Annex A15
of ETA N° 15/0329



*Holes for fixing to protection cap

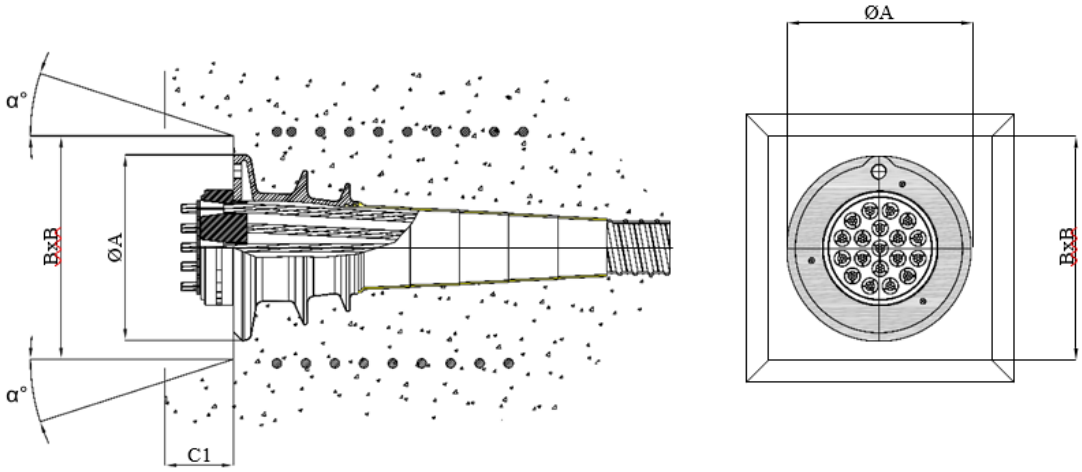


Type	4M15 4MX15	7M15 7MX15	9M15 9MX15	12M15 12MX15	15M15 15MX15	19M15 19MX15	22M15 22MX15	27M15 27MX15
A [mm]	160	200	235	265	290	320	355	380
A_1 [mm]	168	208	243	273	298	328	363	388
B [mm]	103	133	163	180	197	215	260	277
B_1 [mm]	123	153	183	200	219	237	284	300
C [mm]	139	160	190	203	235	270	290	325
D1	M6	M10	M10	M10	M12	M12	M16	M16
D2	M10	M10	M10	M12	M12	M12	M16	M16
α1	60°	60°	60°	60°	60°	60°	60°	60°
α2	180°	120°	120°	120°	120°	120°	120°	120°
Quantity	5	5	6	6	6	6	6	6

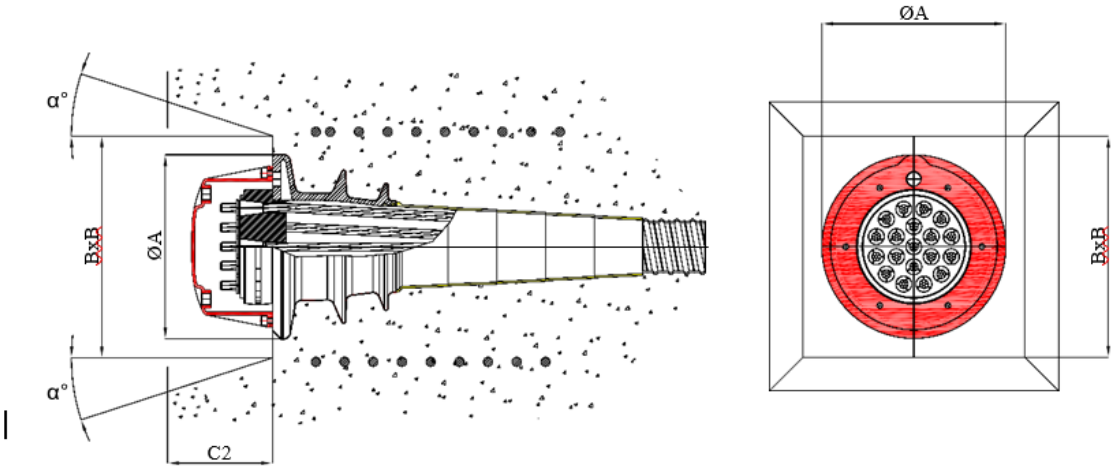
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

Product Description – Connections anchorages

Annex A16
of ETA N° 15/0329



Without protection cap



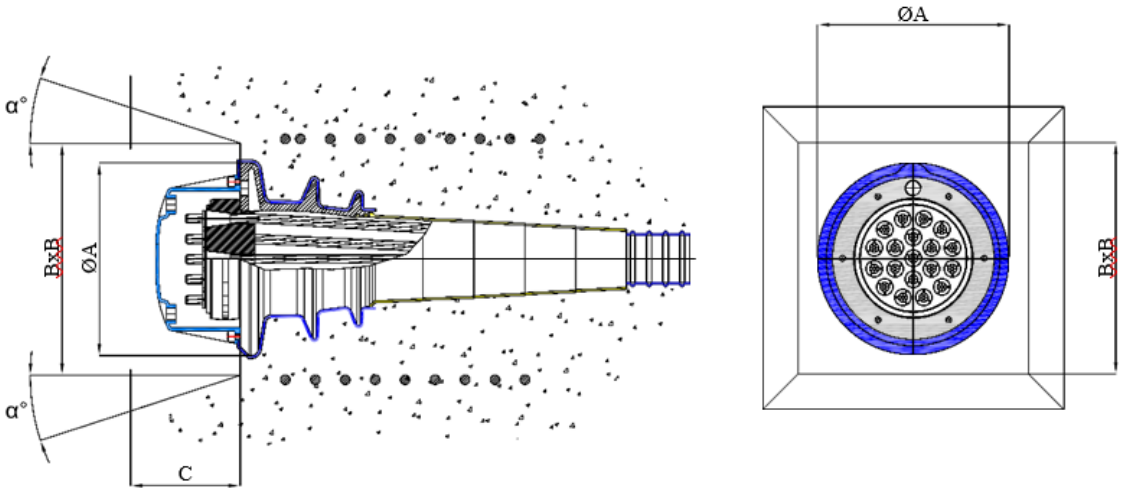
With protection cap

Type	4M15	7M15	9M15	12M15	15M15	19M15	22M15	27M15
A [mm]	160	200	235	265	290	320	355	380
B x B [mm]	200x200	240x240	275x275	305x305	330x330	360x360	395x395	420x420
C1 [mm]	110	110	110	110	110	125	130	140
C2 [mm]	160	160	160	160	160	160	160	160
α°	15	15	15	15	15	15	15	15

