Service d'études techniques des routes et autoroutes
46, avenue Aristide Briand
BP 100
92 225 BAGNEUX CEDEX
Tel : + 33 (0)1 46 11 31 31
Fax : + 33 (0)1 46 11 31 69

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

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Agrément Technique Européen No. ETA-08/0012

(version originale en français)

European Technical Approval No. ETA-08/0012

(Original Version in French Language)

Nom commercial Trade name:	Procédé de précontrainte TENSACCIAI TENSACCIAI Post-tensioning system
Détenteur de l'ATE Holder of approval:	**FINEST S.p.A** Via F.Vegezio 15 20149 Milano (Italy)
Type générique et utilisation prévue du produit de construction Generic type and use of construction product:	Kit de précontrainte de structures par posttension Post-tensioning kit for prestressing of structures
Valid from: to:	**05/03/2008** **05/03/2013**
Producteur du procédé: Kit manufacturer	**TENSACCIAI S.p.A** Via F.Vegezio 15 20149 Milano (Italy)
Le présent agrément technique européen contient : This European Technical Approval contains:	42 pages comprenant 24 pages d'annexes (dessins) 42 pages including 24 pages of annexes (drawings)

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I. LEGAL BASES AND GENERAL CONDITIONS

1. This European Technical Approval is issued by SETRA in accordance with:

   - Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products[1], modified by Council Directive 93/68/EEC[2] and Regulation (EC) N° 1882/2003 of the European Parliament and of the Council[3];

   - décret n°92-647 du 8 juillet 1992[4] concernant l'aptitude à l'usage des produits de construction

   - Common Procedural Rules for Requesting, Preparing and the Granting of European Technical Approvals set out in the Annex to Commission Decision 94/23/EC[5];

   - ETAG 013, Edition June 2002, Post-Tensioning Kits for Prestressing of Structures.

2. SETRA is authorised to check whether the provisions of this European Technical Approval are met. Checking may take place in the manufacturing plant (e.g. concerning the fulfilment of assumptions made in this European Technical Approval with regard to manufacturing). Nevertheless, the responsibility for the conformity of the products to the European Technical Approval and for their fitness for intended use remains with the holder of the European Technical Approval.

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

4. This European Technical Approval may be withdrawn by SETRA according to Article 5.1 of the Council Directive 89/106/EEC.

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

6. The European Technical Approval is issued by SETRA in its official language(s). This version should correspond fully to the version used by EOTA for circulation. Translations into other languages have to be designated as such.

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[1] Official Journal of the European Communities N° L 40, 11.2.1989, p. 12
[2] Official Journal of the European Communities N° L 220, 30.8.1993, p. 1
[3] Official Journal of the European Union N° L 284, 30.10.2003, p. 1
[4] JORF du 14 juillet 1992
[5] Official Journal of the European Communities N° L 17, 20.1.1994, p. 34

II. SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1. Definition of product and intended use

1.1. Definition of product

This European Technical Approval (ETA) applies to a kit, the PT

TENSACCIAI – Bonded strand Post-Tensioning system

consisting of 4 to 37 strands with nominal tensile strength 1860 MPa or 1770 MPa, nominal diameter 15.7 mm (0.62" – 150 mm^2) and 15.2 mm (0,6" – 140 mm^2) which is used in normal-weight concrete with the following anchorages (stressing and fixed anchorages, see Annex 1)

1. Stressing (active) anchorage type MTAI and fixed (passive) anchorage type MTAIM with bonded strands for internal post-tensioning

1.2. Intended use

The post-tensioning system is assumed to be used for the prestressing of structures of normal-weight concrete in concrete and composite structures with internal bonded strands.

1.3. Working life

The provisions made in this European Technical Approval are based on an assumed intended working life of the PT system of 100 years. The indications given on the working life of the PT system cannot be interpreted as a guarantee given by the manufacturer or the Approval Body, but are to be regarded only as means for selecting the appropriate product in relation to the expected, economically reasonable working life of the construction works.

2. Characteristics of product and methods of verification

2.1. General

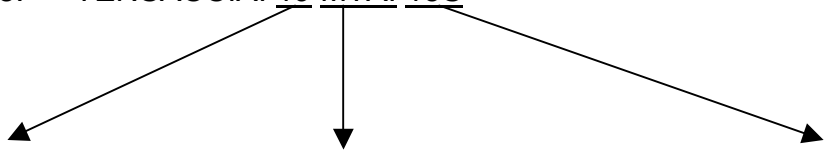
The components correspond to the drawings and provisions given in this European Technical Approval including the Annexes.
The characteristic material values, dimensions and tolerances of the components not indicated in the Annexes or in the following paragraphs correspond to the respective values laid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

2.2. Designation and range of the anchorages

2.2.1. Designation

Each type of anchorage is defined as per the following example, where the three parameters shown below give full information about the product

Anchorage type: TENSACCIAI 19 MTAI 15S



Number of strands Type of anchorage Type of strand

The name of the anchorage type give also identification of the tendon type.

2.2.2. Range

Each single parameter can change according to the following options:

Number of strands: (*classes*)	4 – 7 – 9 – 12 – 15 – 19 – 22 – 27 – 31 – 37 Tendon whose strand number is intermediate between values above given can be obtained by omitting strands in the higher class anchorages.
Type of anchorage:	MTAI: active anchorage – internal post-tensioning MTAIM: passive anchorage – internal post-tensioning
Type of strand:	15S: seven-wire steel strand, external diameter 15.7 mm 15: seven-wire steel strand, external diameter 15.2 mm

System is foreseen to be used with strands whose maximum characteristic tensile strength is 1860 MPa.
In the tables below, describing main technical features, it also mentioned the use of 1770 MPa class of steel.

Table 1 - Main features of tendons using 15.7 mm strand

Strand diameter 15.7 mm – nominal cross section area 150 mm^2 – nominal mass 1172 g/m										
Number of strands	4	7	9	12	15	19	22	27	31	37
Nominal cross section area of steel A_p [mm^2]	600	1050	1350	1800	2250	2850	3300	4050	4650	5550
Nominal mass of steel [kg/m]	4.69	8.20	10.55	14.06	17.58	22.27	25.78	31.64	36.33	43.36
Characteristic tensile strength f_{pk} = 1860 MPa										
Characteristic ultimate resisting force of tendon F_{pk} [kN]	1116	1953	2511	3348	4185	5301	6138	7533	8649	10323
Characteristic tensile strength f_{pk} = 1770 MPa										
Characteristic ultimate resisting force of tendon F_{pk} [kN]	1064	1862	2394	3192	3990	5054	5852	7182	8246	9842

Table 2 - Main features of tendons made with 15.2 mm strand

Strand diameter 15.2 mm – nominal cross section area 139 mm^2 – nominal mass 1086 g/m										
Number of strands	4	7	9	12	15	19	22	27	31	37
Nominal cross section area of steel A_p [mm^2]	556	973	1251	1668	2085	2641	3058	3753	4309	5143
Nominal mass of steel [kg/m]	4.34	7.60	9.77	13.03	16.29	20.63	23.89	29.32	33.66	40.18
Characteristic tensile strength f_{pk} = 1860 MPa										
Characteristic ultimate resisting force of tendon F_{pk} [kN]	1036	1813	2331	3108	3885	4921	5698	6993	8029	9583
Characteristic tensile strength f_{pk} = 1770 MPa										
Characteristic ultimate resisting force of tendon F_{pk} [kN]	984	1722	2214	2952	3690	4674	5412	6642	7626	9102

2.3. Component

2.3.1. Strands

Only 7-wire strands shall be used in accordance with national provisions as long as EN 10138 does not exist.
Main characteristics are given in Table 3, for further information see Annex 22.

Table 3 - Main characteristics of 7-wire steel strand

Characteristic tensile strength f_{pk} [MPa]	1770 or 1860	
Nominal diameter d [mm]	15.2	15.7
Nominal cross section A_p [mm^2]	139	150
Nominal mass of prestressing steel m [kg/m]	1.086	1.172

In a single tendon only strands spun in the same direction shall be used.

2.3.2. Anchor head

Anchor heads are made of steel defined by standard EN 10083-1 as C45 steel grade and have conical holes drilled in circular arrangement to accommodate strands and wedges.
At the rear side each anchor head is provided with a small step, designed to ease centring of the anchorplate inside cast-iron block.
Anchor heads of dead anchorages are also provided with threaded holes for fixing wedge retaining plate and cylindrical seating on each strand's hole for placing retaining spring.
Main characteristics are given in Annex 3.

2.3.3. Wedge

Wedges, with a total length of 43 mm, are made of 3 sectors held together with a spring ring, as shown in Annex 3.
In case of dead anchorages, wedges are kept in place with the use of springs and a retaining plate.
Wedges are made of case hardening steel, defined by reference to standard EN 10084 as steel grade 16NiCr or steel grade C15 as defined by reference to standard EN 10277-2.

2.3.4. Cast-iron block

Cast-iron blocks are made of spheroidal graphite cast-iron defined by reference to EN 1563 as EN-GJS-500-7 and designed with a shape able to transmit prestressing forces from anchor head to concrete.
The front shape is rectangular for better transmission of forces to concrete while the rear side is provided with an inner thread where to join the h.d.p.e. trumpet.
An air vent is provided on one corner of the squared front side of the cast-iron block: a suitable ventilation tube must be fitted to these air-vents.
Main characteristics are given in Annex 4 together with a correct placing scheme.