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

Product Description – Recess for anchorage type M

Annex A17
of ETA N° 15/0329

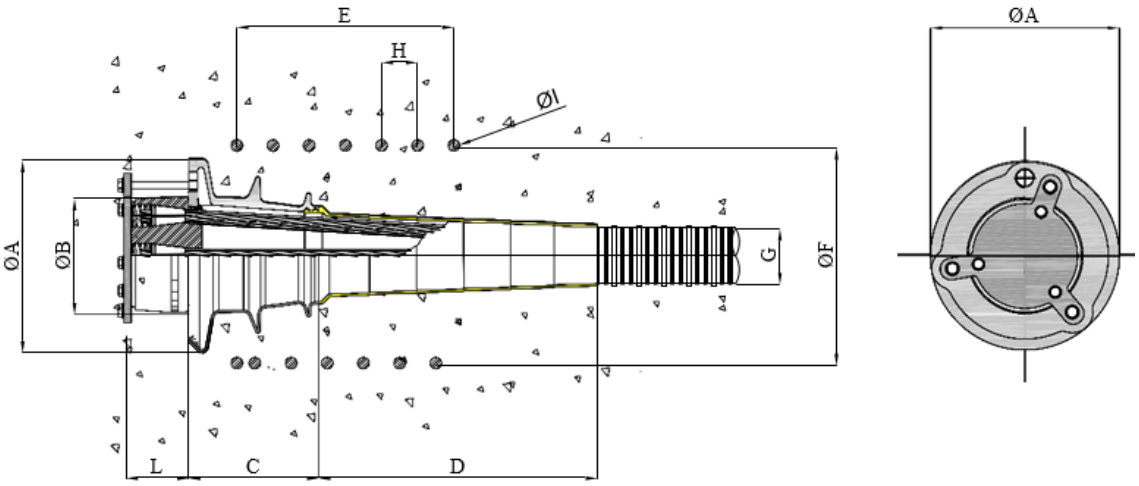


Type	4MX15	7MX15	9MX15	12MX15	15MX15	19MX15	22MX15	27MX15
A [mm]	168	208	243	273	298	328	363	388
B x B [mm]	200x200	240x240	275x275	305x305	330x330	360x360	395x395	420x420
C [mm]	160	160	160	160	160	160	160	160
α°	15	15	15	15	15	15	15	15

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

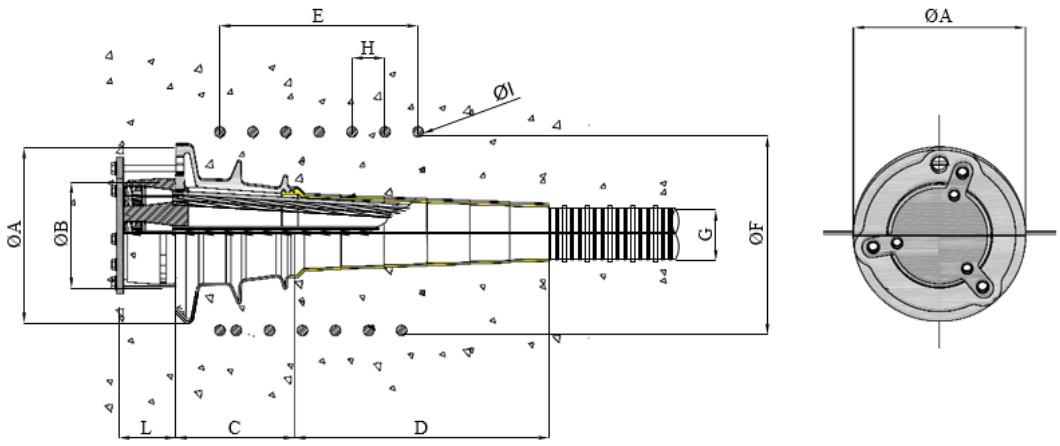
Product Description – Recess for anchorage type MX

Annex A18
of ETA N° 15/0329



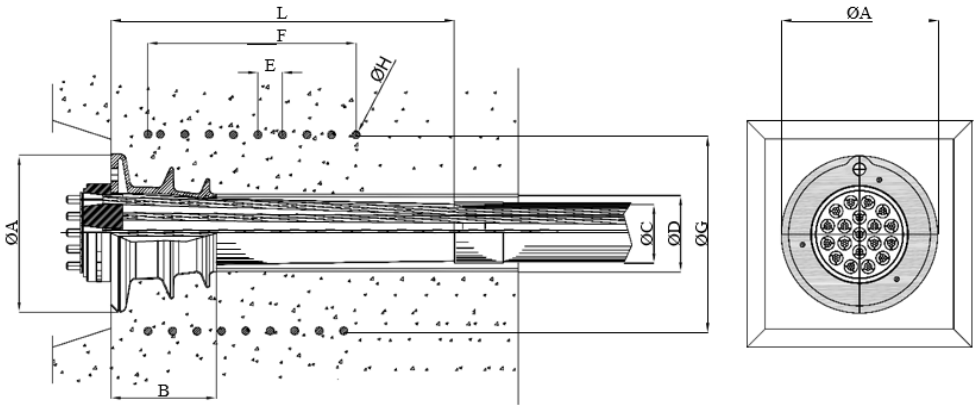
Type	A	B	C	D	E	F	G	H	I	L
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
4D15	160	105	103	300	180	170	45/50	45	12	90
7D15	200	125	133	340	250	220	62/67	45	12	90
9D15	235	146	163	380	250	250	72/77	45	14	90
12D15	265	160	180	385	300	300	80/85	50	16	90
15D15	290	176	197	405	350	355	85/90	50	16	90
19D15	320	200	215	430	425	400	95/100	50	16	106
22D15	355	230	260	430	425	420	100/105	50	18	111
27D15	380	250	277	470	400	460	110/115	50	18	120

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A19** **of ETA N° 15/0329**
Product Description – Passive Anchorage type D – Concrete 45 MPa	



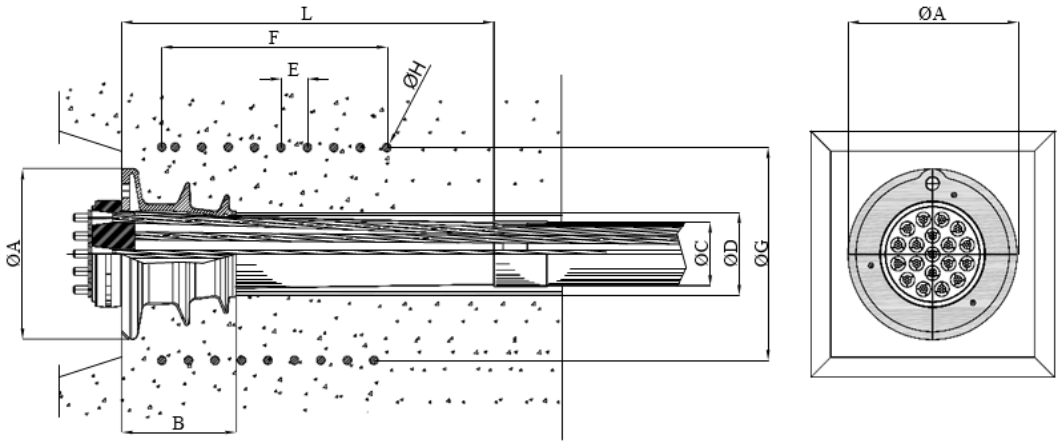
Type	A	B	C	D	E	F	G	H	I	L
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
4D15	160	105	103	300	205	180	45/50	45	12	90
7D15	200	125	133	340	270	240	62/67	45	12	90
9D15	235	146	163	380	270	300	72/77	45	14	90
12D15	265	160	180	385	350	350	80/85	50	16	90
15D15	290	176	197	405	400	410	85/90	50	16	90
19D15	320	200	215	430	450	440	95/100	50	16	106
22D15	355	230	260	430	450	480	100/105	50	18	111
27D15	380	250	277	470	480	530	110/115	60	18	120

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A20** **of ETA N° 15/0329**
Product Description – Passive Anchorage type D – Concrete 35 MPa	



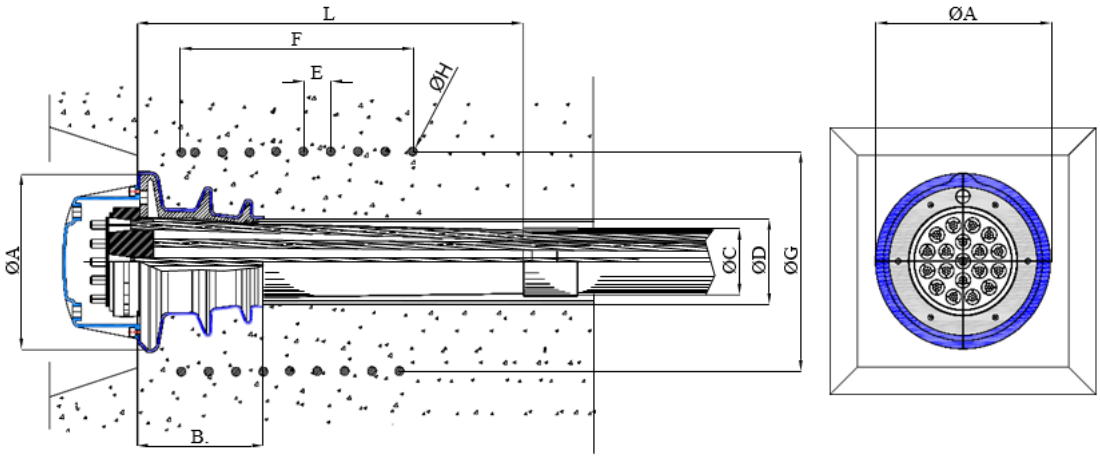
Type	A	B	C	D	E	F	G	H	L
	[mm]	[mm]	[mm]	[mm]	[mm]	(mm)	[mm]	[mm]	[mm]
4ME15	160	103	63	135	45	205	180	12	310
7ME15	200	133	75	160	45	270	240	12	360
9ME15	235	163	90	177	45	270	300	14	430
12ME15	265	180	110	195	50	350	350	16	450
15ME15	290	197	110	210	50	400	410	16	520
19ME15	320	215	125	245	50	450	440	16	645
22ME15	355	260	125	265	50	450	480	18	690
27ME15	380	277	140	295	60	480	530	18	745

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A21** **of ETA N° 15/0329**
Product Description – Anchorages ME – Concrete 35 MPa	



Type	A	B	C	D	E	F	G	H	L
	[mm]	[mm]	[mm]	[mm]	[mm]	(mm)	[mm]	[mm]	[mm]
4ME15	160	103	63	135	45	180	170	12	310
7ME15	200	133	75	160	45	250	220	12	360
9ME15	235	163	90	177	45	250	250	14	430
12ME15	265	180	110	195	50	300	300	16	450
15ME15	290	197	110	210	50	350	355	16	520
19ME15	320	215	125	245	50	425	400	16	645
22ME15	355	260	125	265	50	425	420	18	690
27ME15	380	277	140	295	50	400	460	18	745

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A22** **of ETA N° 15/0329**
Product Description – Anchorages ME – Concrete 45 MPa	

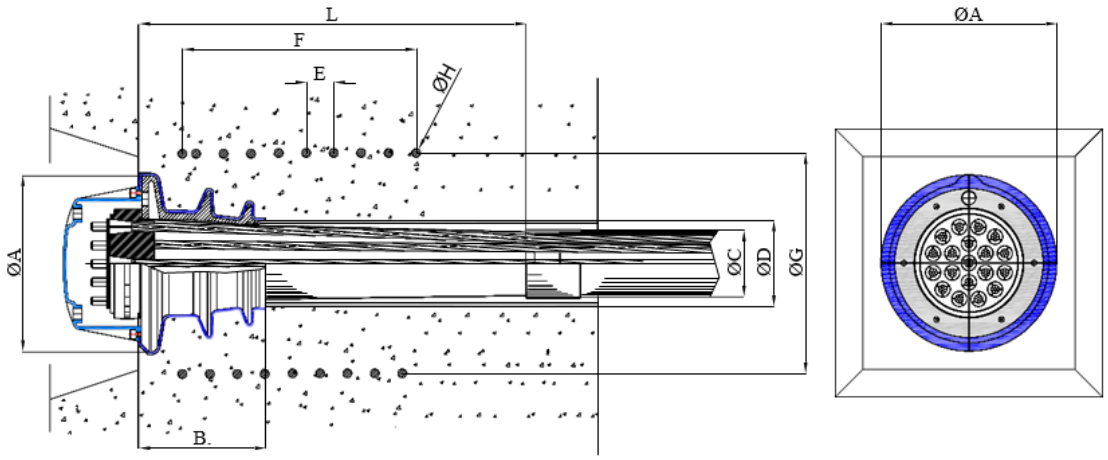


Type	A	B	C	D	E	F	G	H	L
	[mm]	[mm]	[mm]	[mm]	[mm]	(mm)	[mm]	[mm]	[mm]
4MEX15	168	113	63	135	45	205	180	12	310
7MEX15	208	143	75	160	45	270	240	12	360
9MEX15	243	173	90	177	45	270	300	14	430
12MEX15	273	191	110	195	50	350	350	16	450
15MEX15	298	209	110	210	50	400	410	16	520
19MEX15	328	227	125	245	50	450	440	16	645
22MEX15	363	274	125	265	50	450	480	18	690
27MEX15	388	291	140	295	60	480	530	18	745