2.3.5. Trumpet

All trumpets, from the smallest up to the highest tendon's size, are made of high density polyethylene material, whose thickness is increasing with tendon's size.

The external shape is made of single smooth sectors and the device is provided with a threaded end for joining to the cast-iron block.
It is designed in order to provide deviation of strands with a contact between steel strand and hdpe material. No contact between strands and cast-iron steel is allowed by the geometry of this piece.
Main characteristics are given in Annex 5.

2.3.6. Spiral and reinforcement

The spiral and reinforcement are made of ribbed reinforcing steel as defined by standard EN 10080[6] (*).
They must properly fixed in the right position in order to avoid any displacement during concrete pouring.
The relevant dimensions are given in Annex from 6 to 8.
Used steel shall have a yield stress of at least 500 MPa according to EN 1992-1-1.
The resistance to the forces occurring in the structural concrete in the anchorage zone outside the spiral shall be designed and verified. An adequate transverse reinforcement shall be provided in particular for the occurring transverse tension forces.
If required for a specific project design, the reinforcement given in Annex from 6 to 8 can be modified in accordance with the respective regulations in force at the place of use as well as with relevant approval of the local authority and of the ETA holder to provide equivalent performance.

2.3.7. Ducts

Steel sheaths ducts shall be used in accordance with EN 523.
The relevant diameters to be used with each type of tendons are given in Annex 2 and Annex from 10 to 15.
In any case the degree of filling f, ratio between cross sectional area of steel strand and cross sectional area of inner diameter of sheath, should not exceed 0,5 and not be less than 0,35.
A larger inner diameter of sheaths should be selected in the case of long tendons (> 80 m) or if the tensile elements are installed after concreting.
In case of use of plastic sheaths, these must comply with ETAG013, Annex C.3.
Standard and regulations for PE ducts and welding of these ducts valid in place of use shall be considered.

2.3.8. Protection caps

The protection caps are made of steel or alternatively of plastic material.

2.3.9. Grout

Grout shall be used in accordance with EN 447.
In case of use of a special grout, this must comply with ETAG013, Annex C.4.3.
Standards and regulations for grouts and grouting valid in place of use shall be considered.

[6] Until finalisation of EN10080 the requirements for the reinforcement valid at the place of use shall be fulfilled.

2.4. Design

2.4.1. Maximum prestressing force

The maximum prestressing and over-tensioning force to be applied on the tendon are specified in the national standards and regulations in force in the place of use.
Following values are indicative values defined according to EN 1992-1-1, paragraphs 5.10.2 (with recommended values for k_1 and k_2), and according to pr EN 10138.:
- maximum prestressing force $P_{0,\,max} = \min(0{,}8\ F_{pk};\ 0{,}9\ F_{p0,1k})$

where F_{pk} is the characteristic tensile strength of prestressing steel and $F_{p0,1k}$ the characteristic tensile yield force of prestressing steel (0,1% proof load).

Table 4 and Table 5 give indications on the entire range of tendons.

Table 4 – Maximum prestressing force of strand diameter 15.7 mm

Strand diameter 15.7 mm – nominal cross section area 150 mm² – nominal mass 1.172 g/m										
Number of strands	4	7	9	12	15	19	22	27	31	37
Characteristic tensile strength f_{pk} = 1860 MPa										
Maximum prestressing force $P_{0,\,max}$ [kN]	886	1550	1993	2657	3321	4207	4871	5978	6863	8192
Characteristic tensile strength f_{pk} = 1770 MPa										
Maximum prestressing force $P_{0,\,max}$ [kN]	842	1474	1895	2527	3159	4001	4633	5686	6529	7792

Table 5 – Maximum prestressing force of strand diameter 15.2 mm

Strand diameter 15.2 mm – nominal cross section area 139 mm² – nominal mass 1.093 g/m										
Number of strands	4	7	9	12	15	19	22	27	31	37
Characteristic tensile strength f_{pk} = 1860 MPa										
Maximum prestressing force $P_{0,\,max}$ [kN]	821	1436	1847	2462	3078	3899	4514	5540	6361	7592
Characteristic tensile strength f_{pk} = 1770 MPa										
Maximum prestressing force $P_{0,\,max}$ [kN]	778	1361	1750	2333	2916	3694	4277	5249	6026	7193

Nota bene: $P_{0,max}$ is given as indicative value, for the accurate value you have to refer to the National Annex of EN1992, or EN10138, or corresponding National Standards.

In case the number of strands in a tendon is reduced by leaving out some strands, this should be done in the best possible radial symmetrically way, in order to guarantee equal distribution of forces over the anchorplate surface and section.
In order to minimize bending stiffness variation it is recommended to press into the cones not filled short pieces of strands with wedges.

2.4.2. Fatigue resistance

Fatigue resistance of the tendons has been positively tested with a maximum force of $0,65 \times F_{pk}$ and a stress variation of 80 MPa up to $2x10^6$ load cycles.

2.4.3. Minimum centers spacing and edge distances

The minimum center and edge distances of the tendon anchorages shall be those given in Annex 9 depending on the actual mean concrete strength.
In general, spacing shall not be less than the values shown: a reduction up to 15% of the center spacing of the tendon anchorage is permitted in one direction but should not be less than the outside diameter of the spiral. In this case the spacing in the perpendicular direction shall be increased by the same percentage.
The concrete cover given in national standards and provisions shall be taken into account additionally.

2.4.4. Anchorage recess

The anchorage recesses shall be designed as to ensure a minimum concrete cover of at least 30 mm over strands' ends or eventual protection caps embedded into concrete.
Clearance is required for the handling and placing of stressing jacks: an appropriate indication can be obtained starting from stressing jacks dimensions and is described in Annex 18.

2.4.5. Friction losses

The calculation of loss of prestressing force due to friction and wobble effects inside tendons is usually made starting from the following equation, taken from EN 1992-1-1:

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

where:
ΔP_{μ} (x) = loss of prestressing force from 0 up to x distance [kN]
x = distance from the stressing point [m]
P_{max} = force at the stressing end [kN]
μ = friction coefficient between strands and ducts [1/rad]
θ = sum of the angular deviation from 0 up to x distance, irrespective of direction or sign [rad]
k = not intentional angular deviation inside tendons, wobble coefficient [rad/m]

Values for friction coefficient μ are between 0.18 and 0.22 while k values are between 0.005 and 0.01.
Recommended values for calculation are μ = 0.19 [1/rad] and k = 0.005 [rad/m].

2.4.6. Radius of curvature of tendons in the structure

Minimum radius of curvature of tendons is described in Table 6.

Table 6 – Minimum radius of curvature for each type of tendon

Number of strands	Duct inner diameter [mm]	radius of curvature [m]
4	45	4.5
7	62	6.2
9	72	7.2
12	80	8.0
15	85	8.5
19	95	9.5
22	100	10.0
27	110	11.0
31	115	11.5
37	130	13.0

2.4.7. Support of ducts

Spacing of supports for ducts is 1.0 m. In the region of tendon curvatures a smaller spacing is required, around 0.5 m.
In any case ducts shall be systematically fixed in their position so that they are not displaced by pouring and compacting of concrete during usual operations.

2.4.8. Slip at anchorages

For details see paragraph 4.2.3.

2.5. Methods of verification

This European Technical Approval for the “TENSACCIAI Bonded strand post-tensioning system” is issued on the basis of agreed data, deposited at SETRA, which identifies the “TENSACCIAI Bonded strand post-tensioning system” that has been assessed and judged.

Assessment of the fitness of the “TENSACCIAI Bonded strand post-tensioning system” for the intended use in relation to the requirements for mechanical resistance and stability in the sense of Essential Requirements 1 and for ER3 (hygiene, health and environment) has been made in accordance with the ETAG013, European Technical Approvals Guideline of post-tensioning kits for prestressing of structures based on the provisions for all systems.

3. Evaluation of conformity and CE marking

3.1. Attestation of conformity system

According to the decision 98/456/EC of the European Commission[7] the system 1+ of attestation of conformity applies.

This system of attestation of conformity is defined as follows:

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

(a) Tasks of the manufacturer

(1) Factory production control;

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

(b) Tasks for the approved body

(3) Initial type-testing of the products;

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

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

(6) Audit testing of samples taken at the factory.

3.2. Responsibilities

3.2.1. Tasks of the manufacturer

3.2.1.1 Factory production control

The manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures, including records of results performed. This production control system shall insure that the product is in conformity with this European technical approval.

The manufacturer may only use initial material stated in the technical documentation of this European technical approval.

The factory production control shall be in accordance with the "Tensacciai Control Plan" relating to the European technical approval ETA –08/0012 issued on 05/03/2008" which is part of the technical documentation of this European technical approval. The "Control Plan" is laid down in the context of the factory production control system operated by the manufacturer and deposited at SETRA.[8]

The prescribed test plan defined in Annex 19 gives the type and frequency of checks and tests conducted during production and on the final product as part of the continuous internal production control.

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[7] Official Journal of the European communities L201/112 of 3 July 1998

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

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

The records contain at least the following information:

- designation of the product or basic materials and the components;
- type of control or testing;
- date of manufacture and of testing of product or components and of basic materials or components;
- results of controls and tests and, where relevant, comparison with the requirements;
- signature of person responsible for the factory production control.