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

Product Description – Anchorages MEX – Concrete 35 MPa

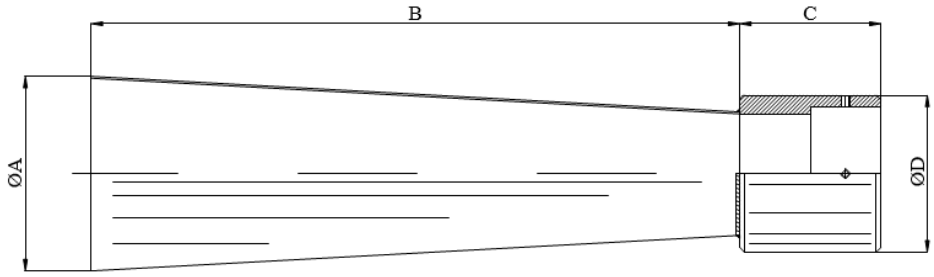
Annex A23
of ETA N° 15/0329



Type	A	B	C	D	E	F	G	H	L
	[mm]	[mm]	[mm]	[mm]	[mm]	(mm)	[mm]	[mm]	[mm]
4MEX15	168	113	63	135	45	180	170	12	310
7MEX15	208	143	75	160	45	250	220	12	360
9MEX15	243	173	90	177	45	250	250	14	430
12MEX15	273	191	110	195	50	300	300	16	450
15MEX15	298	209	110	210	50	350	355	16	520
19MEX15	328	227	125	245	50	425	400	16	645
22MEX15	363	274	125	265	50	425	420	18	690
27MEX15	388	291	140	295	50	400	460	18	745

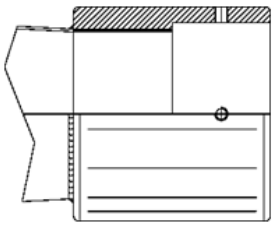
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A24** **of ETA N° 15/0329**
Product Description – Anchorages MEX – Concrete 45 MPa	

INNER STEEL CONE FOR ANCHORAGES ME - MEX

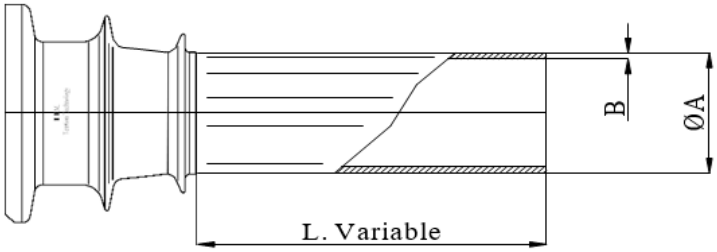


Number of strands	4	7	9	12	15	19	22	27
"ØA" [mm]	75	95	120	130	140	150	190	205
"B" [mm]	300	350	415	430	500	620	665	720
"C" [mm]	110	150	150	150	150	150	150	150
"ØD" [mm]	67	80	100	115	120	135	150	160

In case of bonded application, a plastic ring of HDPE shall be placed to prevent steel friction at the end of the steel cone.



PROTECTION TUBE ANCHORAGES ME - MEX

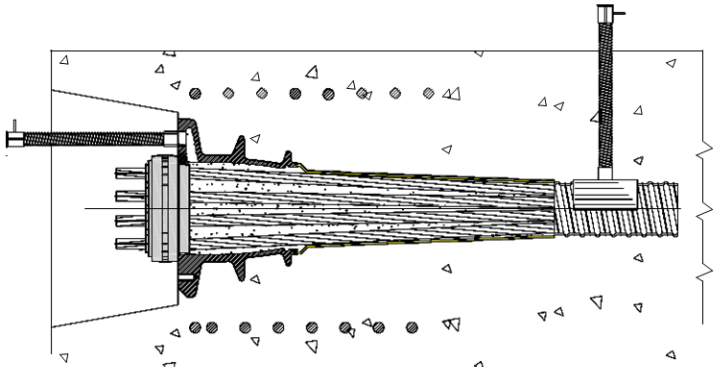


Number of strands	4	7	9	12	15	19	22	27
Tube								
"ØA" [mm]	88,9	101,6	121	139,7	146	159	193,7	203
"B" [mm]	3	3	3	3	3	3	3	3

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A25** **of ETA N° 15/0329**
Product Description – External post tension – Accessories	

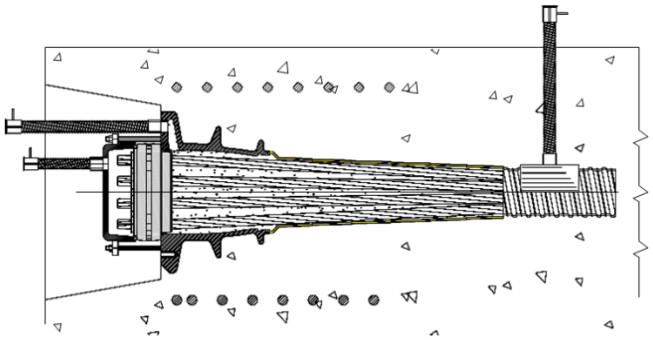
Grouting by infilling

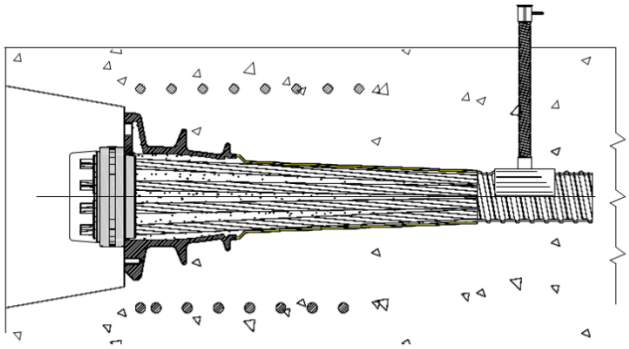
Grouting can be carried out by means of a simple padding using expanding mortar, which must respect the proper covering of the metallic parts of the anchorage.



Grouting with temporary cap

The cap is made up of a cover equipped with a sealing gasket fixed to the casting by means of suitable anchorages which vary in length and size depending on the several applications. A special closing disc tightens the sealing gasket and the cap to the grouting. The disc allows to turn the cap into the most suitable position to allow all the air to come out of the vent tube.