If the test results are unsatisfactory, the manufacturer shall immediately implement measures to eliminate defects. Construction products or components which are not in compliance with the requirements shall be handled such that they cannot be mistaken for products complying with the requirements. After elimination of the defects the relevant tests shall be immediately repeated as far as is technically possible and necessary for verifying the deficiency elimination.

3.2.1.2 Other tasks

The manufacturer shall, on the basis of a contract, involve a body which is approved for the tasks referred to in section 3.1 in the field of Tensacciai post-tensioning system in order to undertake the actions laid down in section 3.3. For this purpose, the "control plan" referred to in sections 3.2.1.1 and 3.2.2 shall be handed over by the manufacturer to the approved body or bodies involved.

The manufacturer shall make a declaration of conformity, stating that the construction product is in conformity with the provisions of the European technical approval ETA – 08/0012 issued on 05/03/2008.

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

3.2.2. Tasks of the Approved body

3.2.2.1 General

The approved body (bodies) shall perform the

initial type-testing of the product,

initial inspection of factory and of factory production control,

continuous surveillance, assessment and approval of factory production control,

audit-testing of samples taken at the factory

in accordance with the provisions laid down in the "Tensacciai Control Plan" relating to the European Technical Approval ETA-08/0012 issued on 05/03/2008.

The approved body (bodies) shall retain the essential points of its actions referred to above and state the results obtained and conclusions drawn in a written report.

The main production centre is checked at least once a year by the approved body. Each component producer is checked at least once every five years by the approved body.

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

In cases where the provisions of the European Technical Approval and its “Control Plan” are no longer fulfilled the certification body shall withdraw the certificate of conformity and inform SETRA without delay.

3.2.2.2 Initial type testing of the products

For initial type testing the results of the tests performed as part of the assessment of the European Technical Approval may be used unless there are no changes in production procedure or factory plant. In such cases, the necessary initial type testing shall be agreed between SETRA and the Approved Body involved.

3.2.2.3 Initial inspection of factory and of factory production control

The Approved Body shall ascertain that, in accordance with the prescribed test plan, the manufacturing plant, in particular personnel and equipment, and the factory production control are suitable to ensure a continuous orderly manufacturing of the PT system according to the specifications given in Section II as well as in the Annexes of this European Technical Approval.

3.2.2.4 Surveillance, assessment and approval of factory production control

The kit manufacturer shall be inspected at least once a year. Each component manufacturer shall be inspected at least once in five years. It shall be verified that the system of factory production control and the specified manufacturing process are maintained taking into account the prescribed test plan.

3.2.2.5 Audit testing of samples taken at the kit manufacturer

During surveillance inspection, the Approved Body shall take samples at the factory of components of the PT system or of individual components for which this European Technical Approval has been granted, for independent testing.
For the most important components Annex 21, complying with ETAG013, Annex E.2, summarises the minimum procedures.

3.3. CE marking

The delivery note of the components of the PT system shall contain the CE marking. The symbol “CE” shall be followed by the identification number of the Approved certification Body and shall be accompanied by the following information:

- The name and address of the producer (legal entity responsible for the manufacture)
- The last two digits of the year in which the CE marking was affixed
- The number of the EC certificate of conformity for the product
- Number of the European Technical Approval
- the category(ies) of use
- "for further information, refer to the ETA"

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

4.1. Manufacturing

TENSACCIAI Bonded Post-tensioning system is manufactured in accordance with the provisions of this European Technical Approval. Composition and manufacturing drawings are deposited at SETRA.
Tendons may be manufactured on site or in the manufacturing plant.

4.2. Installation

4.2.1. General

Assembly and installation of the tendons shall only be performed by qualified post-tensioning specialist companies which have the required technical skills, resources and experiences with this TENSACCIAI multi-strand post-tensioning system.
Reference is made to ETAG013, Annex D.1 and to CWA 14646:2003.
The company's site manager shall have a certificate of the ETA holder certifying that he's instructed by the ETA holder and has the required knowledge and experience with this post-tensioning system. National regulations and standards valid at the place of use shall also be considered.
The ETA holder is responsible to inform anyone concerned about the use of this TENSACCIAI post-tensioning system.
Additional information, as listed in paragraph 9.2 of ETAG013, shall be available at the ETA holder and shall be distributed as needed.

4.2.2. Installation of tendons

Cast-iron body and anchorplate shall be placed perpendicular to the tendon's axis.
Air vent on the front side of the cast-iron body must be placed on the top while fixing it to formwork as shown in Annex 4.
The position of the helix and stirrups shall be ensured to the cast-iron body or to other appropriate mountings by tack-welding or proper fixing.
At the anchorages the tendon layout shall provide a straight section over a length of at least 250 mm beyond the end of the trumpet.
Before placing the concrete a final check of the installed tendons or sheaths has to be carried out.
The connection between trumpet and duct shall be sealed carefully by tape in order to prevent the penetrating of concrete.

4.2.3. Wedging force, slip at anchorages, wedge securing

The draw-in of the wedges into the anchorage must be taken into account for the determination of the elongations and are described in Table 7.
The wedges of all anchorages (fixed) which are no more accessible during tensioning are secured by means of wedge keeping springs, plates and bolts.

Table 7 – Wedges draw-in

	minimum value [mm]	maximum value [mm]	mean value [mm]
stressing side	4	6	5
fixed side	3	5	4

For design, the mean value shall be taken.

4.2.4. Stressing and stressing records

At the time of stressing the mean concrete compressive strength $f_{cm,0}$ shall be at least according to values shown in Annex from 6 to 8.
Table 8 gives indication and relationship between cylindrical and cubic strength. In any case concrete complying with EN 206-1 shall be used.

Table 8 – Compressive strength of concrete

Mean concrete strength		$f_{cm,0}$		
Cylindrical strength, $f_{cm,0\text{ - cyl}}$	MPa	25	33	45
Cubic strength, $f_{cm,0\text{ - cub}}$	MPa	30	40	55

The mean concrete strength $f_{cm,0}$ (cubic or cylindrical) shall be verified by means of at least three specimens (cube with the edge length of 150 mm or cylinder with diameter of 150 mm and height of 300 mm) which shall be stored under the same conditions as the concrete member.
Elongation and prestressing forces shall be checked continuously during stressing operations. The results of the prestressing operations shall be recorded and measured, elongations shall be compared with the prior calculated theoretical values.
Results of stressing operations have to be recorded in the stressing records.
The ETA holder shall keep available information on prestressing jacks and equipment.
Appropriate clearance must be kept behind the jack, complying with safety at work and health protection regulations.

4.2.5. Grouting

Grouting shall be performed in accordance with EN 446, while injection grout have to comply with EN 447. Special grout has to comply with ETAG013 Annex C.4.3.
Grout shall be injected through the inlet hole until it escapes from the outlet tube or outlet hole. Special measures have to be applied for long tendons, for tendon paths with distinct high points or inclined tendons to avoid voids in the hardened grout. All vents and grouting inlets have to be sealed soon after grouting.
Results of grouting operations have to be recorded in the grouting records.

5. Recommendations for the manufacturer

5.1. Recommendations on packaging, transport and storage

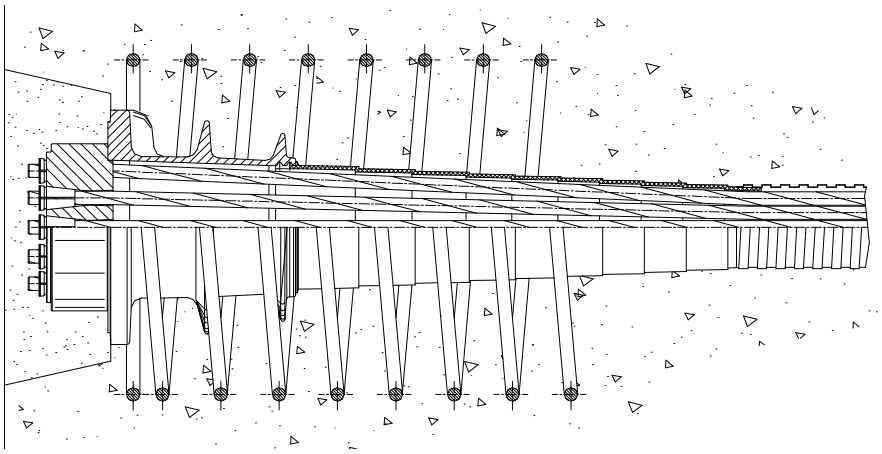
The components and the tendons shall be protected against moisture and staining, taking all necessary measures to avoid conditions for rust and chemical, mechanical and electrochemical damages to components.
Tensile elements shall be kept separate from areas where welding operations are carried out.

5.2. Recommendations on use, maintenance, repair

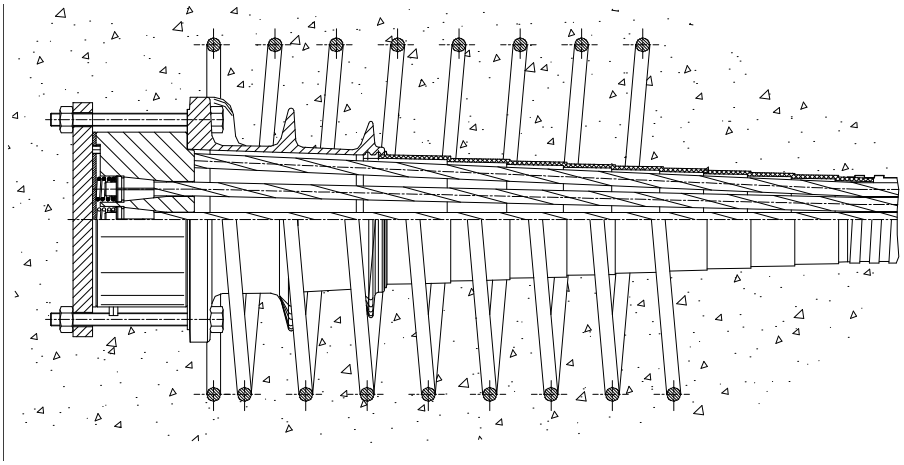
Manufacturer's installation instructions have to complied with, according to ETAG013, Annex D.3. In any case respective standards and regulations in force at the place of use should be observed.
It is highly recommended to apply CWA 14646:2003.

System overview

(from 4 up to 37 strands)



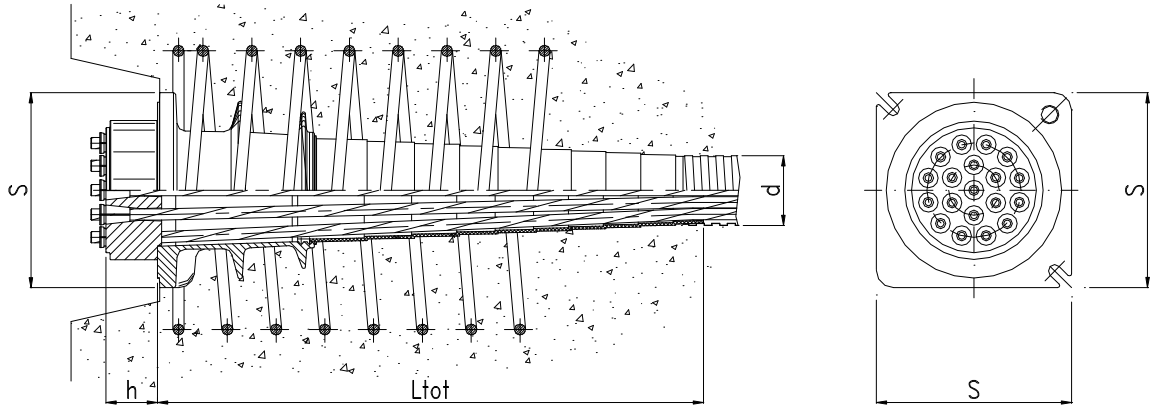
MTAI system – Internal post-tensioning
Active stressing anchorage – accessible fixed anchorage



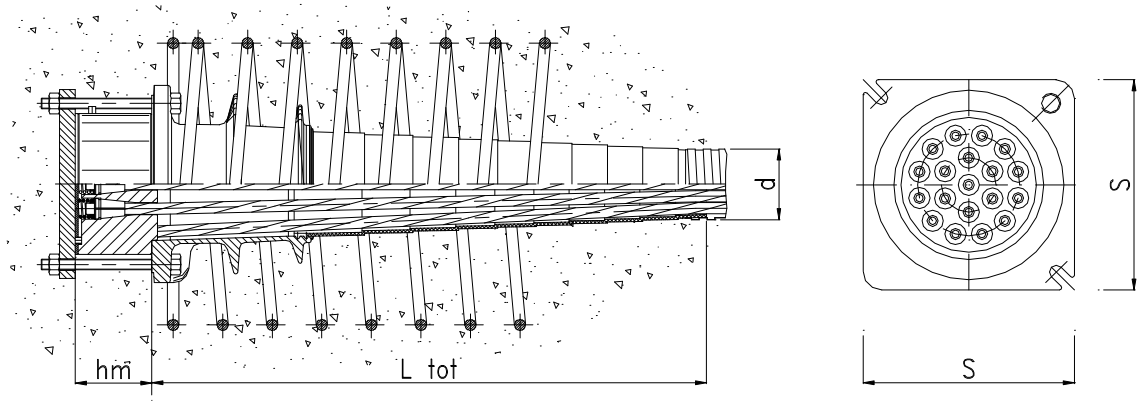
MTAIM system – Internal post-tensioning
Dead fixed anchorage

TENSACCIAI	**Post-tensioning system** **Anchorages overview**	**Annex 1** of European Technical Approval ETA-08/0012

MTAI system



MTAIM system



MTAI system size	4	7	9	12	15	19	22	27	31	37
L_{TOT} [mm]	475	531	688	708	736	783	823	848	1009	1107
S [mm]	150	180	200	220	250	280	300	325	350	400
h [mm]	45	49	52	62	69	74	80	87	91	96
h_m [mm]	77	84	84	92	98	106	110	115	122	131
d (int/ext) [mm]	45/ 50	62/ 67	72/ 77	80/ 85	85/ 90	95/ 100	100/ 105	110/ 115	115/ 120	130/ 135

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Post-tensioning system
Overall dimensions - 1

Annex 2
of European Technical Approval
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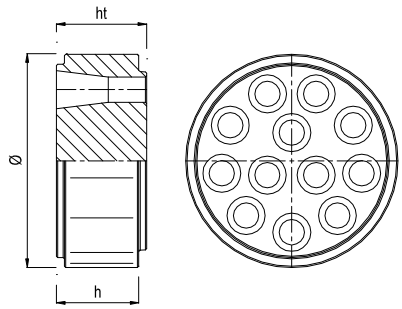
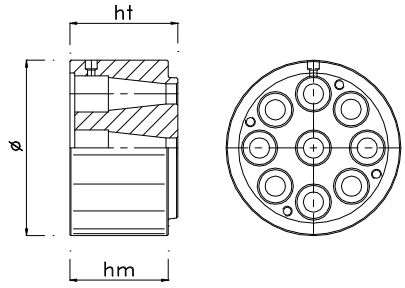
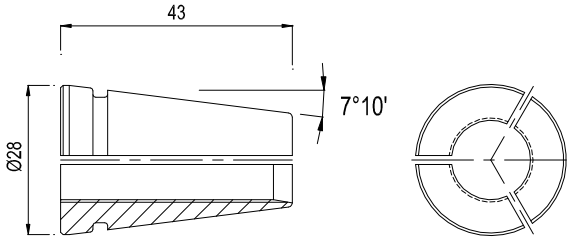
Anchorplate MT (MTAI system)



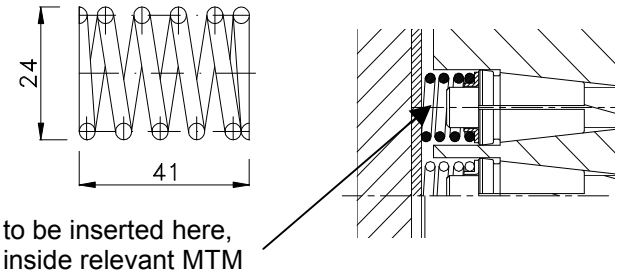
Anchorplate MTM (MTAIM system)



Wedge



Spring (MTAIM system)



to be inserted here, inside relevant MTM anchorplate strand's hole beneath fixing plate

MTAI system size	4	7	9	12	15	19	22	27	31	37
Anchorplate MT										
Φ [mm]	105	125	146	160	176	200	230	250	270	280
h [mm]	45	49	52	62	69	74	80	87	91	96
h_T [mm]	53	55	58	68	75	80	90	97	106	115
weight [kg]	2.8	4	6	8.5	11.3	15.7	23.4	29.9	37.2	42.3
Anchorplate MTM										
Φ [mm]	105	125	146	160	176	200	230	250	270	280
h_m [mm]	77	84	84	92	98	106	110	115	122	131
h_T [mm]	85	90	90	98	104	112	120	125	137	150
weight [kg]	4.1	6.1	8.5	10.9	14.1	20.2	29.4	36	45.6	52.2

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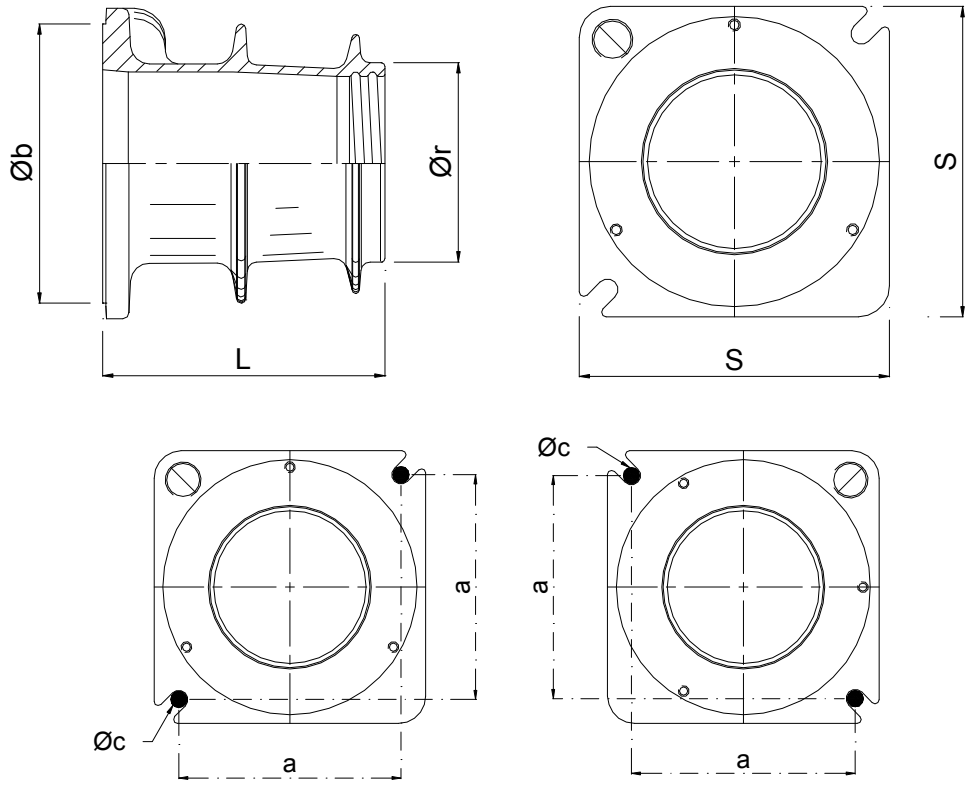
Post-tensioning system
Anchorage parts
Dimensions - 1