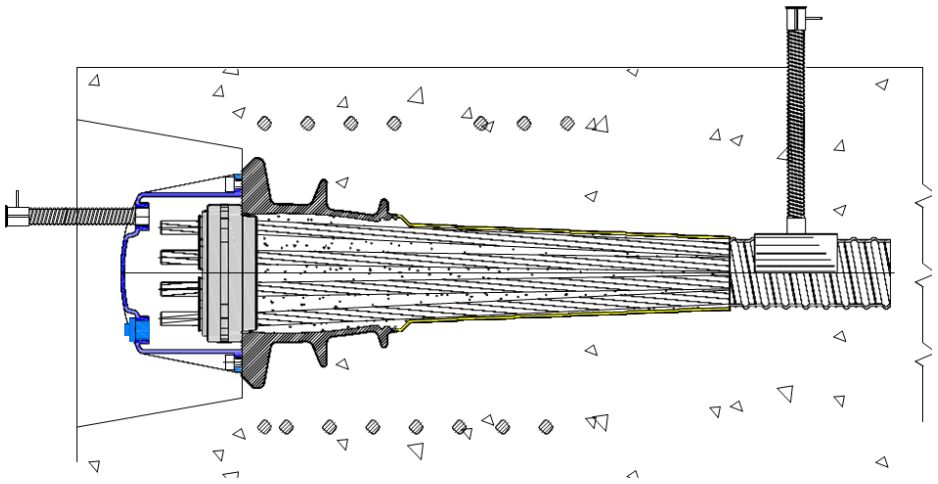


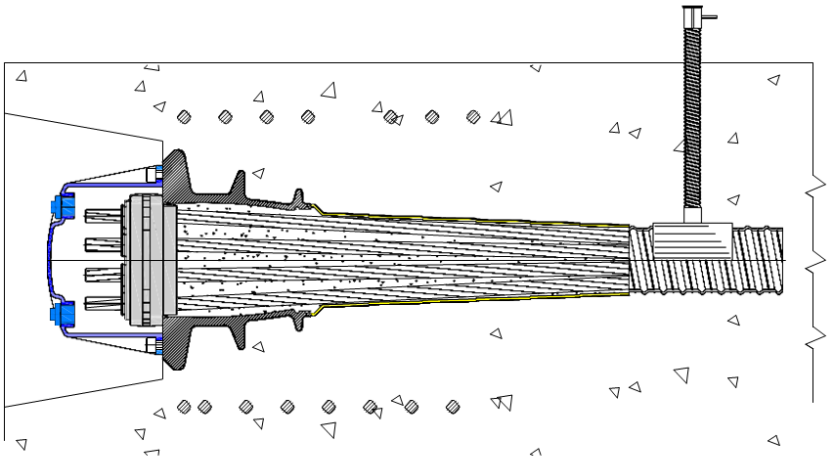


TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A26** **of ETA N° 15/0329**
Product Description – Injections – Anchorages M and MX	

Grouting with permanent cap

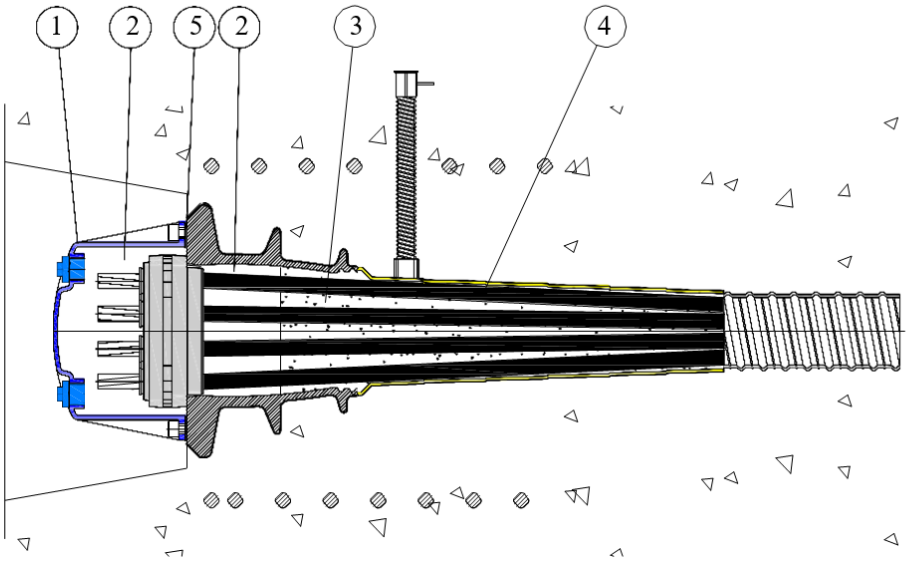
The cap is made of polyethylene and together with a M and MX anchorage guarantees a double protection to corrosion. The cap is provided with plugs to guarantee a correct grouting and vent when filling it.





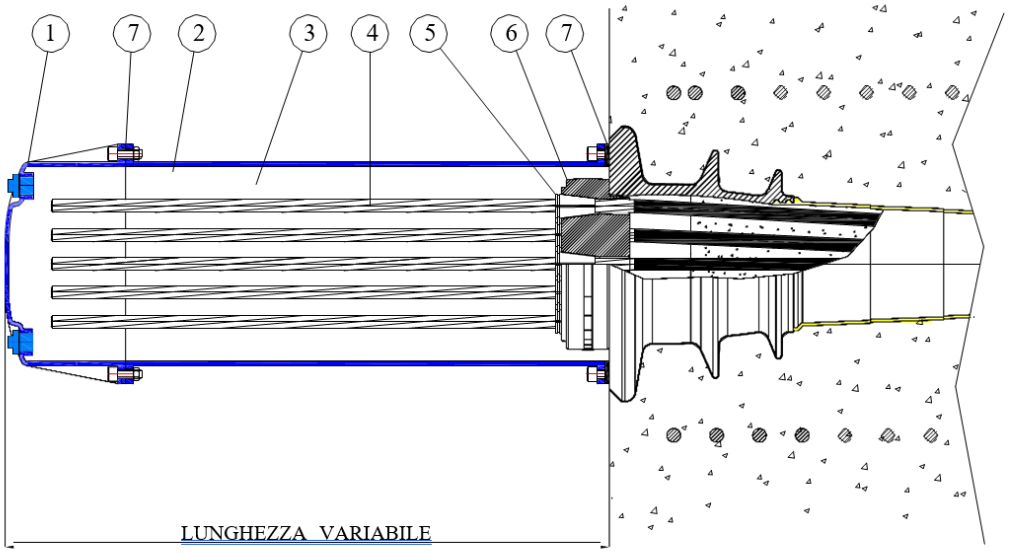
TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A27** **of ETA N° 15/0329**
Product Description – Injections – Anchorages M and MX	

The unbonded post-tensioning with M, MX, and D anchorages is carried out by using unbonded, greased and plastic-coated strands, which are restrained in a mortar grouting with a rubber buffer and allow their following tensioning and the covering with grease of all the parts of the anchorage that are subject to corrosion, such as: anchorage block, wedges and strand are restrained in grease.