Annex 3
of European Technical Approval
ETA-08/0012

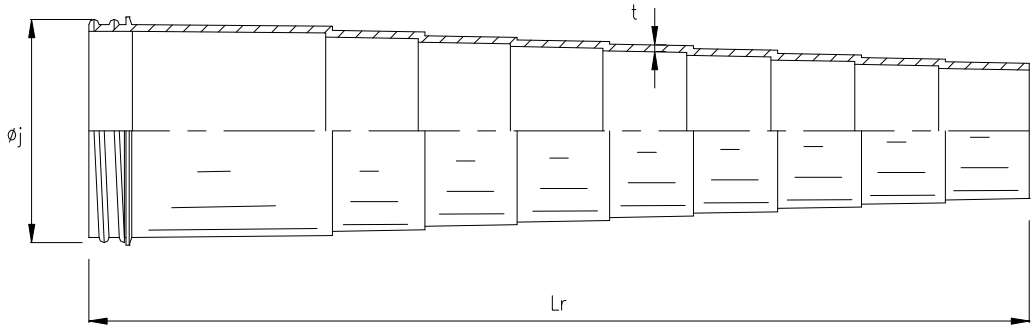
Cast-iron block



fixation to formwork (two only right positions)

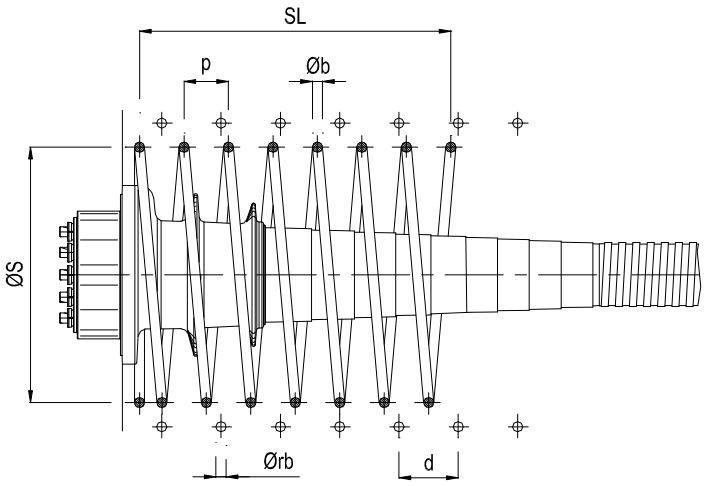
MTAI system size	4	7	9	12	15	19	22	27	31	37
Cast-iron block										
Φ_b [mm]	134	165	186	200	230	252	270	302	330	360
Φ_r [mm]	84	103	130	142	152	166	197	206	230	231
L [mm]	100	120	180	190	208	225	240	250	300	360
S [mm]	150	180	200	220	250	280	300	325	350	400
weight [kg]	2.7	3.5	7	7.8	10.5	15.1	19	25.5	31.4	47.3
a [mm]	112	152	164	182	208	232	255	277	307	357
Φ_c [mm]	10	10	10	10	12	12	12	14	14	14

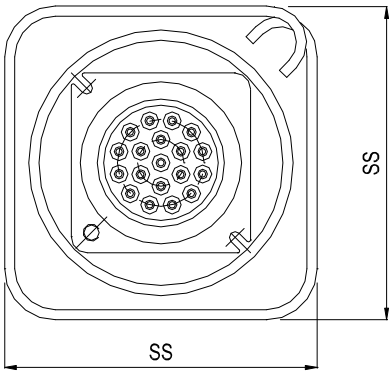
H.d.p.e. trumpet



MTAI system size	4	7	9	12	15	19	22	27	31	37
H.d.p.e trumpet										
Φj [mm]	79	97	118	132	140	154	188	189	216	223
L_r [mm]	390	430	530	540	550	580	605	620	735	775
t [mm]	2.5	2.5	3	3.5	3.5	3.5	3.5	3.5	3.5	3.5

Bursting and additional reinforcement





MTAI system size	4			7			9			12		
Bursting reinforcement												
Concrete strength $f_{cm,0-cyl}$ [MPa]	25	33	45	25	33	45	25	33	45	25	33	45
Φs [mm]	200	170	150	250	210	180	290	260	230	340	310	280
Φb [mm]	10			12			12			14		
SL [mm]	250	225	200	360	300	270	420	360	330	480	420	360
p [mm]	50			60			60			60		
No. of turns	5	4,5	4	6	5	4,5	7	6	5,5	8	7	6
Additional reinforcement												
Concrete strength $f_{cm,0-cyl}$ [MPa]	25	33	45	25	33	45	25	33	45	25	33	45
Φrb [mm]	8			10			10			10		
d [mm]	50			55			55			55		
SS [mm]	230	180	170	310	260	230	380	320	280	440	360	320
No. of stirrups	4	4	4	6	6	5	6	6	6	7	6	6

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Post-tensioning system
Bursting and additional reinforcement - 1

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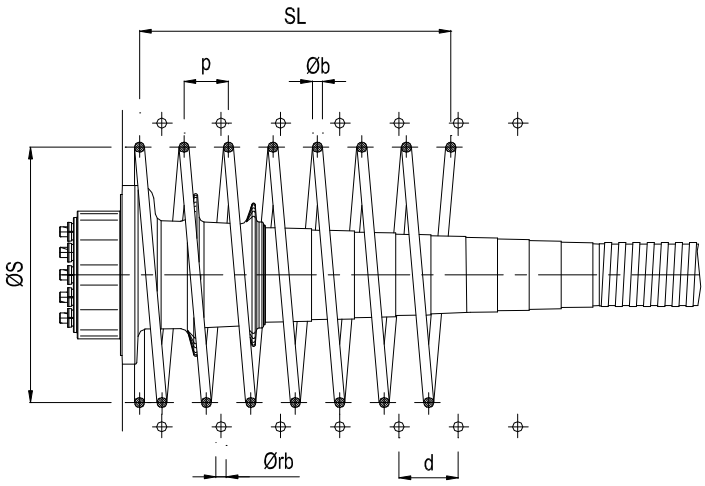
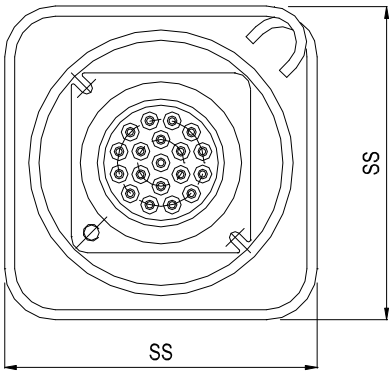
of European Technical Approval ETA-08/0012

Bursting and additional reinforcement





MTAI system size	15			19			22			27		
Bursting reinforcement												
Concrete strength $f_{cm,0-cyl}$ [MPa]	25	33	45	25	33	45	25	33	45	25	33	45
Φs [mm]	380	350	315	410	380	360	470	430	400	500	470	440
Φb [mm]	14			16			16			20		
SL [mm]	510	450	420	570	510	450	660	540	480	720	600	540
p [mm]	60			60			60			60		
No. of turns	8.5	7.5	7	9.5	8.5	7.5	11	9	8	12	10	9
Additional reinforcement												
Concrete strength $f_{cm,0-cyl}$ [MPa]	25	33	45	25	33	45	25	33	45	25	33	45
Φrb [mm]	12			12			12			14		
d [mm]	60			60			60			65		
SS [mm]	490	420	360	540	460	410	610	500	450	680	580	490
No. of stirrups	9	8	8	9	9	8	9	9	8	11	11	10