1 Cap
2 Grease
3 Cement
4 Unbonded strand
5 Gasket

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A28** **of ETA N° 15/0329**
Product Description – Post-tension. Anchorages M, MX and D	



1 Cap
2 Extension Cap
3 Grease
4 Strands
5 Wedge “T15”
6 Anchor Head “M”
7 Gasket

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A29** **of ETA N° 15/0329**
Product Description – Restressing anchorages M and MX	

Type	Internal Diameter (mm)	External Diameter (mm)	Thickness (mm)
STB-45x50x0,25_CE	45	50	0,25
STB-48x53x0,30_CE	48	53	0,30
STB-51x56x0,30_CE	51	56	0,30
STB-54x59x0,30_CE	54	59	0,30
STB-57x62x0,30_CE	57	62	0,30
STB-59x64x0,30_CE	59	64	0,30
STB-62x67x0,30_CE	62	67	0,30
STB-65x70x0,30_CE	65	70	0,30
STB-69x74x0,35_CE	69	74	0,35
STB-72x77x0,35_CE	72	77	0,35
STB-75x80x0,35_CE	75	80	0,35
STB-80x85x0,35_CE	80	85	0,35
STB-85x90x0,35_CE	85	90	0,35
STB-88x93x0,35_CE	88	93	0,35
STB-90x99x0,40_CE	90	99	0,4
STB-95x104x0,40_CE	95	104	0,4
STB-100x109x0,40_CE	100	109	0,4
STB-105x114x0,40_CE	105	114	0,4
STB-110x119x0,40_CE	110	119	0,4
STB-115x124x0,40_CE	115	124	0,4
STB-120x129x0,40_CE	120	129	0,4
STB-125x134x0,40_CE	125	134	0,4
STB-130x139x0,40_CE	130	139	0,4

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

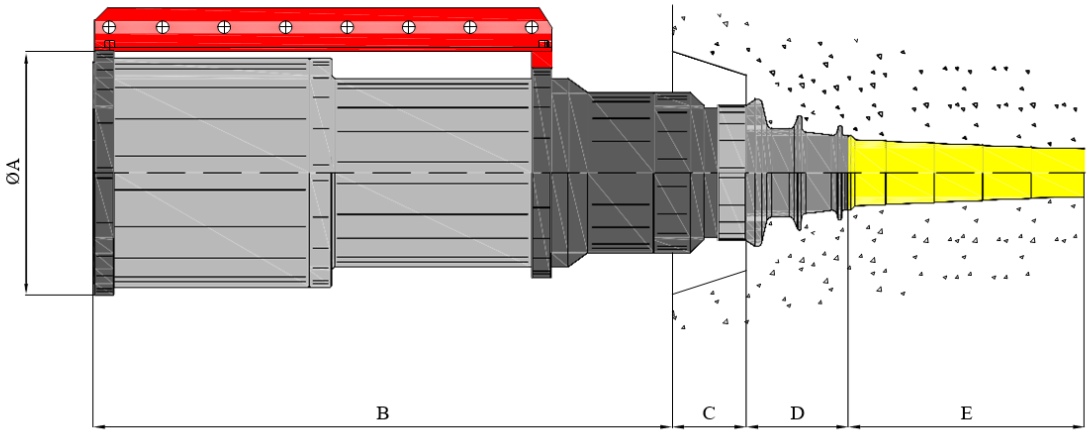
Product Description – Circular steel strip sheaths type

Annex A30
of ETA N° 15/0329

Tensile strength	$f_{p(1)k}$	MPa	1670		
Tensile strength	f_{ptk}	MPa	1860		
	Strand		**T15**	**T15S**	**T15C**
Nominal diameter	D	mm	15.2	15.7	15.2
Nominal cross section	Ap	mm^2	139	150	165
Nominal mass	M	g/m	1093	1172	1289
Characteristic value maximum force	F_m	kN	259	279	307
Characteristic value of 0.1% proof force	$F_{p(0,1)}$	kN	228	246	270
	Coated and Greased Strands				
External diameter	Diam.	mm	18,00	18,50	18,00
Nominal diameter	D	mm	15,2	15,7	15,2
Nominal cross section	Ap	mm^2	139	150	165
Nominal mass	M	g/m	1210	1290	1400
Characteristic value maximum force	F_m	kN	259	279	307
Characteristic value of 0.1% proof force	$F_{p(0,1)}$	kN	228	246	270
	Relaxation after 1000 h				
At 0.7 Rm		%	2.5	2.5	2.5
At 0.8 Rm		%	4.5	4.5	4.5
Modulus of elasticity	E	kN/mm^2	196		

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A31** **of ETA N° 15/0329**
Product Description – Strands	

Characteristics	U.M.	M1600KN	M1800KN	M3000KN	M3600KN	M4800KN	M6800KN
Capacity	kN	1.600	1.800	3.000	3.600	4.800	6.800
Max strands	N°	1-4	4-7	7-12	12-15	15-19	22-27
Stroke	mm	250	250	250	250	250	250
Weight	kg	180	210	280	390	490	650
Stressing section	cm^2	155,51	302,20	424,49	564,21	725,71	879,20
Max. stressing	bar	700	700	700	700	700	700
Max return	bar	250	250	250	250	250	250
Max. looking	bar	250	250	250	250	250	250
Length of the tensioning	mm	400	400	400	450	500	500
Max. diameter	mm	290	330	400	470	520	650
Length	mm	950	1.050	1.000	1.150	1.150	1.270



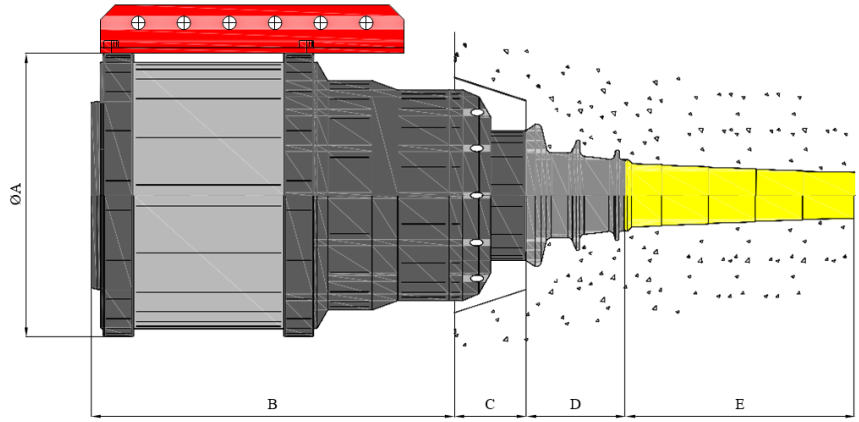
Jack type	N° Strand	Stressing area	Weight	Stroke	Tensioning extension	A	B	C	D	E
		cm^2	Kg.	mm	mm	mm	mm	mm	mm	mm
M1600KN	4	155,51	180	250	400	285	880	110	103	300
M1800KN	7	302,20	210	250	400	330	980	110	133	340
M3000KN	9-12	424,49	280	250	400	400	930	110	163	380
M3600KN	12-15	564,21	390	250	450	470	1090	110	197	405
M4800KN	19	725,71	490	250	500	520	1075	125	215	430
M6800KN	22-27	879,20	650	250	600	650	1270	130	260	430