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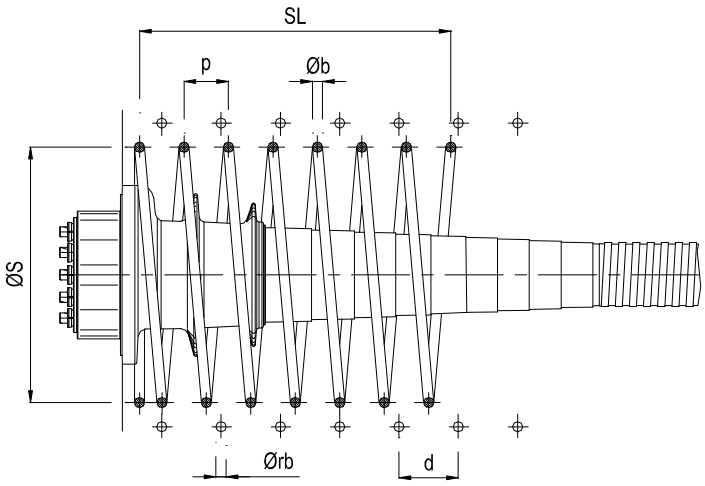
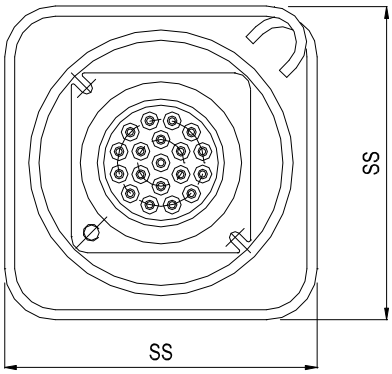
Post-tensioning system
Bursting and additional reinforcement - 2

Annex 7
of European Technical Approval ETA-08/0012

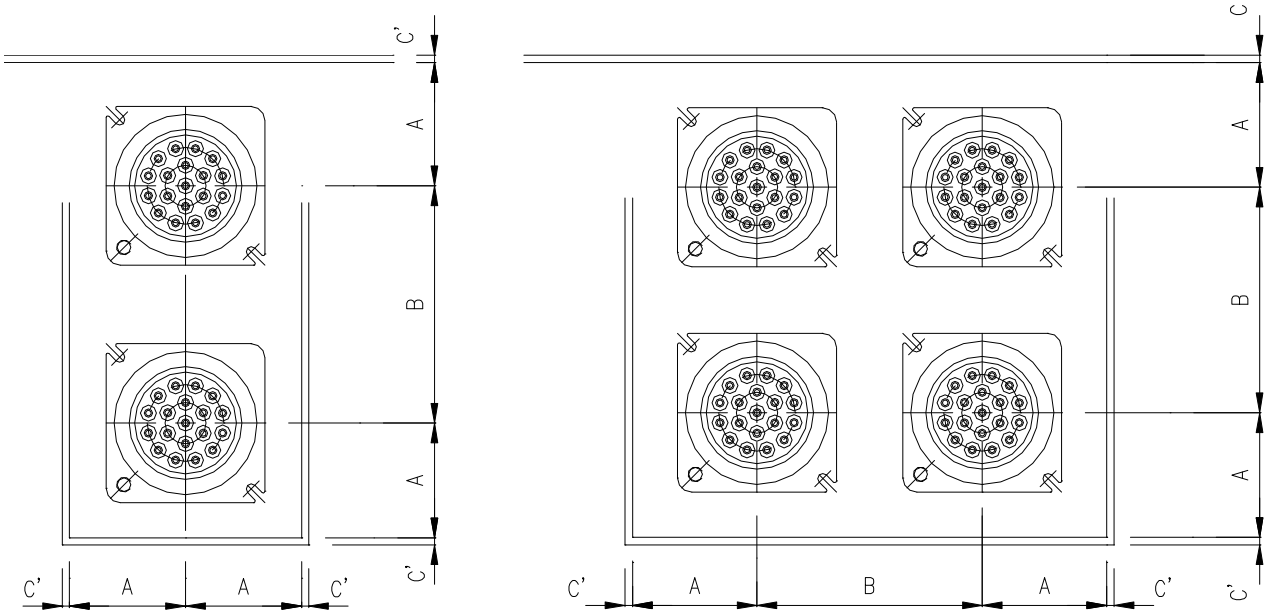
Bursting and additional reinforcement





MTAI system size	31			37		
Bursting reinforcement						
Concrete strength $f_{cm,0-cyl}$ [MPa]	25	33	45	25	33	45
Φs [mm]	540	500	470	560	530	500
Φb [mm]	20			20		
SL [mm]	750	630	570	780	720	630
p [mm]	60			60		
No. of turns	12.5	10.5	9.5	13	12	10.5
Additional reinforcement						
Concrete strength $f_{cm,0-cyl}$ [MPa]	25	33	45	25	33	45
Φrb [mm]	14			16		
d [mm]	65			65		
SS [mm]	720	600	530	800	680	600
No. of stirrups	11	11	10	14	13	13

Center and edge distances



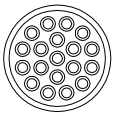
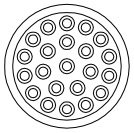
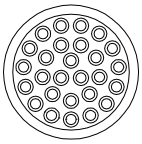
MTAI system size	4	7	9	12	15	19	22	27	31	37
Minimum edge distance (A) [mm] not including cover										
$f_{cm,0\text{ - cyl}}$ = 25 MPa	125	165	190	220	250	280	305	340	365	410
$f_{cm,0\text{ - cyl}}$ = 33 MPa	110	145	165	195	220	245	265	300	325	360
$f_{cm,0\text{ - cyl}}$ = 45 MPa	95	130	144	170	190	215	230	260	280	310
Minimum center distance (B) [mm]										
$f_{cm,0\text{ - cyl}}$ = 25 MPa	270	355	400	465	520	580	630	700	755	840
$f_{cm,0\text{ - cyl}}$ = 33 MPa	240	315	355	410	460	515	555	620	670	740
$f_{cm,0\text{ - cyl}}$ = 45 MPa	210	280	315	360	405	450	485	540	585	640

c' - concrete cover in accordance with European Standard EN 1992-1-1 and national regulations valid at the place of use

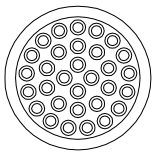
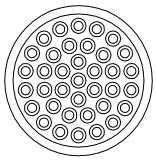
Technical features: system MTAI15S – MTAI15 – Steel grade Y1860

Tendon type		4MTAI	7MTAI	9MTAI	12MTAI
Strand pattern					
Number of strands	n	**4**	**7**	**9**	**12**
Strand 150 mm^2 (T15S)					
Nominal cross section A_p	mm^2	600	1050	1350	1800
Nominal mass	kg/m	4.69	8.20	10.55	14.06
Ultimate force F_{pk}	kN	1116	1953	2511	3348
Max stressing force $P_{0, max}$	kN	886	1550	1992	2656
Strand 139 mm^2 (T15)					
Nominal cross section A_p	mm^2	556	973	1251	1668
Nominal mass	kg/m	4.34	7.60	9.77	13.03
Ultimate force F_{pk}	kN	1040	1820	2340	3120
Max stressing force $P_{0, max}$	kN	821	1436	1847	2462
Ducts					
Inner diameter (minimum)	mm	45	62	72	80
Outer diameter (maximum)	mm	50	67	77	85

Technical features: system MTAI15S – MTAI15 – Steel grade Y1860

Tendon type		15MTAI	19MTAI	22MTAI	27MTAI
Strand pattern					
Number of strands	n	**15**	**19**	**22**	**27**
Strand 150 mm^2 (T15S)					
Nominal cross section A_p	mm^2	2250	2850	3300	4050
Nominal mass	kg/m	17.58	22.27	25.78	31.64
Ultimate force F_{pk}	kN	4185	5301	6138	7533
Max stressing force $P_{0, max}$	kN	3321	4206	4871	5978
Strand 139 mm^2 (T15)					
Nominal cross section A_p	mm^2	2085	2641	3058	3753
Nominal mass	kg/m	16.29	20.63	23.89	29.32
Ultimate force F_{pk}	kN	3885	4921	5698	6993
Max stressing force $P_{0, max}$	kN	3078	3898	4514	5540
Ducts					
Inner diameter (minimum)	mm	85	95	100	110
Outer diameter (maximum)	mm	90	100	105	115

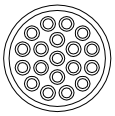
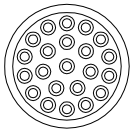
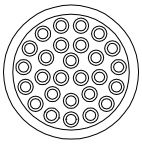
Technical features: system MTAI15S – MTAI15 – Steel grade Y1860

Tendon type		31MTAI	37MTAI
Strand pattern			
Number of strands	n	**31**	**37**
Strand 150 mm^2 (T15S)			
Nominal cross section A_p	mm^2	4650	5550
Nominal mass	kg/m	36.33	43.36
Ultimate force F_{pk}	kN	8649	10323
Max stressing force $P_{0,\,max}$	kN	6863	8192
Strand 139 mm^2 (T15)			
Nominal cross section A_p	mm^2	4309	5143
Nominal mass	kg/m	33.66	40.18
Ultimate force F_{pk}	kN	8029	9583
Max stressing force $P_{0,\,max}$	kN	6361	7592
Ducts			
Inner diameter (minimum)	mm	115	130
Outer diameter (maximum)	mm	120	135

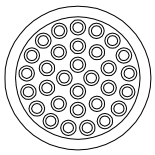
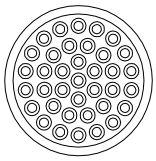
Technical features: system MTAI15S – MTAI15 – Steel grade Y1770

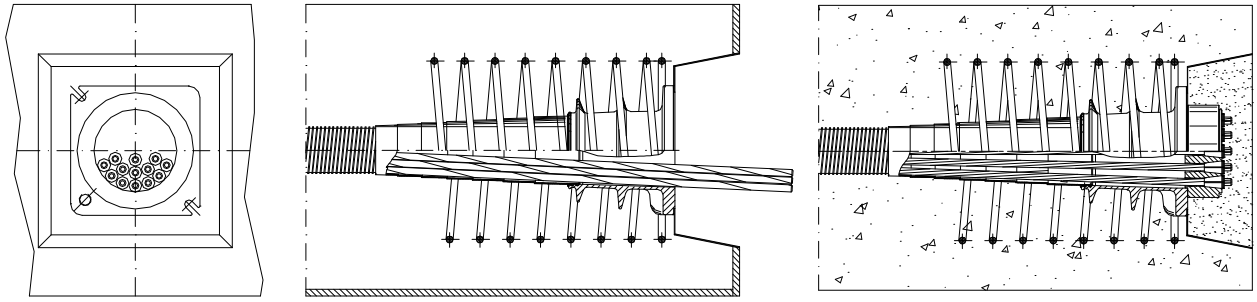
Tendon type		4MTAI	7MTAI	9MTAI	12MTAI
Strand pattern					
Number of strands	n	**4**	**7**	**9**	**12**
Strand 150 mm^2 (T15S)					
Nominal cross section A_p	mm^2	600	1050	1350	1800
Nominal mass	kg/m	4.69	8.20	10.55	14.06
Ultimate force F_{pk}	kN	1064	1862	2394	3192
Max stressing force $P_{0, max}$	kN	842	1474	1895	2527
Strand 139 mm^2 (T15)					
Nominal cross section A_p	mm^2	556	973	1251	1668
Nominal mass	kg/m	4.34	7.60	9.77	13.03
Ultimate force F_{pk}	kN	984	1722	2214	2952
Max stressing force $P_{0, max}$	kN	777	1361	1750	2333
Ducts					
Inner diameter (minimum)	mm	45	62	72	80
Outer diameter (maximum)	mm	50	67	77	85

Technical features: system MTAI15S – MTAI15 – Steel grade Y1770

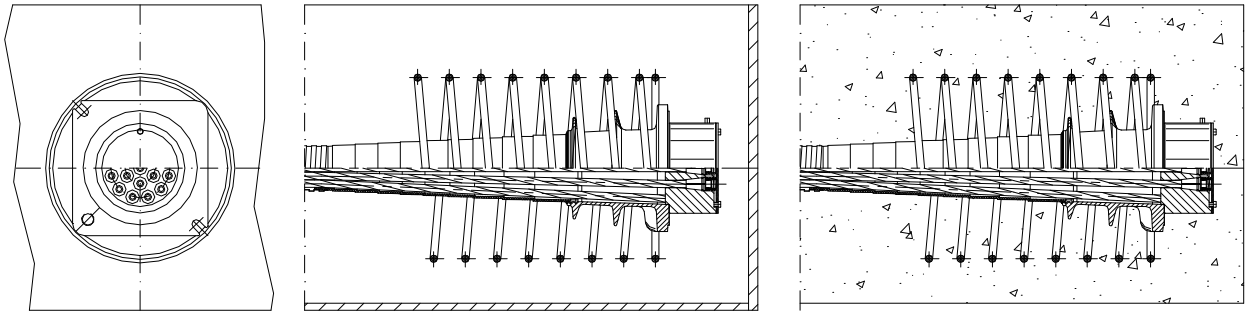
Tendon type		15MTAI	19MTAI	22MTAI	27MTAI
Strand pattern					
Number of strands	n	**15**	**19**	**22**	**27**
Strand 150 mm^2 (T15S)					
Nominal cross section A_p	mm^2	2250	2850	3300	4050
Nominal mass	kg/m	17.58	22.27	25.78	31.64
Ultimate force F_{pk}	kN	3990	5054	5852	7182
Max stressing force $P_{0, max}$	kN	3159	4001	4633	5686
Strand 139 mm^2 (T15)					
Nominal cross section A_p	mm^2	2085	2641	3058	3753
Nominal mass	kg/m	16.29	20.63	23.89	29.32
Ultimate force F_{pk}	kN	3690	4674	5412	6642
Max stressing force $P_{0, max}$	kN	2916	3694	4277	5249
Ducts					
Inner diameter (minimum)	mm	85	95	100	110
Outer diameter (maximum)	mm	90	100	105	115

Technical features: system MTAI15S – MTAI15 – Steel grade Y1770

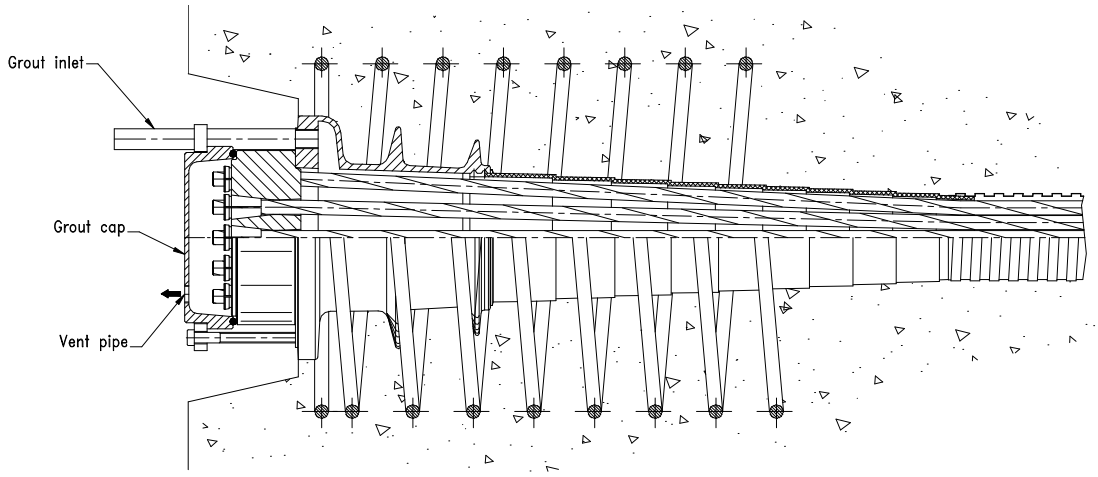
Tendon type		**31MTAI**	**37MTAI**
Strand pattern			
Number of strands	n	**31**	**37**
Strand 150 mm^2 (T15S)			
Nominal cross section A_p	mm^2	4650	5550
Nominal mass	kg/m	36.33	43.36
Ultimate force F_{pk}	kN	8246	9842
Max stressing force $P_{0,\,max}$	kN	6529	7792
Strand 139 mm^2 (T15)			
Nominal cross section A_p	mm^2	4309	5143
Nominal mass	kg/m	33.66	40.18
Ultimate force F_{pk}	kN	7626	9102
Max stressing force $P_{0,\,max}$	kN	6026	7193
Ducts			
Inner diameter (minimum)	mm	115	130
Outer diameter (maximum)	mm	120	135



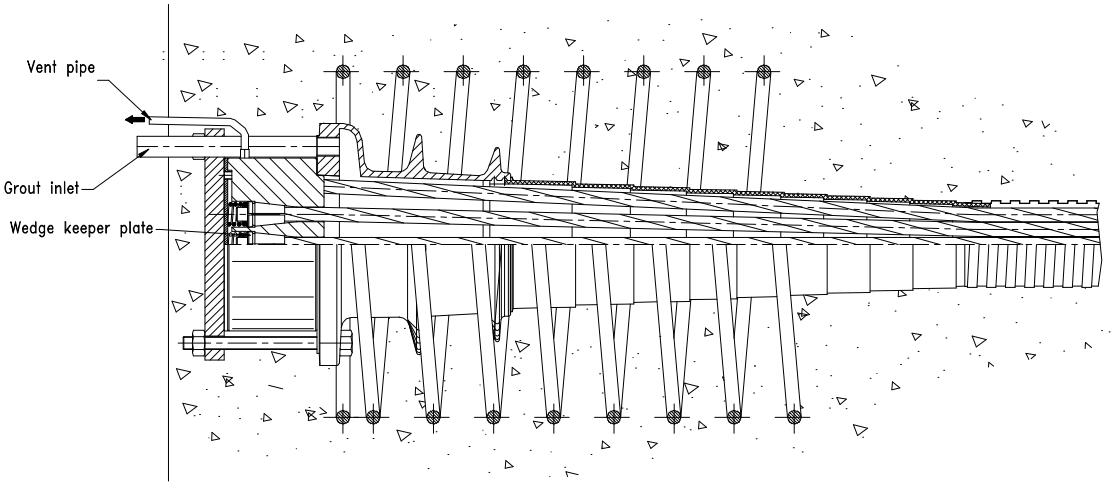
System MTAI – concreting and installation