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

Product Description – Multistrand Jack type M

Annex A32
of ETA N° 15/0329

Characteristics	U.M.	MC3000KN	MC4800KN	MX3600KN
Capacity	kN	3.000	4.80	3.60
Max strands	N°	9-12	15-19	12
Stroke	mm	100	100	100
Weight	kg	350	490	250
Stressing section	cm^2	564,50	636,76	424,49
Max. stressing pressure	bar	700	700	700
Max return pressure	bar	250	250	250
Max. looking pressure	bar	250	250	***
Length of the tensioning strand	mm	400	400	400
Max. diameter	mm	470	540	360
Length	mm	600	650	560

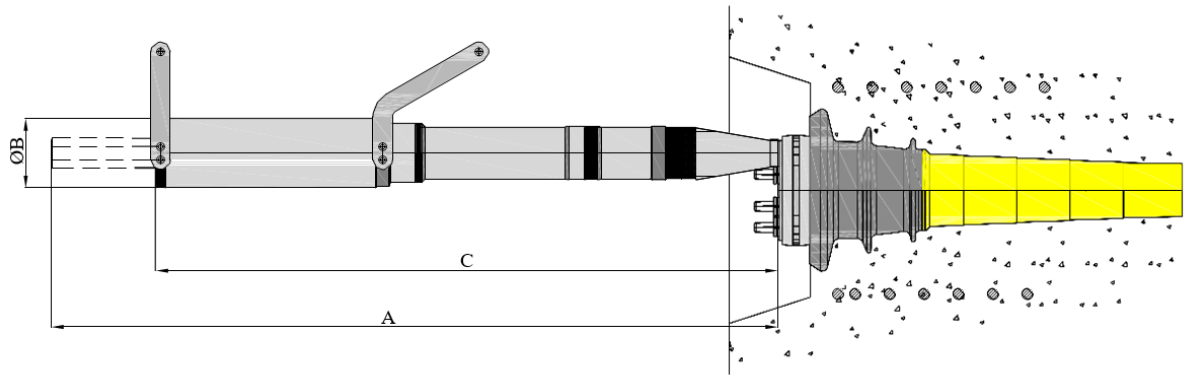


Jack type	N° Strand	Stressing area	Weight	Stroke	Tensioning extension	A	B	C	D	E
		cm^2	kg	mm	mm	mm	mm	mm	mm	mm
MC3000KN	9-12	564,50	350	100	450	470	600	110	163	380
MC4800KN	15-19	636,76	490	100	400	540	650	125	215	430
MX3600KN	12	424,49	250	100	500	360	500	110	180	385

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands

Product Description – Multistrand Jack type M

Annex A33
of ETA N° 15/0329



Jack type	Stressing section	Weight	Stroke	Tensioning extension	A	B	C
	cm^2	Kg	mm	mm	mm	mm	mm
TTM250KN-100	47.2	21.5	100	350	740	100	****
TTM250KN-200	47.2	26	200	350	1150	100	950
TTM300KN-100	68.8	24	100	350	740	110	*****
TTM300KN-200	68.8	28	200	350	1150	110	950

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A34** **of ETA N° 15/0329**
Product Description – Monostrand Jack type TTM	

Design: Maximum prestressing forces

Prestressing and over-tensioning forces have to be set as follows:

- the maximum force P_0 applied to a tendon shall not exceed the force $P_{0,max} = A_p$ min {0,8 f_{pk}; 0,9 $f_{p0,1k}$} laid down in Table A1 (A_p=139 mm^2), in Table A2 (A_p=150 mm^2) or in Table A3 (A_p=165 mm^2).
- the value of the initial prestressing force P_{m0} immediately after tensioning and anchoring shall not exceed the force $P_{m0,max} = A_p$ min {0,75 f_{pk}; 0,85 $f_{p0,1k}$} laid down in Table A 1 (A_p=139 mm^2), in Table A2 (A_p=150 mm^2) or in Table A3 (A_p=165 mm^2).

$$f_{p0,1k} = 0,88 \cdot f_{ptk} = 0,88 \cdot 1860 = 1636,8 \text{ MPa}$$

Table A1: Maximal prestressing forces for tendons with A_p=139 mm^2

Number of strands	**Cross section A_p [mm^2]**	**Prestressing force** $f_{p0,1k}$ = 1636,8*MPa*	
		$P_{m0,max}$ [kN]	**$P_{0,max}$ [kN]**
4	556	774	819
7	973	1354	1433
9	1251	1740	1843
12	1668	2321	2457
15	2085	2901	3071
19	2641	3674	3891
22	3058	4255	4505
27	3753	5221	5529

Table A2: Maximal prestressing forces for tendons with A_p=150 mm^2

Number of strands	**Cross section A_p [mm^2]**	**Prestressing force** $f_{p0,1k}$ = 1636,8*MPa*	
		$P_{m0,max}$ [kN]	**$P_{0,max}$ [kN]**
4	600	835	884
7	1050	1461	1547
9	1350	1878	1989
12	1800	2504	2652
15	2250	3130	3315
19	2850	3965	4198
22	3300	4591	4861
27	4050	5635	5966

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A35/1 of ETA N° 15/0329**
Product Description - Design: Maximum prestressing forces	

Table A3: Maximal prestressing forces for tendons with A_p=165 mm^2

Number of strands	Cross section A_p [mm^2]	Prestressing force $f_{p0,1k}$ = 1636,8*MPa*	
		$P_{m0,max}$ [kN]	$P_{0,max}$ [kN]
4	660	918	972
7	1155	1607	1701
9	1485	2066	2188
12	1980	2755	2917
15	2475	3443	3646
19	3135	4362	4618
22	3630	5050	5347
27	4455	6198	6563

The admissible prestressing force is reduced per strand left out as shown in Table A4.

Table A4: Reduction of the prestressing force when leaving out a strand

A_p [mm^2]	ΔP_{m0} [kN]	ΔP_0 [kN]
139	193	205
150	209	221
165	230	243

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A35/2 of ETA N° 15/0329**
Product Description - Design: Maximum prestressing forces	

Design: minimum concrete strength

For prestressing, the mean compressive strength of concrete shall be at least $f_{cmj,cube}$ or $f_{cmj,cyl}$ according to Table A5.

Table A5: Necessary mean concrete strength, f_{cmj}

Mean concrete strength	Unit	Value	
Cube strength, $f_{cmj,cube}$	MPa	35	45
Cylindric strength, $f_{cmj,cyl}$	MPa	29	37

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

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex A36** **of ETA N° 15/0329**
Product Description - Design: minimum concrete strength	

SPECIFICATION OF INTENDED USE

- **INSTALLATION INSTRUCTIONS**

1. General

Tendons may be manufactured on site or in the manufacturing plant. Assembly and installation of tendons shall only be performed by qualified post-tensioning specialist companies with the required resources in the use of the TTM post-tensioning system. The respective standards and regulations in force at the place of use shall be complied with.

The Manufacturer is responsible to inform anyone concerned about the use of this TTM – Post-tensioning System. Additional information shall be held available at the Manufacturer and shall be distributed as needed. The tendons and the components shall be handled carefully.

2. Installation of tendons

The central position of the helix or stirrups shall be ensured by means of tack-welding to the bearing plate or the anchor body or other appropriate mountings. The bearing plate or anchor body and the anchor head shall be in direction vertical to the axis of the tendon. The tendon shall be placed straightforward for the first meter at the anchorage. The connection between trumpet and duct shall be sealed carefully with tape in order to prevent the penetration of concrete.

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

If the calculated prestressing force is less than 0.7 $P_{m0,max}$ the wedges of fixed anchorages shall be pre-wedged with $P_{0,max}$ (see Annex A35). The wedges of all anchorages which are no more accessible during tensioning shall be secured by means of wedge keeping plates and bolts.

4. Tensioning

Before tensioning the minimum mean concrete strength shall comply with the values given in Annex A36. It is admissible to restress the tendons by releasing and re-using the wedges. After restressing and anchoring, wedge marks on the strands resulting from first stressing shall be moved to the outside by at least 15 mm. The minimum straight length for tensioning behind the anchorages (strand protrusion) depends on the jack which is used on site. All strands of a tendon shall be stressed simultaneously. This can be done by centrally controlled individual jack or by a bundle jack.

5. Grouting

5.1 Grout and grouting procedures (bonded)

Grout according to section 1.2.7 shall be used. Grouting procedures shall be carried out in accordance with EN 447:1996 or EAD 160027-00-0301.

5.2 Cement grout

Cement grout is a stable, uniform mix of cement, additives and water obtained by means of a mechanical mixing process. It is screened and kept agitated in a storage tank until injected into the duct. Prestressing tendons can be injected with:

- a common grout complying with the requirements of the European standards EN 447 (requirements for common grout) and EN 445 (test methods).
- a special grout, according to the requirements stated in EAD 160027-00-0301.

5.3 Grease

The grease for prestressing tendons is a mineral-oil based grease meeting the requirements of EAD 160004-00-0301.

5.4 Water rinse

Normally, tendons shall not be rinsed with water.

5.5 Grouting speed

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

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex B1** **of ETA N° 15/0329**
Intended Use – Installation instructions	

SPECIFICATION OF INTENDED USE

- **INSTALLATION INSTRUCTIONS**

Table B1: Minimum centre spacing

Anchorages		Unit	Value	
Number of strand	$f_{cmj,}$	MPa	35	45
	4	mm	250	230
	7	mm	335	295
	9	mm	370	320
	1	mm	430	380
	1	mm	480	430
	1	mm	545	485
	2	mm	585	520
	2	mm	650	580

Table B2: Minimum edge spacing

Anchorages		Unit	Value	
Number of strand	$f_{cmj,cu}$	MPa	35	45
	4	mm	130	120
	7	mm	175	155
	9	mm	190	165
	1	mm	220	195
	1	mm	245	220
	1	mm	280	250
	2	mm	300	265
	2	mm	330	295

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex B2 of ETA N° 15/0329**
Intended Use – Installation instructions	

Material and standard references

Component	Material	Standard / Specification
Anchor head	C40 - C45	EN 10083-2
Bearing plate	GJS 500-7	UNI ISO 4544
Wedge	16NiCrS4+Pb	EN 10277-4
Helix and additional reinforcements (stirrups)	Re≥500 MPa	Ribbed reinforcement steel B450 C Italian D.M. 17.01.18 EN10080:2005
Spring	C72	EN 10270-1
Cover anchor head	S235	UNI EN 10025-2
Trumpet	HDPE	EAD 160004-00-0301
Steel strip sheaths	Steel	EN 523
PE caps, PE transition tube, PE sleeve	HDPE	EN ISO 1872-1
Concrete	Concrete	EN 206-1
Grouting	Grout	EN 445 – EN 446 – EN 447
Tendon	Strand	pr EN 10138-3

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex B3** **of ETA N° 15/0329**
Intended Use – Installation instructions: Material and standard references	

Table C1: Results of Static tests

Number of Strand	Anchor type	Maximum load F_{max} [kN]	Percentage of the tensile elements ultimate strength [%]	Elongation ε_{Tu} [%]
9	9M15	2768	100.2 (F_{pk} = 2762 kN)	3.45
9	9M15	2714	98.3 (F_{pk} = 2762 kN)	2.96
9	9M15	2699	97.7 (F_{pk} = 2762 kN)	3.10
15	15M15	4587	99.6 (F_{pk} = 4604 kN)	2.97
27	27M15	8205	99.0 (F_{pk} = 8286 kN)	3.54
27	27M15	8108	97.9 (F_{pk} = 8286 kN)	2.89

All the results of the performed tests satisfy the acceptation criteria defined in clause 2.2.1 of EAD.

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex C1** **of ETA N° 15/0329**
Performances – Static Tests	

Table C2: Results of fatigue tests

Number of Strand	Anchor head	n° of broken wires
9	9M15	0
15	15M15	0
27	27M15	1
27	27M15	0

All the results of the performed tests satisfy the acceptation criteria defined in clause 2.2.2 of EAD.

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex C2** **of ETA N° 15/0329**
Performances – Fatigue tests	

Table C3: Results of test for assess the load transfer to structure for anchor head 1E15 – $f_{cm,cube}$ = 35 MPa

Number of strands	$f_{cm,0}$ [MPa]	$f_{cm,e}$ [MPa]	$f_{cm,e}/f_{cm,0}$ [-]	$F_{p,k}$ [kN]	Required load F_{max} [kN]	Ultimate load F_u [kN]	F_u/F_{max} [-]	Max crack width [mm]
9	35	35.5	1.01	2762	3069	3756	1.22	0.12
15	35	37.0	1.06	4604	5368	5935	1.11	0.05
27	35	36.5	1.04	8286	9479	9939	1.05	0.10
27	35	35.0	1.00	8286	9115	9932	1.09	0.12

All the results of the performed tests satisfy the acceptation criteria defined in clause 2.2.3 of EAD.

Table C4: Results of test for assess the load transfer to structure for anchor head 1E15 – $f_{cm,cube}$ = 35 MPa

Strand	$f_{cm,0}$ [MPa]	$f_{cm,e}$ [MPa]	$f_{cm,e}/f_{cm,0}$ [-]	$F_{p,k}$ [kN]	Required load F_{max} [kN]	Ultimate load F_u [kN]	F_u/F_{max} [-]	Max crack width [mm]
9	45	45.0	1.00	2762	3038	3245	1.07	0.10
15	45	46.0	1.02	4604	5166	5243	1.01	0.10
27	45	44.0	0.98	8286	8932	9351	1.05	0.12
27	45	44.0	0.98	8286	8932	9176	1.03	0.12

All the results of the performed tests satisfy the acceptation criteria defined in clause 2.2.3 of EAD.

TTM tension technology - Bonded and unbonded multistrand post-tensioning system with 4 to 27 strands	**Annex C3** **of ETA N° 15/0329**
Performances - Load transfer to structure	