System MTAIM – concreting and installation

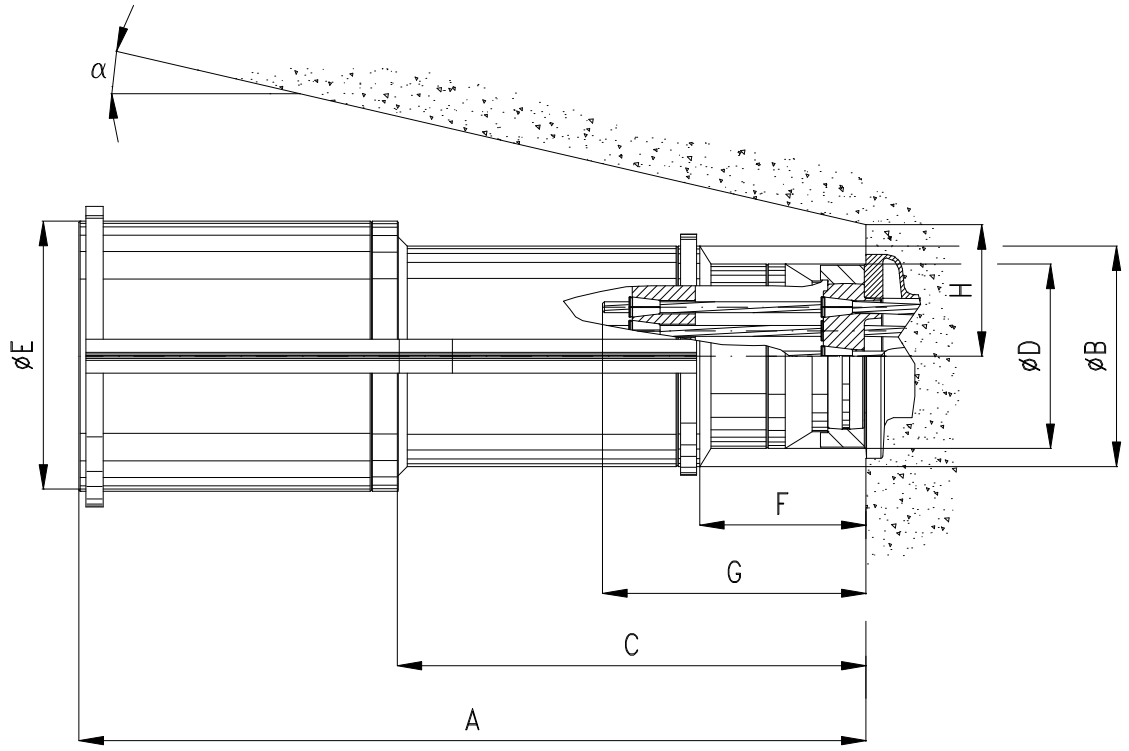


Grouting of active anchorage MTAI



Grouting of passive anchorage MTAIM

Multi-strand jack spacing requirements



Jack	Tendon type (strands no.)	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	F [mm]	G [mm]	H [mm]	a [deg]
MT1000kN	4	990	200	525	165	250	225	390	100	9
MT1500kN	7	980	225	540	185	310	170	415	115	9
MT2500kN	9	1000	255	560	215	345	195	420	130	9
MT3000kN	12	1040	290	610	235	350	210	435	145	10
MT3500kN	15	1035	315	590	255	390	195	445	160	10
MT4500kN	19	1175	420	725	310	470	260	520	190	10
MT6000kN	22/27	1320	460	765	380	560	300	590	200	10
MT9000kN	31/37	1120	480	620	410	700	300	570	240	12

Prescribed test plan - 1

Component	Item [1]	Test / Check	Traceability [2]	Minimum frequency	Documentation
Anchorplate	material	check	full	100 %	"3.1B" [3]
	detailed dimensions	test		5% ≥ 2 specimen	yes
	visual inspection	check		100 %	no
Cast-iron body	material	check	full	100 %	"3.1B" [3]
	detailed dimensions	test		3% ≥ 2 specimen	yes
	visual inspection	check		100 %	no
Wedge	material	check	full	100%	"3.1B" [3]
	treatment, hardness	test		0.5% ≥ 2 specimen	yes
	detailed dimensions	test		5% ≥ 2 specimen	yes
	visual inspection	check		100%	no
Trumpet	material	check	full	100 %	"3.1B" [3]
	detailed dimensions	test		3% ≥ 2 specimen	yes
Duct	material	check	full	100%	"CE"
	visual inspection	check		100 %	no
Strand	material	check	full	100 %	"CE" [4]
	diameter	test		each coil	no
	visual inspection	check		each coil	no
Constituents of filling materials as per EN 447	cement	check	full	100%	"CE"
	admixtures, additions	check		100%	yes
Helix	material	check	full	100 %	yes
	visual inspection	check		100 %	no
Stirrups	material	check	full	100 %	yes
	visual inspection	check		100 %	no

Prescribed test Plan - 2

Footnotes:

(1) Item:
material: defined according to technical specification deposited by the supplier at *SETRA*
detailed dimensions: measuring of all dimensions and angles according to the specification given in the Control Plan
visual inspection: means main dimensions, correct marking and labelling, surface, corrosion, coating, etc.

(2) Traceability:
Full: full traceability of each component to its raw material.
Bulk: traceability of each delivery of components to a defined point

(3) Inspection certificate type “3.1B” according to EN 10204.

(4) As long as the basis for CE marking for prestressing steel is not available, an approval certificate according to the respective rules in force at the place of use shall accompany each deliver.

(5) Test report type “2.2” according to EN 10204.

Audit testing

Component	Item [1]	Test / Check [2]	Sampling – number of components per audit
Anchorplate	material according to specifications	check, test	1
	detailed dimensions	test	
	visual inspection	check	
Cast-iron body	material according to specifications	check, test	1
	detailed dimensions	test	
	visual inspection	check	
Wedge	material according to specifications	check, test	2
	treatment, hardness	test	2
	detailed dimensions	test	1
	main dimensions, surface hardness	test	5
	visual inspection	check	5
Single tensile element test	ETAG 013 Annex E.3	test	1 series

(1) Item:
visual inspection: means main dimensions, correct marking and labelling, surface, corrosion, coating, etc.

(2) All samples shall be randomly selected and clearly identified.

Dimensions and properties of 7-wire strands according to prEN 10138-3 (1)

(notations according to prEN10138-3, in squared brackets to ETAG013 where possible)

Steel name		Y1770S7	Y1860S7	Y1770S7	Y1860S7
Tensile strength R_m [f_{pk}]	MPa	1770	1860	1770	1860
Strand					
Diameter D	mm	15.7	15.7	15.2	15.2
Cross sectional area S_n [A_p]	mm^2	150	150	139	139
Mass M	g/m	1172	1172	1086	1086
Permitted deviation on nominal mass	%	± 2			
Characteristic value of maximum force F_m [F_{pk}]	kN	266	279	246	259
Maximum value of maximum force F_{m-max}	kN	314	329	290	306
characteristic value of 0,1% proof force $F_{p0.1}$ [$F_{p0,1k}$]	kN	234	246	216	228
Minimum elongation at maximum force A_{gt} ($L_0 \geq 500$ mm)	%	3.5			
Relaxation after 1000 hours					
at 0,7 F_m (2)	%	2.5			
at 0,8 F_m (3)	%	4.5			
Modulus of elasticity E	MPa	195000			

(1) Until prEN10138-3 remains a draft norm, standards and regulations valid at the place of installation can be used.
(2) The requirement for 70% F_m is mandatory.
(3) Values for 80% F_m may be agreed between supplier and purchaser.

Materials and standard references

Designation	Material	Standard
Anchor head	Quenched and tempered steel (1)	EN 10083-1: 2006 EN 10083-2: 2006
Cast-iron block	Cast ductile iron (1)	EN 1563: 2004
Wedge	Case hardened steel (1)	EN 10277-2: 1999 EN 10083-2: 1996
Trumpet	Polyethylene (PE)	EN 1872: 2002
Helix	Steel for reinforced concrete	EN 10025: 2005 EN 10080: 2005
Stirrups	Steel for reinforced concrete	EN 10080: 2005
Ducts	Metal sheath	EN 523: 2005
Grout	Cement, additives, water	EN 447: 1997

(1) Exact materials and properties deposited at SETRA

Reference documents

Guideline for European Technical Approval

- **ETAG013: 2002** "Guideline for European Technical Approval of post-tensioning kits for prestressing of structures"

Standards

- **EN 445: 1997** "Grout for prestressing of tendons – Test methods"
- **EN 446: 1997** "Grout for prestressing of tendons – Grouting procedures"
- **EN 447: 1997** "Grout for prestressing of tendons – Specification for common grout"
- **EN 523: 2005** "Steel strip sheaths for prestressing tendons – Terminology, requirements, quality control"
- **EN 1563: 2004** "Founding – Spheroidal graphite cast irons"
- **EN 1992-1-1: 2005** "Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings"
- **prEN 10138-3: 2005** "Prestressing steel – Part 3: strands"
- **EN 10204: 2005** "Metallic products – Types of inspection documents"
- **EN 10083-1: 2006** "Quenched and tempered steel – Part 1: Technical delivery conditions for special steels"
- **EN 10083-2: 2006** "Quenched and tempered steel – Part 2: Technical delivery conditions for unalloyed quality steels"
- **EN 10084: 2000** "Case hardening steel – Technical delivery conditions
- **EN 13391:2004** "Mechanical tests for Post-tensioning systems"
- **EN 1992-1-1:2005** "Eurocode 2: Design of concrete structures. Part 1-1: General rules and rules for buildings"

CEN Workshop Agreement

- **CWA 14646: 2003** "Requirements for the installation of post-tensioning kits for prestressing of structures and qualification of the specialist company and its personnel."